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Highlights 2009|2010

Consiglio Nazionale delle Ricerche

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Preface

The 2009-2010 edition of CNR.it (the CNR Highlights) includes more than 200 scientific papers. Conceived and written in English to present to the international public the dynamic and multi-sided reality of the largest research organization in Italy, this review is a partial but significant collection of works carried out by CNR researchers and published on the main scientific journals. Articles have been selected on the basis of their impact factors among the 14.000 or so articles produced in the last two years, to present our best image to the world.
The present one is only the second of the CNR Highlights, after a first one dedicated to the Italian public, but the series represent already a must for our researchers, to promote their works along best-practice lines followed in research organizations worldwide.

In the present edition, with a more catchy new look, articles, images and scientific popularizations provide a broad outlook of the activities of CNR, reporting, side by side with research articles, about technology transfer and scientific support activities to national and local institutions.
The 2009-2010 Highlights are divided into four sections, similarly to the previous edition. However, as the reader looks through the pages, the interdisciplinary nature of the works will not pass unnoticed, interdisciplinarity being the peculiar feature of CNR, an organization in which the different disciplines find a fertile breeding ground to communicate and share their different knowledges.

In the final part of the Highlights, we illustrate how the CNR research network is organised. With its institutes spread all over Italy, CNR cooperates with academic, social, economic and institutional realities. It represents a model of scientific achievement and a chance of development for Italy. CNR activities extend beyond national frontiers, opened to collaboration with other major international research agencies and to the participation in international infrastructures.
Cnr.it wants to give recognition to all the researchers who work in CNR, confronting every day with the difficulties met by the research sector in Italy, engaged in what we believe is, above all, a most fascinating career. Enjoy reading it.

Luciano Maiani
President
Consiglio Nazionale delle Ricerche

Summary

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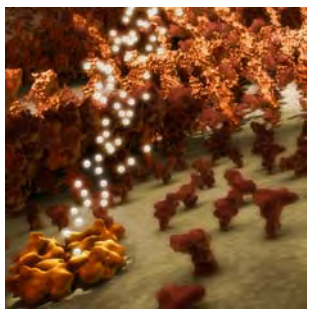
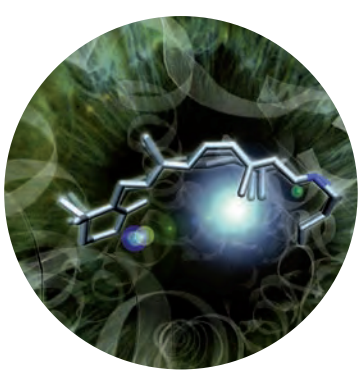
Cover

Image of a portion of the cell membrane, showing a Potassium channel, several glycolipids and a group of proteins in a raft.





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Life & Environment

Highlights

Genetics, Evolution, Health, Antitumorals, Neurosciences, Biology, Molecular biology, Computational biology, Biophysics, Behaviour, Biodiversity, Ecology, Atmosphere sciences / Climate changes, Paleo-climate, Biometereology, Food farming, Hidrology, Hidrodynamics, Water treatment / Water research, Earth sciences, Volcanology, Geo-chemistry, Remote sensing

Long-tailed macaques grooming in Ketambe National Park, Indonesia.

GENETICS

Mutations in the mitochondrial protease gene AFG3L2 cause dominant hereditary ataxia SCA28

Autosomal dominant spinocerebellar ataxias (SCAs) are genetically heterogeneous neurological disorders characterized by cerebellar dysfunction, mostly due to Purkinje cell degeneration, leading to severe movement disorders characterized by gait imbalance, progressive trunk and limb ataxia, and dysarthia. Many different genes have been found in the last 15 years involved in this type of disorders, but many more have been mapped but not identified. SCA type 28 was mapped by research groups in Turin and Milan in 2006. We have collaborated with these groups in identifying *AFG3L2* gene as the gene involved in SCA28[8]. This gene encodes a protein closely related to paraplegin localized in mitochondria. It is a component of the conserved *m*-AAA metalloprotease complex involved in the maintenance of the mitochondrial proteome.

AFG3L2 and paraplegin are proteins highly homologous to two yeast mitochondrial proteins belonging to the superfamily of ATPases active in the mitochondrial inner membrane which is a crucial component of the mitochondrial protein quality-control system.

The mutations found have been tested in m-AAA-deficient yeast cells expressing the human mutated *AFG3L2* complex. The results demonstrated that the mutations alter the proteolytic competence of the *m*-AAA complex, resulting in defective activity of cytochrome *c* oxidase and impairment of cell respiration. Our results indicate an essential specialized role for this component of the *m*-AAA complex in protecting the human cerebellum from neurodegeneration.

Di Bella D., Lazzaro F., Brusco A., Plumari M., Battaglia G., Pastore A., Finardi A., Cagnoli C., Tempia F., Frontali M., Veneziano .L, Sacco T., Boda E., Brussino A., Bonn F., Castellotti B. et al., "Mutations in the mitochondrial protease gene AFG3L2 cause dominant hereditary ataxia SCA28", *Nat Genet.* 2010;42:313-21.

GENETICS

Preventing NHEJ suppresses DNA repair, defects of Fanconi anemia

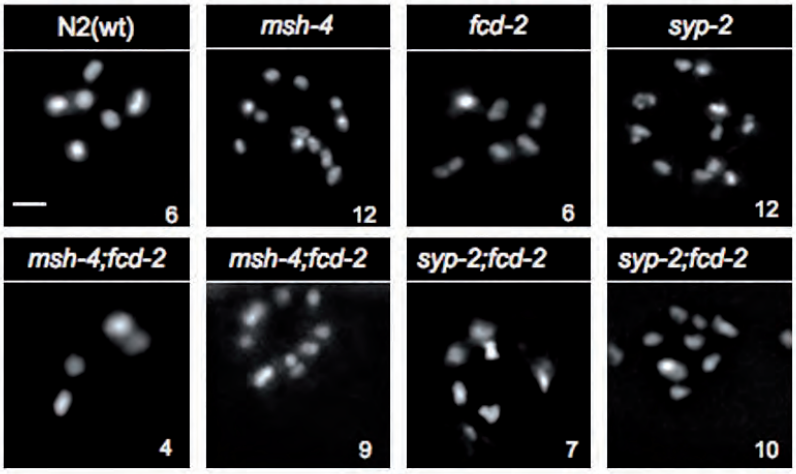
Neoplastic cells are characterized by recurrent and multiple mutations. Among the mutated genes, some cause the disease (drivers) and others are consequence of the disease itself (passengers). Cancer-prone syndromes (such as Fanconi Anemia, Bloom syndrome, Werner syndrome etc.), that are inherited disorders characterized by increased cancer incidence, have helped to discriminate between drivers and passengers not only in these disorders, but also in sporadic cancer. Fanconi anemia (FA) is a complex cancer susceptibility disorder associated with DNA repair defects and infertility.

We investigated the role of the FANCD2 gene in gametogenesis and *in soma* making use of the model system *Caenorhabditis elegans*. We demonstrated that FANCD2 is involved in homologous repair of meiotic breaks and is required to prevent the illegitimate use of the error-prone nonhomologous end-joining (NHEJ) pathway. In mutants defective in the FANCD2 ortholog, oocytes undergo apoptosis, well explaining the infertility problems of Fanconi patients. Landmarks of FA syndrome are also sporadic developmental defects and hypersensitivity of somatic cells to chemothera-

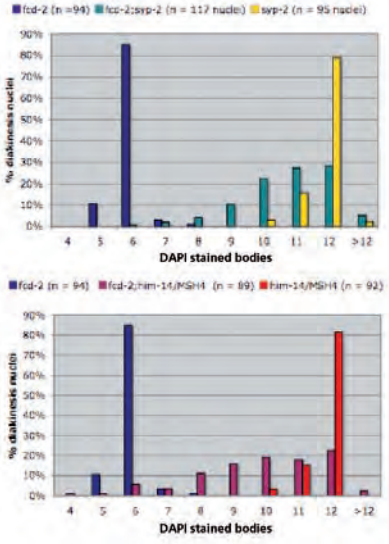
peutic drugs such as cisplatin. This study demonstrated that both phenomena can be suppressed by inhibiting NHEJ. The discovery, made in *C. elegans* in the context of a whole organism, has been confirmed in parallel *ex-vivo* experiments in mammalian cell lines.

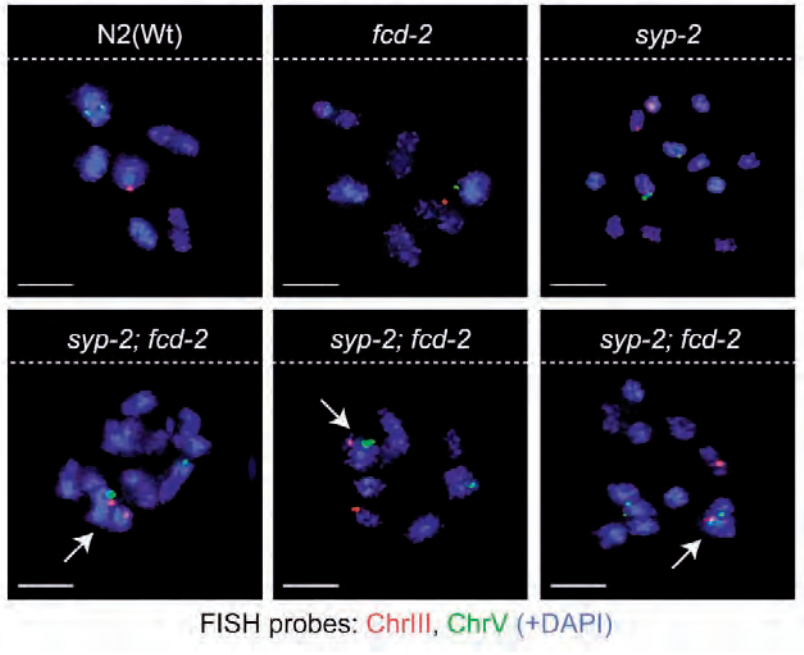
These findings are consistent with the interpretation that FA results from promiscuous action of NHEJ during DNA repair. The study is relevant to the understanding of FA pathology as well as the comprehension of the basic mechanisms leading to developmental defects, sterility, and tumors.

Adamo A., Collis S.J., Adelman C.A., Silva N., Horejsi Z., Ward J.D., Martinez-Perez E., Boulton S.J., La Volpe A., "Preventing nonhomologous end joining suppresses DNA repair defects of Fanconi anemia", *Mol Cell.* 2010 Jul 9;39(1):25-35.



Lack of FCD-2 in crossover-deficient mutants leads to chromosome associations.





NHEJ is responsible for the chromosome associations observed in crossover-deficient mutants lacking FCD-2.

EVOLUTION

Primatologists and archeologists launch a new discipline: primate archeology

Until very recently, archaeology was thought to be the science of past human cultures, through the discovery and analyses of their artefacts. Now, in an article published in *Nature* a team of researchers argue that we can extend this science to non human primate cultures. The article seeks to provide for the first time a truly comparative framework for understanding the biological, environmental and social contexts of primate behavioural evolution, through analyses of tool-making, tool-use and the spatially-patterned accumulation of tools, i.e. the elementary technology of our primate cousins. The focus on technology unites primatologists and archaeologists in striving to establish a new field of research with common goals and shared methods for data collection and analyses. This field is Primate Archaeology and it aims to explore the past and present material record of members of the Order Primates, that is, monkeys and apes. Since any organism that accumulates or modifies durable materials will leave a signature as an archaeological record, this discipline allows to reconstruct extinct behaviours over evolutionary timescales. A new research project, the Pounding Working Group, has just started to compare the use of stone tools to access encased food in chimpanzees, capuchin monkeys and hominins. It is well known that the study of stone tools and flakes produced by our ancestors allow to infer their level of cognitive sophistication and motor skills. Furthermore by investigating the ecological conditions in which stone tool use occurs allows to delineate the likely scenarios in which our ancestors developed it. Ongoing research in West Africa (chimpanzees) and Brazil (capuchins) puts into practice systematic primate archaeology, combining direct ecological and behavioural observation and experimentation in the field with archaeological methods for tool analyses.

M. Haslam, A. Hernandez-Aguilar, V. Ling, S. Carvalho, I. de la Torre, A. DeStefano, A. Du, B. Hardy, J. Harris, L. Marchant, T. Matsuzawa, W. McGrew, J. Mercader, R. Mora, M. Petraglia, H. Roche, E. Visalberghi, R. Warren, "Primate Archaeology", *Nature*, Vol. 460, n. 7253 2009, pp. 339-344.

EVOLUTION

Endogen retroviruses reveal the history of sheep domestication

Animal domestication occurred firstly in sheep and goat about 11,000 years ago in Asia but only later (6,000 years ago), with the diffusion of agro-pasture, animals became, together with some vegetable species, the main system of food production.
In this study involving 27 different research groups from 18 countries, coordinated by prof. Massimo Palmarini (University of Glasgow) and using 65 different sheep genetic types, an endogenous retrovirus (ERVs) family present in all mammalian genomes (including humans) for infections occurred long time ago, was employed.
In sheep, at least 27 ERVs copies of Jaagsiekte Sheep Retrovirus (enJSRVs) are known. This hexogen and pathogen retrovirus is responsible of carcinoma affecting both bronchioles and alveolus's pulmonary characterizing the pulmonary adenomatosis, one of the most important sheep viral pathologies. When a retrovirus enters the germinal line (sperms or oocytes) it can be transmitted to the progeny in a Mendelian fashion and, if it is inserted in the genome close to a gene, it can alter the gene function and influence the host evolution. Endogen retroviruses have a specific chromosome location as we have demonstrated by using cytogenetic molecular techniques (FISH). On the basis of the present study, the history of sheep domestication occurred in dif-

Figure 1. Sheep of Soay breed in the St Kilda island of Ebridi, a group of islands on the western Scotland cost. Soay sheep still has some archaic characters conserved during the time because of the environmental isolation.

ferent migratory steps. Relicts of the first migrations are the mouflon and breeds retained "primitive" as the Orkney, Soay (Figure 1) and Nordic short-tailed. Latest migratory episodes involved the present sheep breeds with improved genetic traits for meat, milk and wool.

This study demonstrated, for the first time, that genetic markers based on endogenous retroviruses can be an useful tool to clarify some aspects concerning the history of domestic species. Furthermore, the possibility to identify genetically more primitive animals from the more modern ones, can be important to preserve rare genetic pools, necessary for the genetic biodiversity.

B. Chessa, F. Pereira, F. Arnaud, A. Amorim, F. Goyache, I. Mainland, R.R. Kao, J. M. Pemberton, D. Beraldi, M. Stear, A. Alberti, M. Pittau, L. Iannuzzi, M.H. Banabazi, R. Kazwala, Y.-P. Zhang, J.J. Arranz, B.A. Ali, Z. Wang, M. Uzun, M. Dione, I. Olsaker, L.-E. Holm, U. Saarma, S. Ahmad, N. Marzanov, E. Eythorsdottir, M.J. Holland, P. Ajmone-Marsan, M.W. Bruford, J. Kantanen, T.E. Spencer, M. Palmarini, "Revealing the history of sheep domestication using retrovirus integrations", *Science* 324: 532-536. 24 April (2009).

GENETICS

The memory gene

Neurogenesis, the ongoing process of the formation of new neurons in the brain, is indispensable for the formation of memory in the hippocampus as demonstrated by recent research. Less clear are the ways in which new neurons become integrated into mnemonic circuits and their contribution to the formation of memories. A *team* at the Institute of Neurobiology and Molecular Medicine of the National Research Council (Inmm-Cnr), comprising a research team from the Institute of Neurosciences (In-Cnr) and the University of Lumsa, and from the foundation of Santa Lucia, has helped to clarify the molecular mechanisms which underlay the coordination among the processes of proliferation, differentiation, and integration of new neurons into existing circuits. In particular, the essential role of the gene, PC3/Tis21/BTG2, was identified for the differentiation of neurons: its absence blocks the maturation of new neurons in the hippocampus. The actions of the gene in the maturation of the neurons in the hippocampus may suggest its involvement in degenerative diseases such as Alzheimer's.

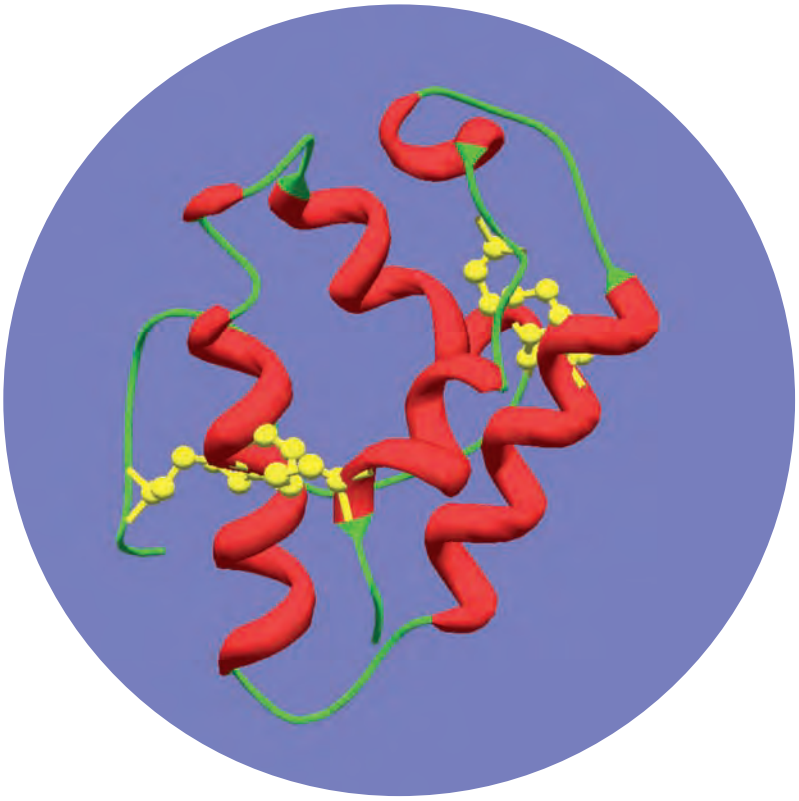
HEALTH

Mulberry: the first allergen identified

An increase in the prevalence of allergic diseases has been observed in the last 30 years. Mulberry (*Morus* spp.) is a fruit commonly eaten in Southern Europe as fresh food or processed for ice creams and jams. However, some subjects have reported skin sensitivity to this fruit, with severe systemic reaction after ingestion. These clinical observations prompted a study of allergenic components in black mulberry. The collaboration among the CNR-Institute of Biomedicine and Molecular Immunology "A. Monroy", the CNR-Institute of Protein Biochemistry, and the Center for Molecular Allergology IDI-IRCCS, has allowed the identification of LTP as a cause of allergic reactions against mulberry fruit. Among the most important sensitizers, Lipid Transfer Protein (LTP) is an allergen that can cause mild or severe symptoms, spanning from local oral symptoms to the life-threatening anaphylactic shock. The prevalence of food-related allergy caused by LTP is especially high in the Mediterranean area, where peach is considered as the most frequent primary sensitizer toward this molecule. Therefore, the definition of a complete spectrum of allergenic LTPs and their degree of cross-reactivity between species is of paramount importance in allergy diagnosis and management of allergic subjects.

This molecule, named Mor n 3 by Official WHO-IUIS allergen nomenclature, represents the first allergen isolated in mulberry. In line with the observed structural similarities with other already known LTPs, the immunological characterization has shown a very high cross-reactivity with other food LTP. The results of this study mark the consumption of mulberry as a potential risk for LTP allergic patients, and open the way to possible applications of Mor n 3 in diagnostic tools and therapeutic options.

M.A. Ciardiello, P. Palazzo, M.L. Bernardi, V. Carratore, I. Giangrieco, V. Longo, M. Melis, M. Tamburrini, D. Zennaro, A. Mari, P. Colombo, "Biochemical, immunological and clinical characterization of a cross-reactive nonspecific lipid transfer protein 1 from mulberry", *Allergy*, 65 (2010), pp. 597-605.



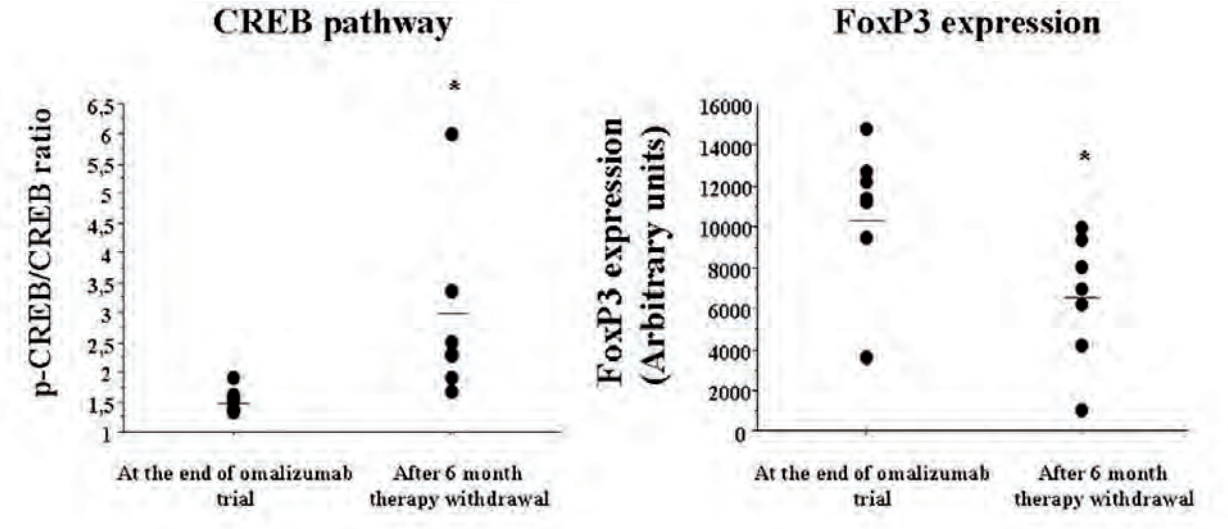
3D structure of lipid transfer protein.

HEALTH

Anti-inflammatory effects of omalizumab in severe asthmatics

Severe persistent asthma causes a substantial morbidity and mortality burden and is frequently inadequately controlled despite intensive guideline-based therapy. Omalizumab represents in these cases an alternative anti-inflammatory therapy. Severe asthmatics show an increased activation of pro-inflammatory markers, including p-CREB and IL-8, and a reduced activity of T regulatory cells. Since the control of inflammation represents the main target of the asthma therapy, it is important to determine the effects of omalizumab on markers of inflammation. Omalizumab was administered to seven severe cortico-steroid-dependent asthmatics for seven years as part of a prospective clinical trial (CIGE0250011-Novartis). In the recruited patients, symptom score, spirometry, and pro-inflammatory markers (pCREB and IL-8) and T regulatory activities were assessed in the peripheral blood of the patients at the end of omalizumab trial and after six months from omalizumab discontinuation. Eligible patients had day or night-time asthma symptoms and at least two documented asthma exacerbations requiring systemic corticosteroids or emergency services/hospitalization during the year before the initiation of omalizumab. After seven years of treatment, omalizumab reduced pro-inflammatory events and increased the regulation of inflammation (Figure 1), all events correlated to improved spirometric values and reduced asthma symptom score. This study provides for the first time compelling evidences that omalizumab is effective in severe uncontrolled asthma by modulating mechanisms crucially involved in the inflammatory processes of the disease. These effects of omalizumab do not persist long after omalizumab discontinuation and need to be further validated in larger patient cohorts.

Pace E., Maria Ferraro, Andreina Bruno, Jean Bousquet, Mark Gjomarkaj, "Anti-inflammatory effects of seven years treatment with omalizumab in severe uncontrolled asthmatics", *Allergy* 2010; 65:1495-1496.



CREB and Foxp3 expression was evaluated after 7 years of omalizumab treatment and after 6 months from omalizumab discontinuation.*p<0.05.

HEALTH

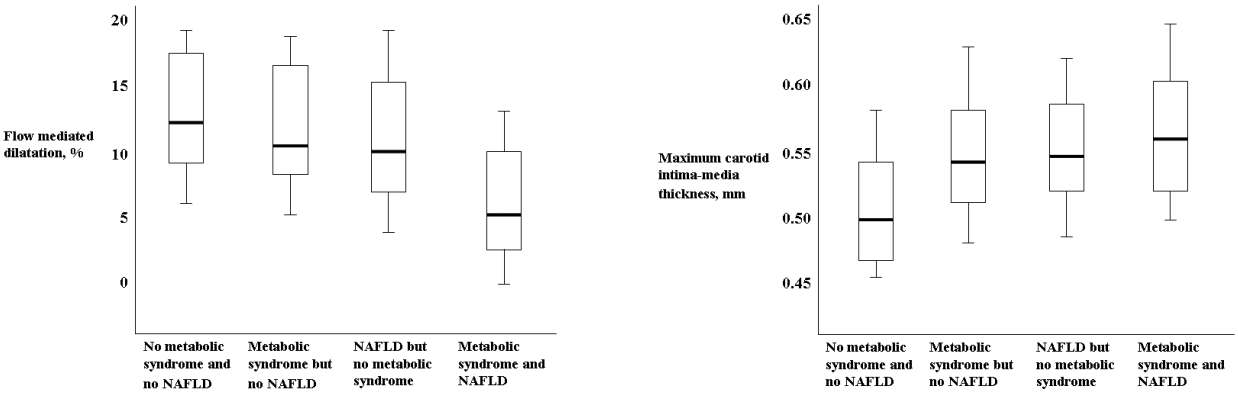
Early atherosclerosis in pediatric nonalcoholic fatty liver disease

L. Pacifico, C. Anania, F. Martino, V. Cantisani, R. Pascone, A. Marcantonio, C. Chiesa, "Functional and morphological vascular changes in pediatric nonalcoholic fatty liver disease", *Hepatology* 2010; 52:1643-51.

Non-Alcoholic Fatty Liver Disease (NAFLD) encompasses a range of liver histology severity and outcomes in the absence of chronic alcohol use. The mildest form is simple steatosis in which triglycerides accumulate within hepatocytes. A more advanced form of NAFLD, Non-Alcoholic Steato-Hepatitis (NASH), includes inflammation and liver cell injury, progressive to cryptogenic cirrhosis. Over the last two decades the rise in the prevalence rates of obesity likely explains the NAFLD epidemic worldwide. NAFLD shares many features of the metabolic syndrome (MS), a highly atherogenic condition, and this has stimulated interest in the possible role of NAFLD in the development of atherosclerosis. Carotid intima-media thickness (cIMT), and brachial flow-mediated dilation (FMD) as assessed noninvasively by ultrasound are preclinical markers of vascular health. Impaired FMD and increased cIMT reflect early abnormalities during atherogenesis and have been found to predict cardiovascular events.

In this study we showed that obese children with NAFLD had significantly lower FMD response and increased cIMT compared to obese children without NAFLD independently of other cardiovascular risk factors and MS, and that obese children exhibited more functional and morphologic vascular changes than healthy lean controls. These findings suggest that children with NAFLD may be at a higher risk for atherosclerosis. Therefore, the rising prevalence of obesity-related MS and NAFLD in childhood may lead to a parallel increase in adverse cardiovascular outcomes. In children, the cardiovascular system remains plastic and damage-reversible if early and appropriate interventions are established effectively. Therapeutic goals for NAFLD should address not only end-stage liver disease but also CVD.

FMD and cIMT values in obese children without Mets and without NAFLD, in patients with MS but without NAFLD, in patients with NAFLD but without MS, and in those with both MS and NAFLD. Box-plots give the median value, 25th and 75th percentiles, and whiskers. $P < 0.001$ for trend.



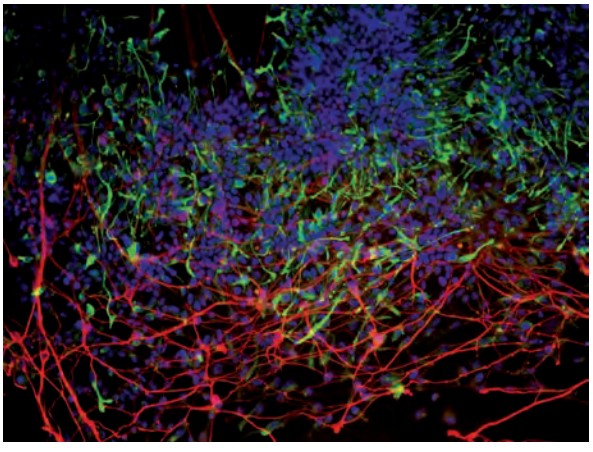
HEALTH

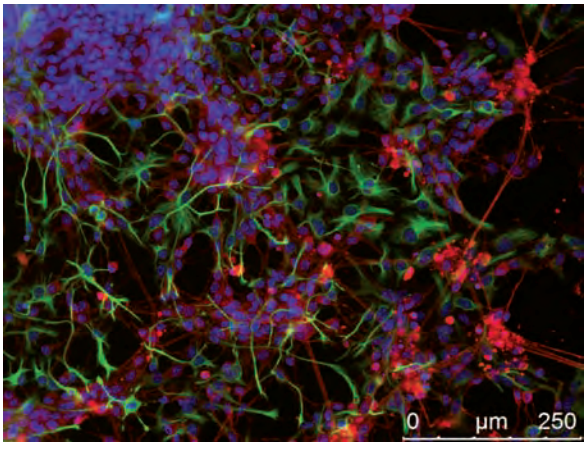
A chemical approach to controlling pluripotent cell fate and function

Lonardo E., Parish C.L., Ponticelli S., Marasco D., Ribeiro D., Ruvo M., De Falco S., Arenas E., Minchiotti G., "A small synthetic cripto blocking peptide improves neural induction, dopaminergic differentiation, and functional integration of mouse embryonic stem cells in a rat model of Parkinson's disease", *Stem Cells.* 2010 Aug;28(8):1326-37.

Pluripotent stem cells provide an almost unlimited source of cells for various applications such as drug discovery, disease modelling and cell replacement therapy. The idea of using stem cells for neurodegenerative disease, such as Parkinsons' disease (PD), has been fuelled by the finding that human ventral midbrain fetal tissue grafts improve the symptoms and reduce the need of L-DOPA in these patients. In this context, pluripotent stem cells have become attractive because they can be easily expanded and can give rise to midbrain dopaminergic neurons, which degenerate in PD. However, several challenges still need to be overcome, amongst which the need to: (i) achieve homogenous populations of neurons, and (ii) improve the safety of cell transplantation by eliminating tumor formation. Cripto is a key player in the signalling pathways controlling stem cell differentiation. Genetic ablation of *cripto* results in the enhanced ability to generate neurons and the reduced tumor formation. As an extracellular molecule, Cripto is a promising target for therapeutic purposes, because its activity can be blocked without genetic manipulation of the cells. In this study, we identify a novel small synthetic molecule (Cripto BP) that blocks Cripto signalling and promotes neuronal differentiation of pluripotent stem cells. Cripto BP–treated stem cells when transplanted into the brain of parkinsonian rats, enhanced functional recovery and reduced tumor formation, mimicking the effect of genetic ablation of *cripto*.
We suggest that specific small molecules can be used for efficient generation of dopaminergic neurons from pluripotent stem cells, bringing us closer toward an application in drug discovery and therapy.

Differentiated mouse ESCs showing βIII tubulin (red) and GFAP (green) -immunoreactive neurons and glia, respectively. DAPI -stained nucleai (blue).





HEALTH

Identification of multiple sclerosis susceptibility genes

Multiple Sclerosis (MS) is an autoimmune disease that affects the brain and spinal cord (central nervous system). The disease is more likely to occur in relatives of an affected person and shows a rapid fall off in risk with decreased genetic relatedness to affected individuals. Still, the empirical risk for a monozygotic twin of an affected patient is about 35%, thus considerably less than 100%, indicating that the disease risk depends on the complex interplay between several co-inherited susceptibility alleles interspersed throughout the genome and unknown environmental factors.
This manuscript describes the identification of a novel disease gene by association analysis of the entire genomes (GWAS). This was achieved by initially assessing 882 and 872 MS patients and unaffected individuals, respectively, with advanced techniques as high-throughput genotyping arrays and statistical inference methods to impute millions of genetic variants discovered within the "1000 Genomes Project". While imputation methods have become a common step in GWAS, this was the first report of successful use of data from this international sequencing project.
Looking at the frequency distribution of alleles between patients and healthy individuals, variants within the *CBLB* gene were found to be strongly associated with MS and the result was then replicated in a larger sample set. The study, performed in the Sardinian island, where an anomalously high MS prevalence is observed, gives important insights on the understanding of biological mechanisms underlying the disease in humans. The *CBLB* gene or "E3 ubiquitin-protein ligase" plays indeed an important role in regulating our immune system, and it was previously been involved in mice models of MS.

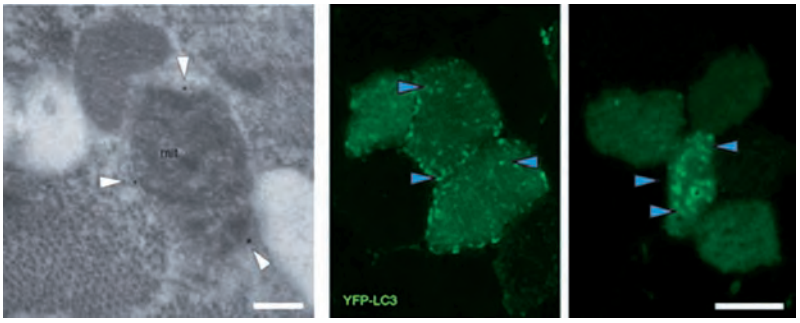
Sanna S., Pitzalis M., Zoledziewska M., et al., "Variants within the immunoregulatory CBLB gene are associated with multiple sclerosis", *Nature Genetics*, 42(6) (2010), pp. 495-497.

HEALTH

Low protein diet or drugs reactivate autophagy and restore muscle survival

Congenital muscular dystrophies represent an heterogeneous group of inherited muscle disorders with a progressive clinical course. At present, no curative therapy has reached a clinical level. However, we have previously found that muscular dystrophies linked to collagen VI deficiency show dysfunctional mitochondria and spontaneous apoptosis, leading to myofiber degeneration (Irwin et al., Nat Genet, 2003); furthermore, using low doses of Cyclosporin A we obtained the rescue of myofibers in both mice and in a selected group of patients (Merlini et al., Proc Natl Acad Sci USA, 2008). In this study we demonstrate that the persistence of abnormal mitochondria and apoptosis are caused by defective autophagy. Forced activation of autophagy by genetic, dietary and pharmacological approaches restore myofiber survival and ameliorate the dystrophic phenotype in mice. In particular, a specifically designed low-protein diet has significant effects on the removal of abnormal mitochondria by reactivated autophagy. Furthermore, also pharmacological tools, including rapamycin and Cyclosporin A, are able to reactivate autophagy, to reduce the amount of altered mitochondria releasing apoptotic factors, and to prevent muscle cell degeneration. Since also muscle cells from subjects with Bethlem myopathy or Ullrich congenital muscular dystrophy present a defective activation of the autophagic machinery, it will be possible to restore this activity by using a low protein diet.

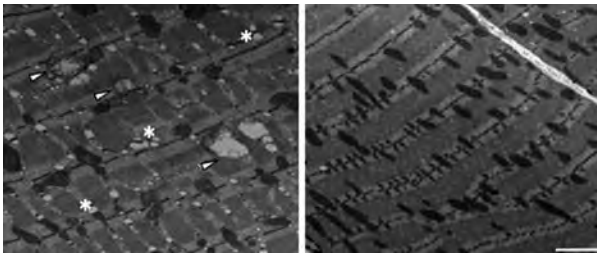
The finding that modulation of autophagy through nutritional and pharmacological treatments is beneficial for collagen VI dystrophic muscles paves the way for investigating autophagy defects also in other muscular dystrophies.



P. Grumati, L. Coletto, P. Sabatelli, M. Cescon, A. Angelin, E. Bertaggia, B. Blaauw, A. Urciolo, T. Tiepolo, L. Merlini, N.M. Maraldi, P. Bernardi, M. Sandri, P. Bonaldo, "Autophagy is defective in collagen VI muscular dystrophies, and its reactivation rescues myofiber degeneration", *Nat Med* 16:1313-20, 2010.

Detection of autophagosomes by LC_3 labeling by EM and immunofluorescence in muscles of myopathic mice.

a



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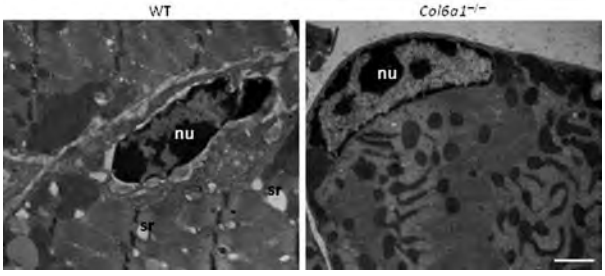

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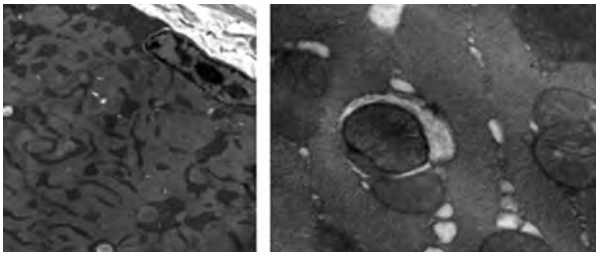

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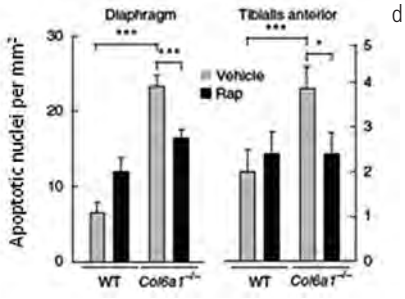
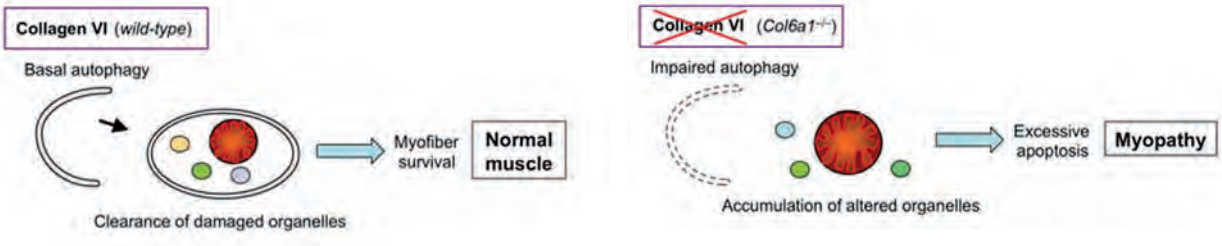


Altered myofiber ultrastructure in myopathic mice is rescued by starvation (A) and LPD (B). Rapamycin ameliorates morphotype (C) and apoptosis (D).

Defective autophagy causes abnormal organelle retention and muscle fibre degeneration, whilst restoration of autophagy rescues myofiber degeneration.



HEALTH

Che-1 promotes tumor cell survival sustaining mutant p53 transcription

The product of the p53 gene is a tumor suppressor mainly involved in the transcriptional regulation of a large number of growth arrest- and apoptosis-related genes. Upon several cellular stresses, p53 contributes to cell cycle arrest at the G1/S or G2/M checkpoints through diverse mechanisms. The p53 gene is the most frequent target for genetic alterations in human cancer, and mutant p53 proteins not only lose wild-type p53 tumor suppressor activity, but gain specific properties that mainly contribute to tumor aggressiveness, chemoresistance and are often correlated with poor prognosis. Therefore, several therapeutic rationales targeting mtp53 activity are currently under investigation including attempts to inhibit mtp53 expression.
Che-1 (also named AATF and Traube) is an evolutionary conserved RNA polymerase II binding protein involved in the regulation of gene transcription. Recently, we have showed that in response to DNA damage, Che-1 is localized to the p53 promoter, increasing transcription of this gene and contributing to the increase in p53 protein levels after DNA damage. In the present study, we have provided evidence that Che-1 inhibition strongly decreases mutant p53 expression in human cancer cells. In addition, Che-1 depletion induces p73 transcription and apoptosis (programmed cell death) by activating DNA damage checkpoint in these cells. These findings suggest a new therapeutic approach that, allowing simultaneous modulation of p73 and mutant p53 levels, might be used to target the large fraction of human tumors harboring p53 mutations.

T. Bruno, A. Desantis, G. Bossi, S. Di Agostino, C. Sorino, F. De Nicola, S. Iezzi, A. Franchitto, B. Benassi, S. Galanti, F. La Rosa, A. Floridi, A. Bellacosa, C. Passananti, G. Blandino, M. Fanciulli, "Che-1 promotes tumor cell survival sustaining mutant p53 Transcription and Inhibiting DNA Damage Response Activation", *Cancer Cell.* Aug 9;18(2) (2010), pp. 122-134.

ANTITUMORALS

Crystal structure of the catalytic domain of the tumor-associated human carbonic anhydrase IX

Carbonic anhydrase (CA) IX is a plasma membrane-associated member of the α-CA enzyme family, which is involved in solid tumor acidification. It is a marker of tumor hypoxia and a prognostic factor in several human cancers. An aberrant increase in CA IX expression in chronic hypoxia and during development of various carcinomas contributes to tumorigenesis through at least two mechanisms: pH regulation and cell adhesion control. Here we report the X-ray structure of the catalytic domain of CA IX in complex with a classical, clinically used sulfonamide inhibitor, acetazolamide. The structure reveals a typical α-CA fold, which significantly differs from the other CA isozymes when the protein quaternary structure is considered. Thus, two catalytic domains of CA IX associate to form a dimer, which is stabilized by the formation of an intermolecular disulfide bond. The active site clefts and the PG domains are located on one face of the dimer, while the C-termini are located on the opposite face to facilitate protein anchoring to the cell membrane. A correlation between the three-dimensional structure and the physiological role of the enzyme is here suggested, based on the measurement of the pH profile of the catalytic activity for the physiological reaction, CO_2 hydration to bicarbonate and protons. On the basis of the structural differences observed between CA IX and the other membrane-associated α-CAs, further prospects for the rational drug design of isozyme-specific CA inhibitors are proposed, given that inhibition of this enzyme shows antitumor activity both in vitro and in vivo.

V. Alterio, M. Hilvo, A. Di Fiore, C.T. Supuran, P. Pan, S. Parkkila, A. Scaloni, J. Pastorek, S. Pastorekova, C. Pedone, A. Scozzafava, S. M. Monti, G. De Simone, "Crystal Structure of the Catalytic Domain of the Tumor-Associated Human Carbonic Anhydrase IX", *Pnas*, 2009, 106:16233.

NEUROSCIENCE

Erasing fear memories

Events that are associated with trauma and fear often leave memories that reoccur spontaneously, leading to excessive fear, anxiety and, in some cases, to posttraumatic stress disorder. Such relapses of fear memories constitute a major clinical problem, and their elimination is a major corner-stone of psychological therapy. Recent results show that treating adult mice with chondroitinase ABC targeting the extracellular matrix restores fear memory acquisition to the erasure-prone modality that typifies young rodents. These results suggest that maturation of the extracellular matrix could be a mechanism used by different brain circuits to change from a malleable to a more crystallized state during development.

T. Pizzorusso, "Erasing Fear Memories", *Science*, Vol. 325, n. 5945 (2009), pp. 1214-1215; Gogolla et al., *Science*, Vol. 325 (2009), pp. 1258-61.

NEUROSCIENCE

Experimental and clinical evidence of neuroprotection by nerve growth factor eye drops: implications for glaucoma

A. Lambiase, L. Aloe, M. Centofanti, V. Parisi, F. Mantelli, V. Colafrancesco, G.L. Manni, M.G. Bucci, S. Bonini, R. Levi-Montalcini, "Experimental and Clinical Evidence of Neuroprotection by Nerve Growth Factor Eye Drops: Implications for Glaucoma", *Pnas*, ago 2009.

Elevated intraocular pressure (IOP) in glaucoma causes loss of retinal ganglion cells (RGCs) and damage to the optic nerve. Although IOP is controlled pharmacologically, no treatment is available to restore retinal and optic nerve function. We evaluated the effects of NGF eye drops in a rat model of glaucoma. We also treated three patients with progressive visual field defects despite IOP control.

Glaucoma was induced in rats through injection of hypertonic saline into the episcleral vein. Initially, two doses of NGF (100ug/ml and 200ug/ml) were tested on 24 rats and the higher was found more effective. Glaucoma was then induced in an additional 36 rats: half untreated and half treated with 200ug/ml NGF QID for 7 weeks. Apoptosis/survival of RGCs was evaluated by histological, biochemical and molecular analysis. Three patients with advanced glaucoma underwent psychofunctional and electrofunctional tests at baseline, after 3 months of NGF eye drops, and after 3 months of follow-up.

Seven weeks of elevated IOP caused RGC degeneration resulting in 40% cell death. Significantly less RGC loss was observed with NGF treatment (2530±121 vs 1850±156 RGCs/mm2) associated with inhibition of cell death by apoptosis. Patients treated with NGF demonstrated long lasting improvements in visual field, optic nerve function, contrast sensitivity, and visual acuity.

As final result, NGF exerted neuroprotective effects, inhibiting apoptosis of RGCs in animals with glaucoma. In three patients with advanced glaucoma, treatment with topical NGF improved all parameters of visual function. These results may open therapeutic perspectives for glaucoma and other neurodegenerative diseases.

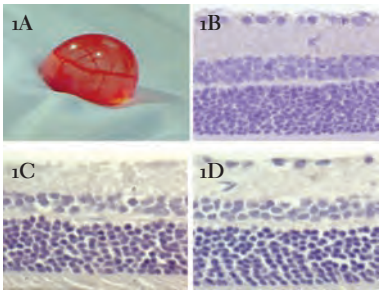


Figure 1A reports the eye globe of a rat during the early, but progressive development of glaucoma, induced sperimentally by endocular pressure. Figures 1B,C and D, are representative histological sections of retinal cells of control and experimental eyes. Thus, figure 1 shows the structural aspect of retinal cells of control eye; figure 1C, a section of retina of glaucomatous eye and figure 1D a section of glaucomatous retina treated with eye topical NGF application. In figure 1D, note that the NGF administration, during the early stage of glaucoma blocks the degeneration of retinal cells and prevents the development of vision loss.

BIOLOGY

Check the side effects induced by siRNA

siRNA are small double strand RNA molecules long 21 base pairs present in the cells of all living organisms having the physiological function of controlling gene expression. The discovery of siRNA has open important therapeutic perspectives based on the possibility to specifically modulate the expression of genes involved in pathological conditions, by introducing in the cell synthetic siRNA having specific sequence for the gene of interest. If siRNA are not delivered in an opportune mode, toxicity for endothelial cells of blood and lymphatic vessels has been evidenced, independently from their sequence.
Indeed, it has been demonstrated in two different pathological states, the corneal neovascularization and the hind limb ischemia, both characterized by new formation of blood and lymphatic vessels, that, if siRNA are delivered in the extracellular space they interact with Tool-like receptor 3 (TLR3). The function of this intracellular receptor is of immunological surveillance for viral infection, thanks to its ability to bind double strand RNA. Once activated, TLR3 induces the apoptotic cascade determining cell death. Interestingly, in this manuscript it has been reported for the first time that this receptor is also localized on the endothelial cell surface, and it has been demonstrated that the final effect of binding siRNA with TLR3 on endothelial cells is an aspecific inhibition of new vessels formation.
Data reported in this manuscript have been crucial for the evaluation of side effects triggered by the delivery of synthetic siRNA in the extracellular space.

W. Choa, R.J.C. Albuquerque, M.E. Kleinman, V. Tarallo, A. Greco, M. Nozaki, M.G. Rich, J.Z. Baffi, B.K. Ambati, M. De Falco, J.S. Alexander, A. Brunetti, S. De Falco, J. Ambati, "Small Interfering RNA-induced TLR3 Activation Inhibits Blood and Lymphatic Vessel Growth", *Pnas*, 2009, Vol. 106, No. 17, pp 7137-7142.

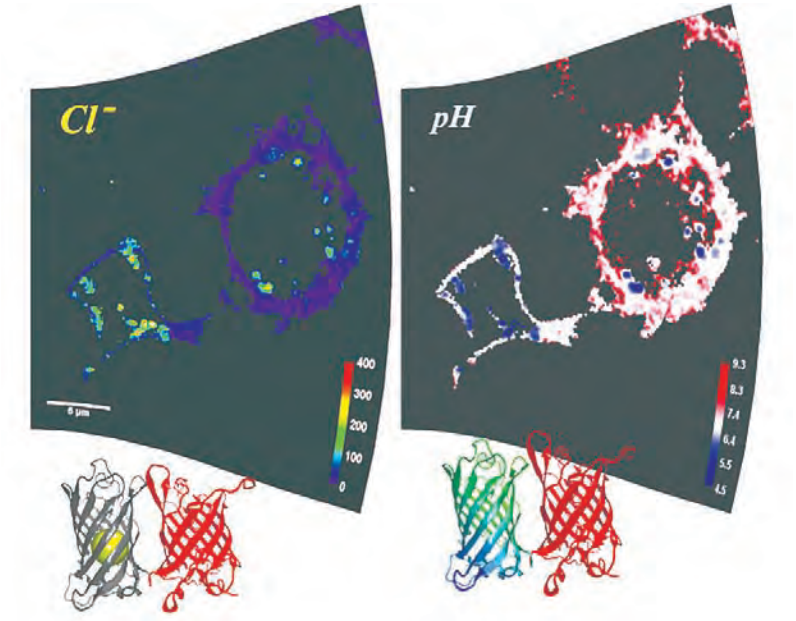
CARDIOLOGY

The proteins that make up the heart

Two studies from the Institute of Genetics and Biophysics "Adriano Buzzati Traverso" (Igb-Cnr) of Naples, published in *Circulation Research* provide new knowledge of the biology of cardiac stem cells for the treatment of Ischemic heart disease, the leading cause of death in the industrialized countries. The first study examines the functions of the "Krypton" protein which acts as a "molecular switch" by promoting the differentiation of stem cells in cardiomyocytes: if it is switched off or altogether absent, it blocks the cardiogenesis and promotes the formation of neurons. The second study demonstrated that the Tbx1 protein is essential for a sufficient proliferation and for the normal development of "tripotent cells" of the heart, therefore capable of differentiating into cardiomyocytes, endothelial cells of blood vessels and cardiac chambers, and smooth muscle cells. This research helps us to understand how cardiomyocytes can be formed from stem cells and, therefore, how to identify the molecular targets for developing treatments for the regeneration of cardiac tissue. The laboratories of IGB are committed to achieving this goal.

BIOLOGY

Simultaneous intracellular chloride and ph measurements using a GFP-based sensor

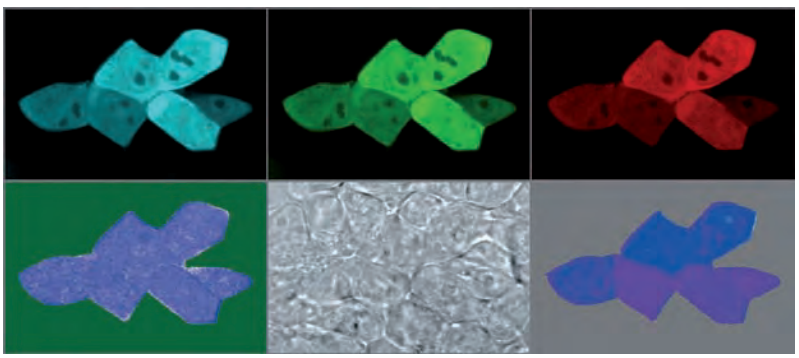


Chloride is the most abundant anion in living organisms and regulates many physiological processes, including synaptic transmission, regulation of charge balance and cell volume, and excitation-inhibition equilibrium of GABA-ergic synapses. The membrane permeability and consequently the intracellular chloride concentrations are tightly regulated by several chloride-selective channels and chloride transporters. Alterations of these proteins functions lead to various hereditary or acquired human diseases as diverse as cystic fibrosis, myotonia congenita, epilepsy, hyperekplexia, lysosomal storage disease, Bartter syndrome, deafness, renal salt loss, kidney stones and osteopetrosis; all sharing unbalances of chloride homeostasis.

Following the observation that the native fluorescence of Yellow Fluorescent Protein (YFP) is quenched by anions (including chloride), we developed a powerful biosensor, named ClopHensor and based on a GFP variant carrying a specific binding site for chloride. ClopHensor was shown to report real-time changes of intracellular pH and chloride concentrations in living cells. Moreover, ClopHensor allowed us to discover high chloride concentrations in large dense-core exocytosis granules, the dominant secretory organelles of neuroendocrine cells.

Genetically-encoded ratiometric biosensors, like ClopHensor, represent the most promising tool for the effective analysis of chloride homeostasis in live cells, the comprehension of the mechanisms underlying many diseases, and thus the development of new drugs that specifically modulate the function of chloride channels or transporters. In particular, ClopHensor is unique for monitoring biological processes in which chloride and proton have a combined role.

D. Arosio, F. Ricci, L. Marchetti, R. Gualdani, L. Albertazzi, F. Beltram, "Simultaneous intracellular chloride and pH measurements using a GFP-based sensor", *Nature Methods*, 7 (2010), pp. 516-518.



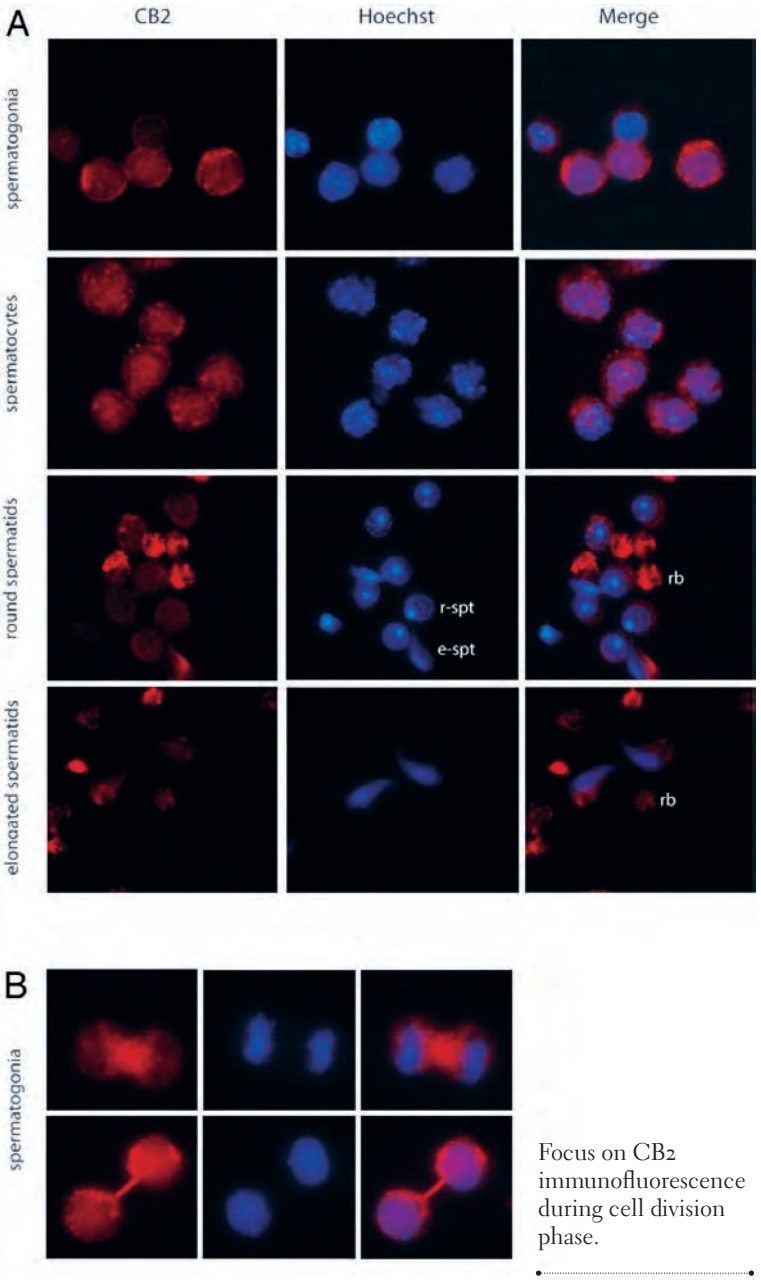
Top: Schematic representation of ClopHensor. Chloride (yellow spheres) binding to the GFP moiety promotes static quenching of fluorescence and allows chloride reading free from the influence of pH.

Bottom: Confocal micrograph of live HEK 293 cells. Representation of the 3 channels and the simultaneously obtained pH and chloride maps.

BIOLOGY

The key role of endocannabinoids in spermatogenesis

The last 20 years have witnessed an increase of male infertility due to oligospermy (drastic decrease of sperm number, often accompanied by a reduction of sperm motility) or azospermy (complete absence of sperm cells).The causes of these disorders are to be looked for in the process of sperm cell formation, known as *spermatogenesis*. Several cases are of genetic origin, or due to anatomical and morphological malformations, but a high percentage of patients escape any kind of classification. Assisted fertilization techniques can solve, in many cases, the problem of infertility due to oligospermy, although the offspring from oligospermic men may be affected by genetic diseases (e.g. syndromes of Beckwith-Wiedemann, Angelman and Prader-Willi), which are caused by defective *imprinting*. This is because spermatogenesis is a process requiring epigenetic modifications of paternal DNA, including DNA methylation, which, in the fertilized egg, is inverted (demethylation) except for those DNA regions known as *imprinted*. In oligospermic spermatozoa, instead, also the imprinted DNA regions undergo demethylation, thus increasing the number of transcriptionally active gene copies and, consequently, the probability of developing syndromes caused by defective imprinting. The CNR Institutes of Biomolec-



CB_2 immunofluorescence staining of differentiating male germ cells. Immunofluorescence staining for CB_2 receptors (red signal), Hoechst nuclear counterstain (blue signal) and merged images of isolated testicular germ cells at different stages of differentiation. Immunodetection of CB_2 receptors in: spermatogonia (Top), pachytene spermatocytes (Middle) and round (r-spt) and elongated (e-spt) spermatids (Bottom).

Focus on CB2 immunofluorescence during cell division phase.

ular Chemistry, of Cybernetics and of Protein Biochemistry collaborate since 1995 within the Endocannabinoid Research Group (ERG), and recently started collaborating with the University of Rome "Tor Vergata" in the framework of studies on the role of the endocannabinoid system in spermatogenesis. The research activity of the ERG are, in fact, devoted to studies, both of basic nature and applied to medicine, of the endocannabinoid system. This is a signaling system based on the action of lipid mediators (the endocannabinoids) on cannabinoid receptors of type 1 and 2 (CB_1 and CB_2). Previous studies had shown that endocannabinoids, via activation of CB_1 receptors, could regulate sperm cell motility and the acrosome reaction, which are crucial for egg cell fertilization. In this study, instead, the key role of endocannabinoids and CB_2 receptors in spermatogenesis was demonstrated. It was observed that male germ cells possess a complete endocannabinoid system and that CB_2 receptors are involved in the process of meiosis, through which the sperm cell precursors, known as "spermatogonia" (which have 46 chromosomes in humans) are differentiated into "spermatides" (with 23 chromosomes), which in turn will yield spermatozoa in the final process of "spermiogenesis". This discovery will open new avenues in our knowledge of male infertility and of how the abuse of Cannabis may modify it.

P. Grimaldi, P. Orlando, S. Di Siena, F. Lolicato, S. Petrosino, T. Bisogno, R. Geremia, L. De Petrocellis e V. Di Marzo, "The Endocannabinoid System and Pivotal Role of the CB2 Receptor in Mouse Spermatogenesis", *Pnas*, USA 2009.

BIOLOGY

Identification of 18 new loci associated with body mass index

Speliotes E.K. et al., "Association analyses of 249,796 individuals reveal 18 new loci associated with body mass index", *Nat Genet.* 42(11) (2010), pp. 937-948.

Obesity is defined as abnormal or excessive fat accumulation associated with an increased risk of illness, disability, and death. Once considered a problem only in high income countries, it is now dramatically increasing in prevalence also in low- and middle-income countries. Like several other medical conditions, most cases of obesity are the result of an interplay between many genetic and environmental factors responsible for variation throughout the distribution of Body Mass Index (BMI). Although heritability of human BMI is high, the genes so far identified only explain a small fraction of the estimated genetic variance. To identify new genetic loci for obesity susceptibility the GIANT (Genetic Investigation of ANthropometric Traits) Consortium has performed a meta-analysis of GWAS (Genome Wide Association Study) data based on 123,865 individuals of European ancestry followed by confirmatory analyses for the 42 best independent loci in up to 125,931 independent individuals. In addition to confirming the 14 known loci, 18 novel BMI-associated loci ($p<5x10-8$) were identified. Notably, several of the new loci point to genes involved in key hypothalamic pathways of energy balance. Overall, since current lifestyle interventions are largely ineffective in addressing the challenges of growing obesity, this study provides new insights into the biology of obesity, critically needed to guide the development and application of future therapies and interventions.

BIOLOGY

Wheat flour quality and the complex structure of glutenin polymers

Wheat flours have specific technological properties that make them different from the flours obtained from any other cereal. In fact, only wheat flour can form a dough which is suitable for the production of leavened bread and of all the other foods that can be obtained taking advantage of its specific technological properties. What makes wheat unique is the presence of large protein polymers, that are an essential component of gluten. These polymers are composed of subunits (glutenin subunits) that are interconnected by disulfide bonds, i.e. covalent bonds linking cysteine residues. Each wheat variety is characterized by a specific set of glutenin subunits. How they assemble to form a polymer remains largely unknown, but it is clear that the presence of specific subunits is associated with good flour quality. To study the process of polymer formation, we have expressed individual subunits in tobacco cells. The results indicate that each subunit can associate with other subunits in different ways (i.e. using different cysteine residues), and that the process can lead to the formation of a very heterogeneous polymer population. This system will allow to compare the characteristics of the different subunits and to study how subunit composition affects the technological properties of wheat flours.

Lombardi A., Barbante A., Della Cristina P., Rosiello D., Castellazzi C.L., Sbano L., Masci S., Ceriotti A. "A relaxed specificity in interchain disulfide bond formation characterizes the assembly of a low-molecular-weight glutenin subunit in the endoplasmic reticulum", *Plant Physiol.*, 2009, 149, 412-423.

BIOLOGY

Role of plant RNA-dependent RNA polymerases in the antiviral response

Research in the last two decades has unveiled a RNA-based defense mechanism, which is ancient and conserved among species from different kingdoms (fungi, animals, and plants). This system is now referred to as RNA silencing or RNA interference (RNAi), and eventually it has been recognized as an alternative "immune system" of the eukaryotic cell that relies on mechanisms that are intriguingly similar among different organisms.

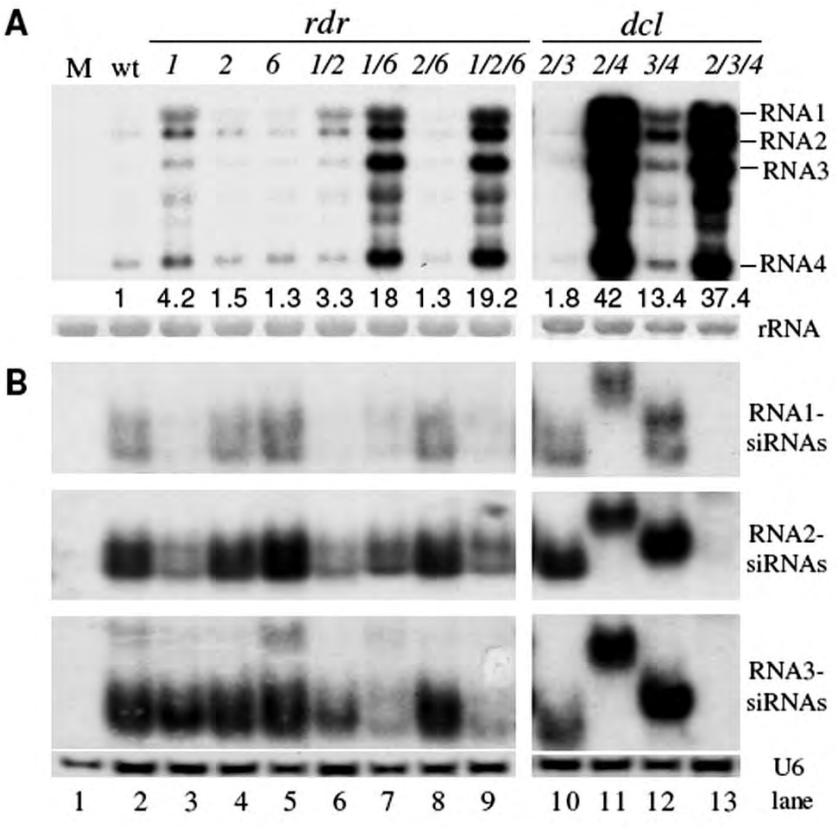
In plants, there are three lines of evidence that prove RNA silencing as an active antiviral immune system. Firstly, virus infection triggers RNA silencing in infected plants that specifically targets the viral RNA genome for degradation, generating virus-specific small interfering RNAs (siRNAs) of both sense and antisense polarities. Secondly, most plant viruses encode proteins capable of suppressing RNA silencing. The fact that silencing suppression remains as a conserved genomic function also among unrelated viruses is indicative of RNAi as being a major antiviral response of plants.

The third line of evidence is provided by genetic studies on mutant lines of the model plant species *Arabidopsis thaliana*, functionally impaired in key genes of the RNA silencing pathways. For instance, plants coding for Dicer-like (DCL) or Argonaute (AGO) mutant proteins are more susceptible to viral infections.

In this study, deriving from a collaboration between CNR and the

University of California, Riverside, the role of RNA-dependent RNA polymerases (RDRs) is assessed as essential in the plant RNAi-mediated viral immunity.
It is shown that the antiviral response in *A. thaliana* develops through two different phases, the first dependent on the production of "primary" siRNAs (i.e., directly generated by cleavage of double-stranded (ds) RNA deriving from replicative activity), and the second represented by a signal amplification step that requires new dsRNA synthesized by two host RDRs, RDR1 and RDR6, to produce "secondary" siRNAs. We found that the two antiviral RDRs exhibited specificity in targeting different regions of the RNA genome of *Cucumber mosaic virus* (CMV). RDR1 preferentially amplified siRNAs targeting the 5′-termini of each of the three viral genomic RNAs, whereas the production of siRNAs targeting the 3′ half of viral RNAs appeared to be RDR6-dependent. Our work thus identifies distinct mechanisms for the amplification of anti-viral siRNAs that can be considered true immunity effectors. From an evolutionary point of view, eukaryotic RDRs emergence and differentiation may now be explained also by their role in antiviral defence.

Wang X.-B., Wu Q., Ito T., Cillo F., Li W.-X., Chen X., Yu J.-L., Ding S.-W., "RNAi-mediated viral immunity requires amplification of virus-derived siRNAs in Arabidopsis thaliana", *Proceedings of the National Academy of Sciences USA*, 2010, vol. 107 (1), 484-489.



(A) viral RNAs and (B) viral siRNAs derived from viral genomic RNAs 1 to 3 in the WT, *rdr*, and *dcl* mutant plants after inoculation with CMV.

NEUROSCIENCE

The female ability to recognize errors

A research team at the Institute of Bioimaging and Molecular Physiology (Ibfm) of the CNR of Milan and the University of Milano-Bicocca has recorded the bioelectric brain potentials in human beings while looking for "mirror neurons," which have already been identified in monkeys with single cell recording. The study, published in the journal of *Neuropsychologia*, allows one to understand the neuronal processes which are activated in the moment in which we observe an "improper" action which leads us, for example, to not imitate that action. The results seem to suggest a great feminine sensibility to the recognition of the incoherent actions. The data obtained by the research team provides new evidence for the existence of "mirror neurons" and of their role in the complex social behaviours of imitation, learning, and evaluation of appropriateness.

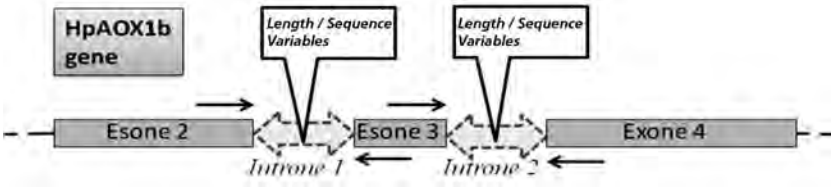
BIOLOGY

Genomic profiling of individuals of the St. John's wort (hypericum perforatum)

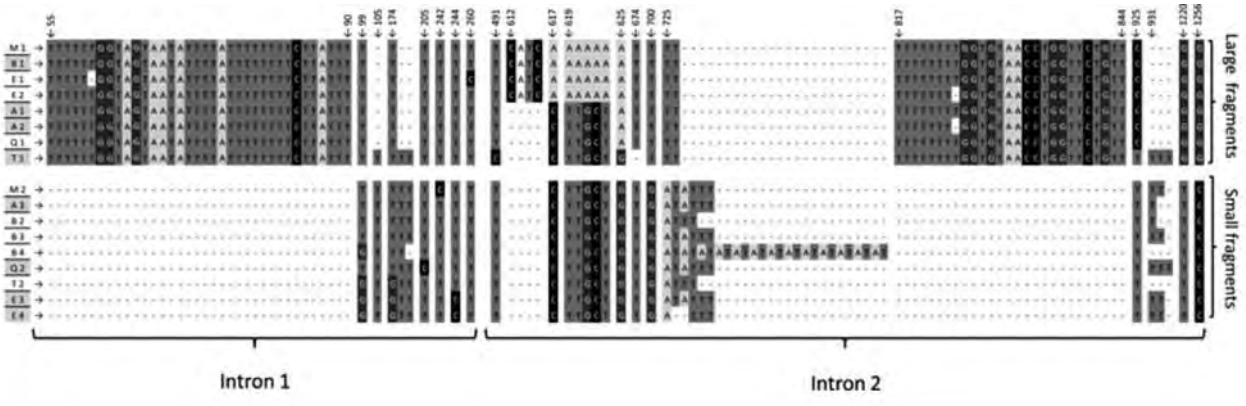
A rapid, reliable and easy assignment of a specific genomic profile to single individuals belonging to the plant species *Hypericum perforatum*, the St. John's wort, is reported to be achievable. The St.John's wort is an aromatic plant that can be used for curing insomnia, anxiety and depression. Individual genomic profiling is achieved by a method that is based on the rapid and selective amplification of the two introns normally present within the coding sequence of the AOX1b gene that encodes for a mitochondrial enzyme involved in the response to oxidative stress. The method represents a further step toward the accomplishment of a full scale genetic characterization of the plant germplasm. It follows up similar techniques originally developed in the laboratory of the Institute for Plant Biology and Biotechnology (IBBA) of the CNR in Milan. These approaches use introns as an easy source for monitoring genetic variability in land plants.
It is in fact unreasonable and not convenient to think to characterize, through full scale genome sequencing, all of the plant germplasm at the different levels of species, varieties and individuals. Plant introns offer a real faster and more convenient alternative. They can easily discriminate among species and subspecies because they are polymorphic in sequence and length. In strict evolutionary terms, they represent more relaxed sequences nested within the exons, the protein coding portions of the genes. Data on the AOX1b small gene family demonstrate that diagnostic methods based on the use of introns as the source of variability can be discriminatory even at the single individual level. The IBBA laboratory not only has inspired this research but it has developed and protected such methods with the aim of using them in diagnosis, certification and traceability of plant cultivations and products.

A.O. Ferreira, H.G. Cardoso, E.S. Macedo, D. Breviario e B. Arnholdt-Schmitt, "Intron Polymorphism Pattern in AOX1b of Wild St John's Wort (Hypericum perforatum) Allows Discrimination Between Individual Plants", *Physiologia Plantarum*, 137 (2009), pp. 520-531.

Graph representing the rationale of using introns as source of genetic variability. The 4 black arrows indicates the primers of a simple Polymerase-Chain-Reaction (PCR).



Deletions/insertions and nucleotide sequence variability identified in the two introns of the HpAOX1b gene in 6 individual samples of St John's wort harvested in different area of South Portugal (*Ferreira et al. 2009).



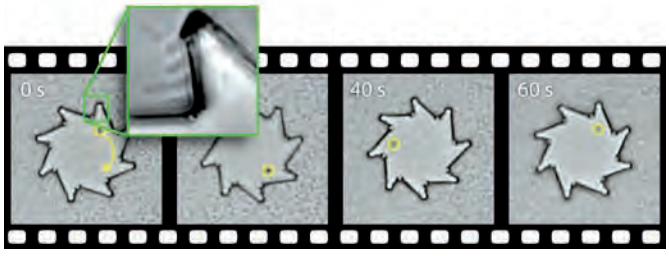
BIOLOGY

Bacterial ratchet motors

When pushing the miniaturization of devices down to the microscopic scale, one inevitably faces the challenge of producing efficient and autonomous micro-engines. In our efforts to get control over the world at the micron scale we often find out that we have so much to learn from living organisms that have been surviving and evolving in it for billions years. Bacteria are a beautiful example of micron-sized, self-propelled machines. These unicellular organisms are not just capable of living and reproducing, but they can swim very efficiently, and looking for food: all packaged in a body measuring a few microns. They achieve propulsion in an inertialess world by spinning helical flagella a hundred times in a second by a rotary nano-motor: a kind of dream for modern nanotechnology. Being still far away from synthesizing an artificial nano-motor of comparable efficiency, we came back to the very old idea of harnessing living systems in quite the same way we've been doing with animals before the invention of engines. But can we conceive a totally autonomous microdevice that is propelled by bacteria in a predictable motion with no need of external control? Or, in other words, can bacteria spontaneously rectify their random motions and cooperatively work to propel a micro-machine? Such questions are inevitably connected with the more fundamental problem of what the necessary conditions are for the emergence of an ordered behavior by a self-organization mechanism. Symmetries play a fundamental role in this sense. We have demonstrated that a micron-sized object, designed with a proper asymmetric shape, can break the relevant spatial symmetries and trigger the self-organization of bacteria on its boundary. We made a variety of symmetrical and asymmetrical gears, 48 or 80 micrometres wide. The shape of the asymmetrical gears means that bacteria swimming into them either slide off the end of a cog tooth or become stuck in a corner. Bacteria that stick exert a force that drives the gear around until they free themselves. When we placed the cogs in a liquid bacterial suspension, we observed about one rotation per minute for the asymmetrical gears, showing that geometry can be used to convert chaotic bacterial motion into predictable movement. Based on our results we foresee a completely new and exciting technology, where micromachines can be fabricated and simply actuated with a drop of bacterial active fluid.

R. Di Leonardo, L. Angelani, D. Dell'Arciprete, G. Ruocco, V. Iebba, S. Schippa, M.P. Conte, F. Mecarini, F. De Angelis, and E. Di Fabrizio, "Bacterial ratchet motors", *Proceedings of the National Academy of Sciences of the United States of America*, 107 (2010), pp. 9541-9545

Snapshot from a computer simulation of an asymmetric micro-gear immersed in a bath of self-propelled bacteria.



A microfabricated asymmetric gear is spontaneously set into rotation when immersed in an active bath of E. coli bacteria. Inset shows a magnified view on pushing bacteria.

BIOLOGY

Production of recombinant toxins targeted to cancer cells

Ribosome-inactivating proteins (RIPs) are protein toxins produced by many different plants. These molecules have been fused to antibody fragments or to growth factor domains to obtain recombinant protein toxins that can selectively kill cancer cells.
Saporin is a RIP that can be extracted from the soapwort plant (*Saponaria officinalis* L). The production of this RIP in *Escherichia coli* is hampered by different factors, including host toxicity and aggregation. To overcome these problems and to obtain correctly folded and biologically active recombinant saporin, we have utilized an expression system based on the yeast *Pichia pastoris*. To obtain high levels of expression, the sequence encoding saporin was modified to match yeast codon usage. In addition, the sequence was engineered to obtain the secretion of the protein in the incubation medium. Using this strategy we have produced, in addition to saporin itself, a chimeric toxin (ATF-saporin) with potential anticancer activity. In ATF-saporin, the saporin moiety is fused to a targeting domain derived from the human urokinase-type plasminogen activator (uPA). ATF-saporin selectively kills cells expressing the uPA receptor, which is present at high levels on the surface of many aggressive tumor cells. These results will allow the production of different saporin-containing chimeric toxins targeted to cancer cells.

Lombardi A., Bursomanno S., Lopardo T., Traini R., Colombatti M., Ippoliti R., Flavell D.J., Flavell S.U., Ceriotti A., Fabbrini M.S., "*Pichia pastoris* as a host for secretion of toxic saporin chimeras", *FASEB J.*, 2010, 24, 253-265.

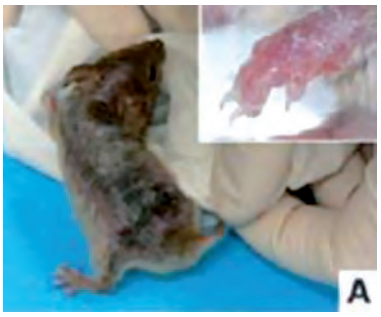
BIOLOGY

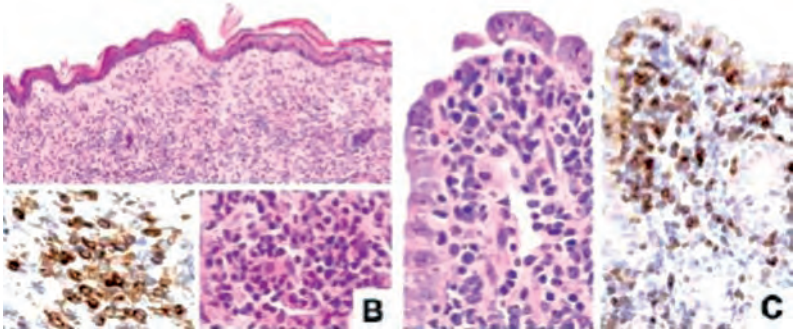
Homeostatic expansion of autoreactive immunoglobulin-secreting cells in the Rag2 mouse model of Omenn syndrome

The production of animal models of human diseases represents a powerful tool to investigate and eventually treat affected patients. In this research, we created and investigated a mouse model for Omenn Syndrome (OS), a peculiar severe combined immunodeficiency associated with autoimmune-like manifestations, due to mutations in RAG genes. This rare disease, if untreated, is fatal, but so far, the only effective treatment is bone marrow transplantation, which is possible only when a matched donor is available. After identifying RAG genes as the ones responsible for OS, we have inserted in the mouse genome the same mutation (R229Q) found in a human child affected by OS. This "knock-in" model, fully recapitulates OS symptoms. In the present work, after detecting plasma cells in lymphoid organs of OS patients, we investigated in the mouse model whether B cells play a role in OS pathogenesis. Our knock-in mice revealed, beyond severe B cell developmental arrest, a normal or even enlarged compartment of immunoglobulin-secreting cells (ISC). The size of this ISC compartment correlated with increased expression of Blimp1 and Xbp1. The detection of high affinity pathogenic autoantibodies toward target organs indicated defaults in B cell selection and tol-

erance induction. We hypothesize that impaired B cell receptor editing and a serum B cell activating factor (BAFF) abundance might contribute to the development of a pathogenic B cell repertoire in our Rag2(R229Q) knock-in mice. Interestingly from a therapeutic point of view, BAFF-R blockade reduced serum levels of nucleic acid-specific autoantibodies and significantly ameliorated inflammatory tissue damage. These findings highlight a role for B cells in the occurrence of autoimmune manifestations in OS.

Cassani B., Poliani P.L., Marrella V., Schena F., Sauer A.V., Ravanini M., Strina D., Busse C.E., Regenass S., Wardemann H., Martini A., Facchetti F., van der Burg M., Rolink A.G., Vezzoni P., Grassi F., Traggiai E., Villa A., "Homeostatic expansion of autoreactive immunoglobulin-secreting cells in the Rag2 mouse model of Omenn syndrome", *J. Exp Med.,* 207 (2010) pp. 1525-1540.





The mouse model recapitulates the clinical picture of Omenn Syndrome patients. This model bears the same Rag2 mutation found in a patient. (A) Aspect of a 3-month-old Rag2R229Q/R229Q mouse, showing severe alopecia and skin erythrodermia. (B) Skin biopsy revealed marked dermal inflammation (top) composed of CD3+ lymphocytes (bottom left) and containing numerous eosinophils (bottom right). (C) Similarly, the gut showed dense inflammatory infiltration (left), mainly composed of CD3+ cells (right).

MEDICINE

A project to increase heart transplants

Heart transplants are still the best solution for many patients with serious, advanced heart disease especially since the alternatives such as artificial heart transplants or transplants from genetically engineered animals are still being studied. On the Italian and International level there is a constant shortage of donors which is made even more difficult by the age limit which is set at 55 years of age. Given the high number of potential Italian donors over fifty-five years of age, the Institute of Clinical Physiology of the CNR in Pisa (Ifc-Cnr) conducted a survey with the Heart and Lung Transplant centre of "Sant'Orsola" in Bologna in order to verify, through a diagnostic, pharmacological eco-test, the "goodness" of the hearts of these "marginal donors" and have published the results in the *Journal of Heart and Lung Transplantation*. The results were promising and gave birth to the project "Donation of Marginal Hearts" in which the "Core Eco Lab" of the Ifc-Cnr in Pisa certifies approved cardiologists which are fit to carry out the test and has adopted a web portal, http://adonhers.ifc.cnr.it, in order to classify it on the basis of potential donors.

BIOLOGY

Molecular mechanisms involved in gene expression in potato tuber amyloplasts

Plastids, containing multiple copies of their own genome (plastome) and participating to various cellular functions, are subcellular organelles typical of plant cells. Chloroplasts, present in leaves and other green tissues, are the site of photosynthesis. Chromoplasts, amyloplasts, leucoplasts and others, are present in non-green tissues, such as fruits, tubers and roots. Although all plastid types host the same genetic information, gene expression is extremely reduced in non-green plastids.

In our laboratory, the molecular mechanisms involved in gene expression in potato tuber amyloplasts have been investigated by plastome gene array and other approaches, and compared with gene expression in leaf chloroplasts. In amyloplasts, genes with different functions showed a variable reduction in the expression level, with control occuring at transcriptional and post-transcriptional levels (trascription rate, RNA stability, processing and editing, and ribosome-transcript association). The simultaneous reduction of the expression of nuclear genes involved in the plastome expression, confirms the role of crosstalk between the plastids and the nucleus in the differentiation and functionality of different plastid types.

The results obtained contribute to the understanding of molecular mechanisms that control gene expression during plant development, opening up new perspectives to increase the yield efficiency of crops. Further, they help develop innovative technologies for the expression of transgenes in plastids of specific organs, for the production of next generation PGMs, ensuring a higher gene containment and other advantages compared to nuclear transformation.

Published as: V.T. Valkov, N. Scotti, S. Kahlau, D. MacLean, M.S. Grillo, J.C. Gray, R. Bock, T. Cardi, "Genome-Wide Analysis of Plastid Gene Expression in Potato Leaf Chloroplasts and Tuber Amyloplasts: Transcriptional and Posttranscriptional Control", *Plant Physiology*, Vol. 150 (Aug. 2009), no. 4, pp. 2030-2044.

BIOLOGY

Inhibition of ceramide biosynthesis preserves photoreceptor structure and function in a mouse model of retinitis pigmentosa

In Retinitis Pigmentosa (RP), progressive photoreceptor degeneration leading to blindness occurs through an active form of cell death known as apoptosis. This word, derived from Greek and referring to the process of tree foliage, is a complex mechanism, implicating a number of biochemical reactions, precisely controlled by the cell.

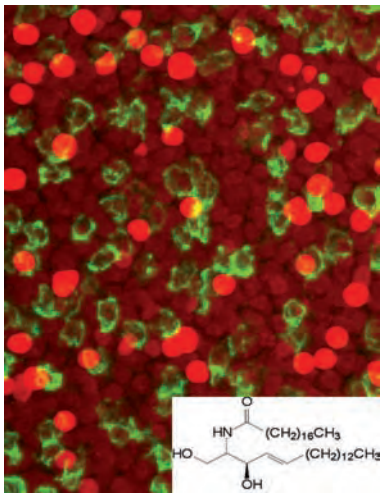
Using the retinal degeneration 10 (rd10) mouse model of RP, we investigated the role of ceramide, a lipid molecule used by cells as a pro-apoptotic messenger, in retinal degeneration, testing the possibility that photoreceptor loss could be slowed or blocked by interfering with ceramide signaling in vivo. While the role of ceramide as an apoptotic mediator is well known in several disorders, and exploited in cancer therapy to promote death of tumour cells, its involvement in retinal degeneration has been poorly investigated so far. However, targeting apoptotic messengers with pharmacological tools can effectively lead to delay the symptoms caused by cellular loss. In RP, the final outcome could be a showing down of vision loss and an overall improvement of the quality of life.

Actually, the experiments lead to the finding that retinal ceramide levels increased in rd10 mice during the period of maximum photoreceptor death. Moreover, single intraocular injections of myriocin, a powerful inhibitor of the rate limiting enzyme of ceramide biosynthesis, lowered retinal ceramide levels to normal values and rescued photoreceptors from apoptotic death. Non-invasive and

long term treatment was achieved using eye drops consisting of a suspension of solid lipid nanoparticles loaded with myriocin. Such treatment lowered retinal ceramide in a manner similar to intraocular injections, indicating that nanoparticles functioned as a vector permitting trans-ocular drug administration. Prolonged treatment (over 20 days) with solid lipid nanoparticles increased photoreceptor survival, preserved photoreceptor morphology, and extended the ability of the retina to respond to light as assessed by electroretinography.

In conclusion, pharmacological targeting of ceramide biosynthesis slowed the progression of RP in a mouse model, and therefore may represent a therapeutic approach in treating this disease in humans. Trans-ocular administration of drugs carried in solid lipid nanoparticles, as experimented in this study, may facilitate continuous, non-invasive treatment of patients with RP and other retinal pathologies.

Strettoi E., Gargini C., Novelli E., Sala G., Piano I., Gasco P., Ghidoni R., "Inhibition of ceramide biosynthesis preserves photoreceptor structure and function in a mouse model of retinitis pigmentosa", *Proc Natl Acad Sci USA*. 2010 Oct 26;107(43):18706-11. Epub 2010 Oct 11. PubMed PMID: 20937879; PubMed Central PMCID: PMC2972949.



Photoreceptors of a retinal degeneration mouse. Red staining: dying rods. Green staining: still intact cones. Inset: ceramide, the "killer" molecule.

BIOLOGY

Meiotic homologous chromosomes pairing during meiosis

This study reveals how three evolutionary conserved recombination proteins play essential roles in pairing of homologous chromosomes during meiosis.

A central issue of meiosis is how homologous chromosomes find each other and pair. The filamentous fungus Sordaria macrospora is a particularly attractive experimental system for examining this process. Chromosome pairing, as well as correct segregation and thus formation of gametes, are all strictly connected to DNA recombination. Available evidence suggests that mammals, higher plants and fungi like budding yeast and Sordaria all exhibit the same standard progression of DNA events, in defined temporal correlation with the events of homologous chromosome alignment and pairing. This study shows that three recombination proteins, Mer3, Msh4 and Mlh1 are required, each in a different way, for a correct execution of these events. The distinct phenotypes of the three corresponding mutants demonstrate that pairing not only brings homologous chromosomes together, but also ensures that homologous pairs are not entangled with unrelated chromosomes. Further, recombination is not involved in pairing simply for the purpose of homology recognition but, instead, is an integral mediator of diverse aspects of the pairing process at all stages. Mer3, Msh4 and Mlh1 exert their influence on homologous pairing a full stage prior to their known role in mediating the biochemical progression of recombination.

Overall, these results emphasize the power of cytological studies, in combination with molecular and genetic approaches, for dissecting complex developmental processes and the roles of individual molecules in those processes.

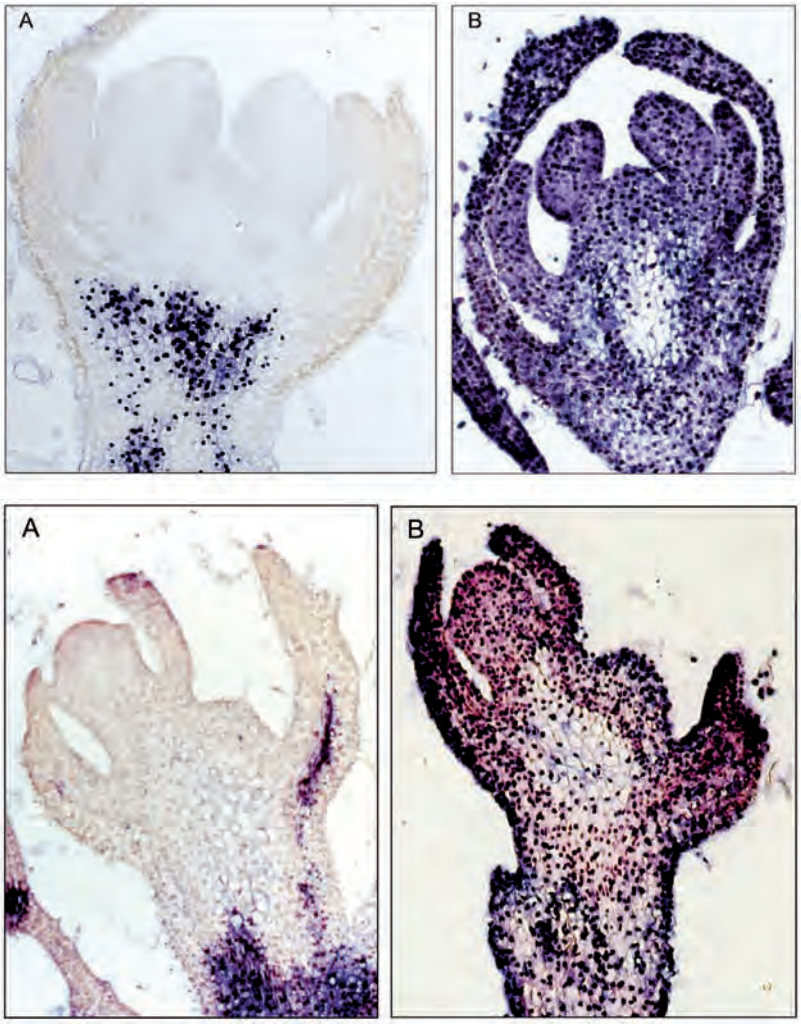
Storlazzi A., Gargano S., Ruprich-Robert G., Falque M., David M., Kleckner N., Zickler D., "Recombination proteins mediate meiotic spatial chromosome organization and pairing", *Cell*, 141 (2010), pp. 94-106.

BIOLOGY

RNA silencing acts as a defence mechanism against viroid infection

Viroids are small plant pathogenic RNAs that, in contrast to viruses, lack protein-coding ability. These RNAs, by mimicking structural features of some cellular RNAs, usurp host proteins needed for their replication and trafficking. This unique feature makes viroids useful models for dissecting general RNA structural-functional relationships.

Plants react to virus infections by deploying RNA silencing, a sequence-specific degradation mechanism that is activated by primary small interfering RNAs (siRNAs, 21 to 24 nucleotides [nt]) deriving from the invading nucleic acid, and amplified by secondary siRNAs generated by host RNA-dependent RNA polymerases (RDRs). While RNA silencing is a well-established antivirus response, its role in containing viroid infection is still fragmentary, with the involvement of RNA silencing in plant-viroid interaction being supported by the identification of viroid-derived small RNAs (vd-sRNAs) similar to siRNAs in viroid-infected plants. However, the functional roles of vd-siRNAs have remained elusive. Here, using a *Nicotiana benthamiana* line impaired in the expression of RDR6, which mediates RNA silencing and antiviral defense, we show that this protein is also engaged in: i) impairing accumulation levels of the nuclear-replicating *Potato spindle tuber viroid* (PSTVd), and ii) restricting PSTVd trafficking in floral and vegetative meristems. These findings supply the first firm genetic evidence for an antiviroid RNA silencing mechanism. Additional results of this study include high-throughput sequencing of vd-sRNAs and host-derived small RNAs, providing data about the mechanisms underlying their genesis and possible additional roles.



F. Di Serio, A.E. Martínez de Alba, B. Navarro, A. Gisel, R. Flores, "RNA-dependent RNA polymerase 6 delays accumulation and precludes meristem invasion of a viroid that replicates in the nucleus", *Journal of Virology*, 84 (2010), pp2477-2489.

Top: The viroid is excluded from floral meristem of *Nicotiana benthamiana* (A), but not of a transgenic line in which RDR6 has been silenced (B). The concentrated hybridization signals result from the nuclear localization of PSTVd.

Bottom: The viroid is excluded from the shoot apical meristem of *Nicotiana benthamiana* (A), but not of a transgenic line in which RDR6 has been silenced (B). The concentrated hybridization signals result from the nuclear localization of PSTVd.

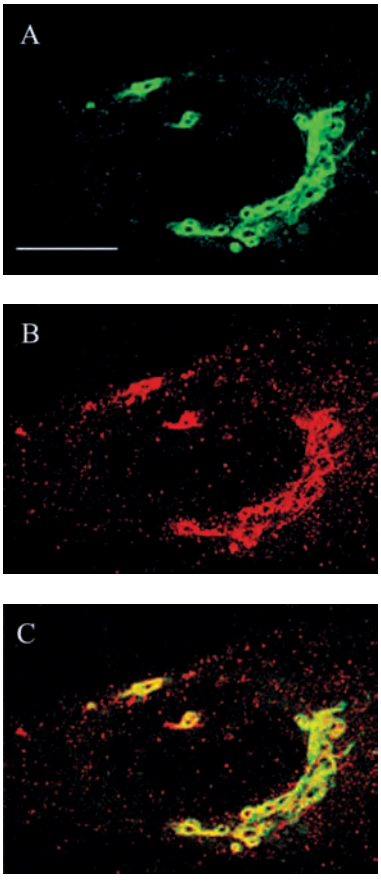
BIOLOGY

The trans-Golgi: an intracellular Ca^{2+} store with unique properties

The Golgi apparatus (GA) is a specialized organelle involved in lipid and protein modification during transport from their site of synthesis in the endoplasmic reticulum (ER) to other sub-cellular compartments, such as secretory vesicles and plasma membrane. Morphologically it is quite heterogeneous and it is possible to distinguish stacks of flat cysternae (cis- and medial Golgi), tubular-reticular networks and vesicles (trans-Golgi). These morphological differences parallel a distinct functionality: different enzymes, acting on newly synthesized proteins, have distinct distributions and complementary roles in the various GA compartments.

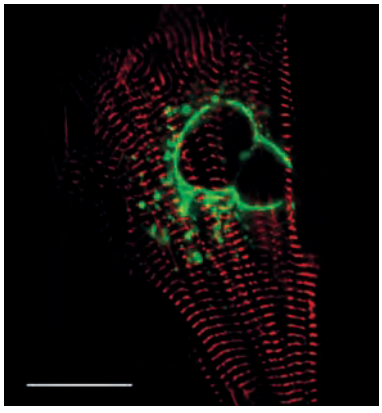
The GA also plays a role in Ca^{2+} homeostasis: similarly to the ER, the GA is endowed with a toolkit for Ca^{2+} uptake and release, i.e. the sarco-endoplasmic reticulum Ca^{2+} ATPase, SERCA, the secretory pathway Ca^{2+} ATPase1, SPCA1, and inositol-trisphosphate receptors, IP_3Rs. The GA as a whole, therefore, represents a dynamic Ca^{2+} store that can participate in determining the spatio-temporal complexity of the Ca^{2+} signal within the cell. Whether in terms of Ca^{2+} handling the GA behaves homogeneously or whether each compartment has unique characteristics, is not known.

We have addressed this problem by developing a new, genetically encoded fluorescent, Ca^{2+} indicator specifically targeted to the trans-Golgi that allows the quantitative and dynamic measurement of luminal Ca^{2+} concentration in this compartment at the single cell level. This probe has revealed that the trans-Golgi behaves differently from the overall GA: it takes up Ca^{2+} almost exclusively via SPCA1 (while the SERCA predominates in the other compartments) and does not release Ca^{2+} in response to IP_3 generation (unlike the cis-Golgi). Down-regulating SPCA1, thus impairing trans-Golgi Ca^{2+} homeostasis, results in a disturbed trafficking of different classes of proteins as well as in marked morphological alterations of the entire GA structure. Keeping the correct luminal Ca^{2+} concentration within the trans-Golgi is thus essential not only for its specific functions, but also for the entire GA architecture. Of interest, mutations in one allele for SPCA1 cause the human skin pathology, Hailey Hailey disease. Keratinocytes from these patients show multiple defects in protein sorting and other specific cell functions, suggesting that Ca^{2+} homeostasis in this GA compartment plays a key role in in cell pathophysiology.



Localization of the new trans-Golgi Ca^{2+} probe in HeLa cells (green, A) compared with that of the trans-Golgi marker TGN46 (red, B). Scale bar, 10 μm.

V. Lissandron, P. Podini, P. Pizzo, T. Pozzan, "Unique characteristics of Ca^{2+} homeostasis of the trans-Golgi compartment", *Proc Natl Acad Sci USA*, 107 (2010), pp. 9198-9203.



Confocal merge image of a cardiomyocyte expressing both the new trans-Golgi sensor (green) and the sarcomeric protein Zasp (red). Scale bar, 10 μm.

MOLECULAR MEDICINE

Fast three dimensional pharmacophore virtual screening

Suppression of estrogen biosynthesis by aromatase inhibition is an effective approach for the treatment of hormone sensitive breast cancer. Third generation non-steroid aromatase inhibitors have shown important benefits in recent clinical trials with postmenopausal women. In this study we have developed a new ligand-based strategy combining important pharmacophoric and structural features according to the postulated aromatase binding mode, useful for the virtual screening of new potent non-steroid inhibitors. A small subset of promising drug candidates was identified from the large NCI database, and their antiaromatase activity was assessed on an in vitro biochemical assay with aromatase extracted from human term placenta. New potent aromatase inhibitors were discovered to be active in the low nanomolar range, and a common binding mode was proposed. These results confirm the potential of our methodology for a fast in silico high-throughput screening of potent non-steroid aromatase inhibitors.

G. Colombo, "Fast Three Dimensional Pharmacophore Virtual Screening of New Potent Non-Steroid Aromatase Inhibitors", *Journal of Medicinal Chemistry*, Vol. 52 (2009), Issue 1, pp. 143-150.

MOLECULAR MEDICINE

High-resolution structure of a misfolded intermediate

Gianni S., Ivarsson Y., De Simone A., Travaglini-Allocatelli C., Brunori M., Vendruscolo M., "Structural characterization of a misfolded intermediate populated during the folding process of a PDZ domain", *Nature Structural & Molecular Biology*, 17, 1431-1437 (2010).

The study, carried out by CNR-IBPM and Sapienza University of Rome, and published in *Nature Structural and Molecular Biology*, was able to unveil the structural features of a misfolded intermediate. It reports for the first time the structure of a misfolded state and represents a significant step towards our understanding of the misfolding cascade, the cause of several human pathologies.

Incorrectly folded states transiently populated during the protein folding process are potentially prone to aggregation and have thus been implicated in a range of misfolding disorders that include Alzheimer's and Parkinson's diseases. Despite their importance, however, the structures of these states have largely escaped detailed characterization because of their fleeting nature.

By studying the folding pathway of a simple model system, such as the PDZ domain family, and by applying a combination of experimental and theoretical approaches, the Italian researchers (S. Gianni, M. Brunori et al.), together with M. Vendruscolo from University of Cambridge(UK), provided the first detailed structural characterization of a misfolded state. Surprisingly, the misfolded intermediate displays an overall topology that is largely native-like, with minor folding defects that are mainly located in the ligand-binding pocket of the protein, suggesting that folding and function might trigger conflicting constraints.

In the context of the fight against many neurodegenerative diseases, this work paves the way for future studies aimed at restoring the function of misfolded proteins by stabilizing their native fold.

COMPUTATIONAL BIOLOGY

Bioinformatics and computational biology to decode and interpret biological phenomena

Functional alterations in biological processes, such as cell cycle, development, differentiation, response to oxidative stress, aging and so on, are the causes of many socially disabling diseases. Understanding how these processes are regulated is of fundamental importance to develop more sensitive clinical diagnostic and prognostic protocols, more and more effective therapies and to implement proper social policies of prevention. The regulation of gene expression, which is at the basis of the correct functioning of each cell, is a highly complex process occurring at different spatio-temporal stages and controlled by the multiple interactions of several regulatory factors with one or more target genes. Bioinformatics and computational biology are disciplines aiming to decode and interpret biological phenomena by using computer technology. They provide the most effective analysis tools for modern scientific research to study the mechanisms underlying these interactions and to understand how possible changes to these mechanisms can affect our health. The aim of our research in this field is to develop a bioinformatics tool making use of data mining technologies to enable the discovery of the *cis-regulatory* modules controlling the expression of functionally related genes. The basic criteria used for the discovery of modules are statistical overrepresentations of translation regulatory motifs co-occurring in functionally related genes in the same species, and the conservation of the structural features of these modules in the homologous sequences of different species. UTRminer is a prototype currently under further development.

A. Turi, C. Loglisci, E. Salvemini, G. Grillo, D. Malerba, e D. D'Elia, "Computational annotation of UTR CIS-regulatory modules through Frequent Pattern Mining", *BMC Bioinformatics*, 10 (Suppl 6), 2009, S25. IF 2008: 3,781.

HEALTH

A spatial experiment to combat stress

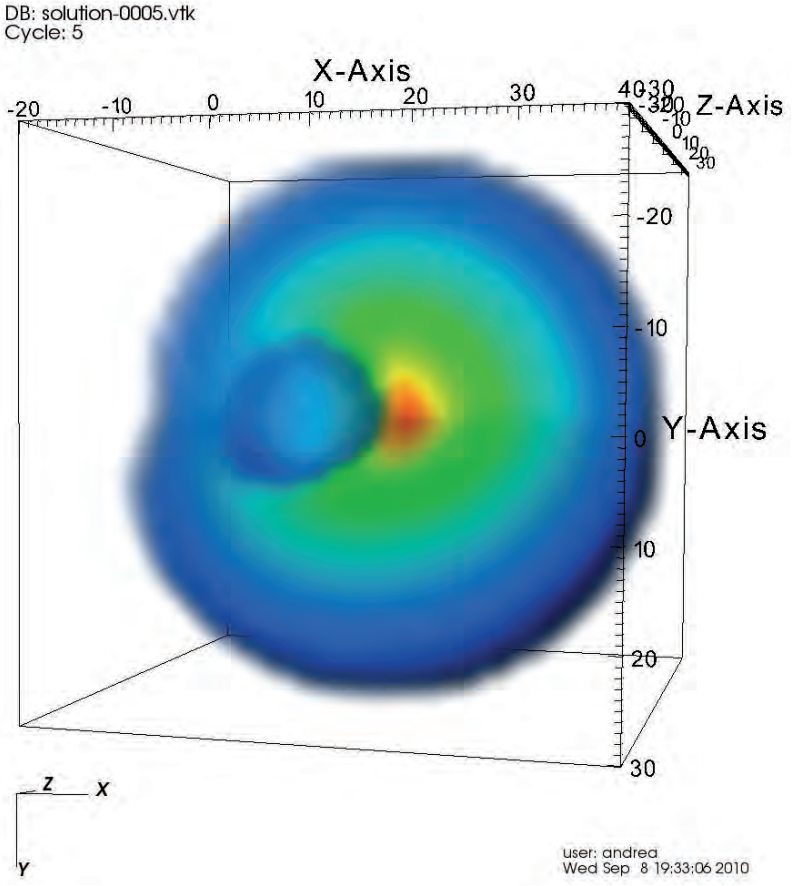
On June 3rd 2010, at the Institute for Biomedical Problems (Ibmp), the simulated space mission, *Mars 500*, took off; it was an experiment of prolonged confinement organized by the Russian Space Agency and the European Space Agency, which reproduced, for 520 days, the living conditions for the mission of 2020 to Mars in the Russian simulator Nek. A team at the Centro Extreme in Pisa, composed of researchers from the Institute of Clinical Physiology of the CNR, at the Scuola Superiore of Sant'Anna and the University of Pisa, is dealing with the clinical significance of the effects of stress on the heart, brain, and lungs of the six volunteer astronauts (among which is the Columbian-Italian Diego Urbina). Among the objectives is the measure of the psychological vulnerability to stress in order to assess possible non-medicated remedies, which are also applicable to common patients. Mars 500 could help to identify the parameters in order to determine the individual risk profiles, especially for those whose activities are considered "extreme," such as firefighters or members of the military, providing a contribution to predictive medicine.

COMPUTATIONAL BIOLOGY

Multidimensional mathematical models of intracellular signal transduction

Any external stimulus acting on the eukaryotic cell membrane activates a cascade of reactions that regulate almost all the aspects of cell behavior, as for instance metabolism, movement or proliferation. Cells being a highly compartmentalized systems, with many different regions, the signal has to be transduced to the correct compartment. For instance, the nucleus of eukaryotic cells, and specifically the genomic DNA, is the target of many intracellular transduction pathways, which influence the expression of specific genes. In this paper, we concentrate on molecular trafficking across the nuclear envelope and nucleocytoplasmic transport. For large molecules, the translocation across the nuclear envelope may proceed through the nuclear pore complexes using a system based on the Ran protein. Unlike other models, which have been proposed in the past, often formulated in terms of the averaged molecular concentrations, we propose here the first fully three dimensional integrated model for Ran-driven nuclear import of molecules, which incorporates diffusion and membrane transport for a large-scale model of living cell, and we support it with a detailed discussion of the crucial problem of parameters and pathways localization. For the first time, we also take into account the active transport along the microtubules of the importin-cargo complex, which is responsible for enhancing various signaling processes, as for instance the anti-tumor protein p53. The arising system of nonlinear partial differential equations is solved using an original numerical scheme based on Discontinuous Galerkin methods. Simulations are performed using experimental data in a realistic framework, with a nice agreement between virtual and laboratory results.

A. Cangiani, R. Natalini, "A spatial model of cellular molecular trafficking including active transport along microtubules", *Journal of Theoretical Biology*, 267 (2010), pp. 614-625.



3D-simulation of Rb nuclear import. Concentration of the complex cargo+ importin after 100 seconds with microtubules transport active.

BIOPHYSICS

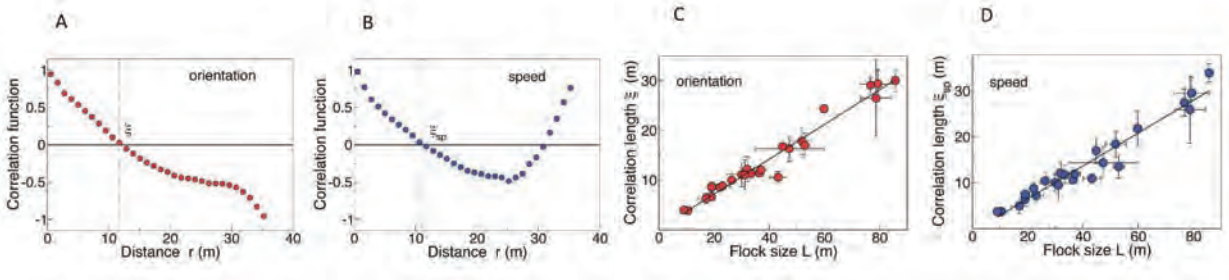
Scale-free correlations in starling flocks

Flocks of birds, swarms of insects, schools of fishes, represent paradigmatic examples of self-organized collective motion, where global coordinated patterns emerge and the group behaves like a single organism. For long, theoretical and experimental studies have focused on the presence of global ordering. Still, this is not always the most significant aspect of collective behaviour. The remarkable thing about a flock of birds, for example, is not merely the globally ordered motion of the group, but the way the flock dodges a falcon's attack. Collective response, namely the way the group as a whole reacts to its environment, is a crucial feature of self-organized animal groups, which may yield a significant adaptive advantage in presence of strong predatory pressure. Here, for the first time, we investigate collective response and the mechanisms leading to it. We show that collective response in animal groups is achieved through scale-free behavioural correlations. By reconstructing the three-dimensional position and velocity of individual birds in large flocks of starlings, we measured to what extent the velocity fluctuations of different birds are correlated to each other. We found that the range of such spatial correlation does not have a constant value, but it scales with the linear size of the flock. This result indicates that behavioural correlations are scale-free: the change in the behavioural state of one animal affects and is affected by that of all other animals in the group, no matter how large the group is. Scale-free correlations provide each animal with an effective perception range much larger than the direct inter-individual interaction range, thus enhancing global response to perturbations. Our results suggest that flocks behave as critical systems, poised to respond maximally to environmental perturbations.

A. Cavagna, A. Cimarelli, I. Giardina, G. Parisi, R. Santagati, F. Stefanini, M. Viale., "Scale Free Correlations in Starling Flocks", *Proceedings National Academy of Sciences USA*, 107 (2010), pp. 11865-11870.

A flock of starlings during aerial display above the roosting site of the Termini railway station, where data acquisition has been performed.

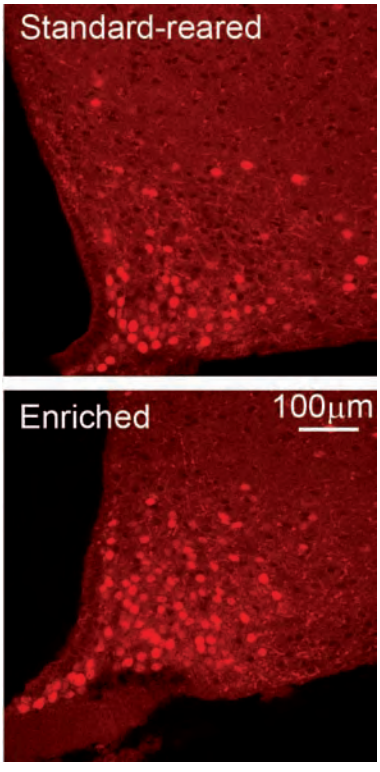
Correlation functions of the orientations (A) and the speeds (B) of birds at distance r. The correlation lengths (C and D) scale with system size, indicating scale free behaviour.



BEHAVIOUR

Environment and obesity

The sedentary lifestyle of developed countries is a major contributor to metabolic dysregulation and obesity. Main player of body weight (BW) homeostasys is leptin, a satiety hormone secreted by fat cells, that signals the status of body energy stores to the arcuate nucleus of the hypothalamus (ARC). Leptin action is achieved through the fine tuning of neurons expressing anorectic and orexigenic peptides, that are respectively activated and inhibited by the hormone. Such seemingly clear view of the regulation of feeding behaviour and BW is challenged by the fact that the majority of obese people exhibit high levels of circulating leptin to which they are apparently resistant. Leptin resistance is therefore emerging as a permissive condition for obesity and efforts to enhance leptin sensitivity could be determinant in the treatment/prevention of the disorder. Our recent study asked whether multifaceted modifications of the environment might influence leptin sensitivity and neural circuits involved in the control of feeding behaviour. To address this issue we exposed adult and newborn mice to a drastic change in their life style adopting the environmental enrichment (EE) paradigm, a manipulation of the rearing environment including enhanced physical activity, sensory, cognitive, and social stimulation. Mice exposed to EE showed enhanced leptin sensitivity, a parameter that we could evaluate by measuring food intake and activation of leptin downstream effectors in response to leptin administration. This outcome depends on the age at which EE is experienced: EE in adulthood does not affect in fact the leptin system, whereas EE since birth results in an enhanced response to leptin. Further, the ARC of young EE mice exhibited structural changes, resulting in increased excitation on anorectic neurons and enhanced inhibition of orexigenic neurons. Interestingly, this aspect persisted even if mice were removed from EE conditions and assessed later in life. To disentangle the physical activity component from the rest of EE, mice were exposed to voluntary exercise in normal rearing conditions. In this case no ARC structural changes were observed and leptin sensitivity amelioration was less pronounced than in EE, thus emphasizing the need of a synergism between different stimuli to obtain important changes in the feeding system.
Our findings stress the importance of investing educational, social and cultural interventions aimed at establishing a correct lifestyle since early infancy.



Images from the arcuate nucleus of the hypothalamus showing higher cell activation induced by leptin in animals reared in environmental enrichment.

M. Mainardi, G. Scabia, T. Vottari, F. Santini, A. Pinchera, L. Maffei, T. Pizzorusso, M. Maffei, "A Sensitive Period for Environmental Regulation of Eating Behavior and Leptin Sensitivity", *PNAS*, 107 (2010), pp. 16673-16678.

BEHAVIOUR

The evolution of altruistic behaviours

The evolution of altruistic behaviours has puzzled scientists ever since Darwin. How can behaviours that benefit other individuals be favoured by natural selection? Several hypotheses have been proposed, the main two being kin selection and reciprocity. Their relative roles in explaining actual cases of animal altruism are, however, unclear. Despite a lack of studies comparing the relative prevalence of kin selection and reciprocity, a general consensus can be found in the literature: kin selection is widely believed to have a pervasive influence on animal behaviour, while reciprocity is often considered to be of minor importance. In this study, we carried out a quantitative comparison of the relative roles of kinship and reciprocity in explaining the distribution of allogrooming in primates, grooming being probably the most common altruistic behaviour among mammals. We applied meta-analytical techniques to a very large database including 25 social groups belonging to 14 different species and 9 genera. In direct contrast to the prevailing view, reciprocity resulted to play a much larger role than kinship in explaining primate allogrooming. These results point to a much more significant role of reciprocity in the evolution of animal altruism than is generally acknowledged. Reciprocity has been suggested to require complex cognitive abilities. However, its being so common among cognitively limited animals suggests it may in contrast be based on simpler, emotionally-driven mechanisms.

G. Schino, F. Aureli, "The relative roles of kinship and reciprocity in explaining primate altruism", *Ecology Letters* 13 (2010), pp. 45-50.

Long-tailed macaques grooming in Ketambe National Park, Indonesia

BIODIVERSITY

World's vertebrates conservation

Conservation of biodiversity is one of the emerging priorities for environmental sciences in the last decade: the number of threatened species is increasing. Vertebrates are for sure among the most threatened of all animal taxa, and they have been the main target of study for conservation biologists in recent years. We presented, for the first time in this work, an assessment of the status of the world's vertebrates by using data for 25,780 species categorized on the International Union for Conservation of Nature (IUCN) Red List. One-fifth of species are classified as threatened, and we show that this figure is increasing. However, this overall pattern conceals the impact of conservation successes, and we show that the rate of deterioration would have been at least one-fifth as much again in the absence of these. Nonetheless, current conservation efforts remain insufficient to offset the main drivers of biodiversity loss in these groups: agricultural expansion, logging, overexploitation, and invasive alien species. Using an index of extinction risk – based on category movements in the IUCN Red Lists of threatened mammals, reptiles, birds, amphibians and fishes (including some listings dating back as far as 1980) — it was showed that, on average, 52 vertebrate species have moved one Red List category closer to extinction every year. Amphibians are the most likely to be sliding towards extinction: 42% are classified as 'threatened', mainly due to the poorly understood infectious disease chytridiomycosis, which has decimated populations around the world. Increases in extinction risk are most marked in Southeast Asia, although wealthier countries such as the United States and Australia have also suffered declines. The true impact of conservation may be very positive. In some cases, conservation efforts have brought species back from the brink, such as those that repopulated parts of North America with the still-endangered black-footed ferret (*Mustela nigripes*) and a three-decade programme that saw the golden lion tamarin (*Leontopithecus rosalia*) downlisted to "endangered" from "critically endangered" in 2003.

M. Hoffmann, C. Hilton-Taylor, A. Angulo, M. Böhm,T.M. Brooks, S.H.M. Butchart, K.E. Carpenter, J. Chanson, B. Collen, N.A. Cox, W.R.T. Darwall, N.K. Dulvy, L.R. Harrison,V. Katariya, et al., "The Impact of Conservation on the Status of the World's Vertebrates", *Science*, 330 (2010) pp. 1503-1509.

BIODIVERSITY

Chemical and biological diversity in cork oak

Among the Mediterranean oaks, cork oak (*Quercus suber* L.) is characterized by a strong phylogeographic structure. In particular, the diversity of chloroplastic DNA allows to precisely characterize the different geographic provenances. Such geographic structure was maintained across millions of years, during which cork oak migrated from west (the Iberian peninsula) toward east, in spite of the strong human pressure for selection of agriculturally suitable traits.
The work by Loreto, Bagnoli and Fineschi has shown that differences in the profile of monoterpene emission are associated to geographic provenances of cork oaks. Thus, the monoterpene profile may change even at intra-specific level, at least in this species. In other oaks, the monoterpene profile is constant and does not depend on the geographic origin. Why is this? Cork oak emission profiles might indicate ancient episodes of introgression of genetic material from other oaks into cork oak germplasm. Namely, cork oak profiles might suggest introgression of *Quercus cerris* (a low monoterpene-emitter) in Italy, and of *Quercus rotundifolia* (a *Quercus ilex*-like strong monoterpene emitter) in Portugal. However, the philogeographic differences of emission in cork oaks are not always coherent with the emission profile of introgressing oak species. It is therefore surmised that these differences also (or rather) reflect association to a productive trait (for instance the quality of cork) for which cork oaks have been selected, especially in the Portuguese area.

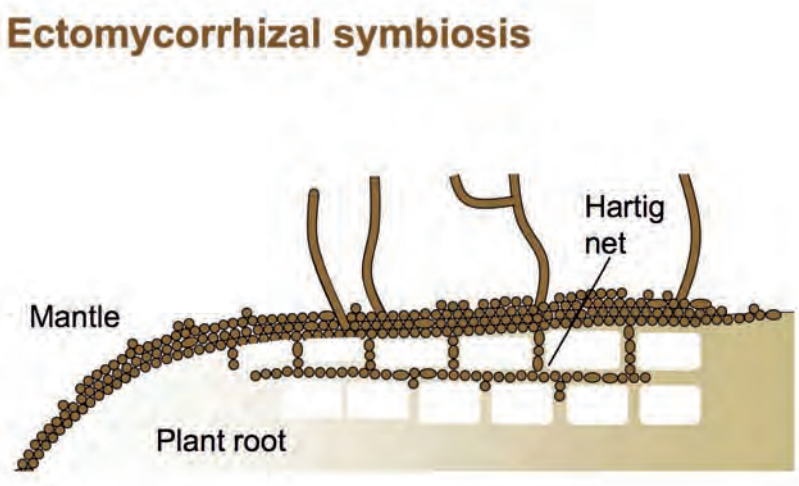
F. Loreto, F. Bagnoli, S. Fineschi, "One Species, Many Terpenes: Matching Chemical and Biological Diversity", *Trends Plant Science*, 14 (2009), pp. 416-420.

GENETICS

The genome of the black truffle

Several plant genome projects have highlighted on the plant genes involved in symbiosis, while less information are available on the fungal side. Many aspects of the biology of mycorrhizal fungi are still enigmatic; complete genome sequences are seen as valuable tools to better understand the molecular mechanisms involved in their symbiotic life style. Among the few projects dedicated to mycorrhizal fungi, two have been completed: one on the Basidiomycete *Laccaria bicolor*, the other on the Ascomycete *T. melanosporum*. *Tuber* is of great interest due to the fact that, as result of its symbiotic association with woody plants, it produces fruit bodies which are highly appreciated for their organoleptic properties. The Périgord black truffle and the Piedmont white truffle dominate today's truffle market. In 2007, *T. melanosporum* genome sequencing project has been launched in Turin as a common project by a French-Italian consortium. The working hypothesis was that identification of processes that condition and trigger fruit body and symbiosis formation, ultimately leading to a more efficient production, would be facilitated by a thorough analysis of truffle genomic traits. The research revealed that truffle genome with 125 megabases is the largest and most complex fungal genome sequenced so far. This expansion results from a proliferation of transposable elements accounting for 58% of the genome. In contrast, this genome only contains about 7,500 protein-coding genes with very rare multigene families. It lacks large sets of carbohydrate cleaving enzymes, but a few of them involved in degradation of plant cell walls are induced in symbiotic tissues. Considering the black truffle as a gastronomic delicacy it is interesting to underline its very low allergenic potential and the lack of key mycotoxin biosynthetic enzymes. Useful information for truffle identification has been also obtained discovering thousands of genetic markers that can be employed in order to trace the truffles on the base of their origin. Despite their similar symbiotic structures, *T. melanosporum* and *L. bicolor* encode different proteomes: compact with very few multigene families in *Tuber*, versus large with many expanded multigene families in *Laccaria*; differences are present in the symbiosis regulated genes. The comparison of genomic traits in the two ectomycorrhizal fungi suggests that genetic predispositions for symbiosis evolved along different ways in ascomycetes and basidiomycetes.

F. Martin, A. Kohler, C. Murat, R. Balestrini, P. Coutinho, O. Jaillon, B. Montanini, E. Morin, B. Noel, R. Percudani, B. Porcel, A. Rubini et al., "Perigord black truffle genome uncovers evolutionary origins and mechanisms of symbiosis", *Nature*, 464 (2010), pp. 1033-1038.



Scheme of an ectomycorrhiza (ECM) illustrating the two fungal compartments: the mantle and the Hartig net. *ref.* mycor.nancy.inra.fr/

Laccaria bicolor (Martin *et al.*, 2008)

Tuber melanosporum (Martin *et al.*, 2010)

BIOLOGY

NMR metabolic profiling in the study of transgenic lettuce

The introduction of engineered DNA sequences into the plant genome to confer new properties and improve the plant is an active research field. NMR spectroscopy has been used to study transgenic plants since as a high-throughput analytical method is a powerful tool to monitor their metabolic profiles. NMR-based identification and quantification of metabolites requires minimal preparation and handling, and no derivatization. Here, the NMR-metabolomic methodology has been applied to the study of three genetically modified lettuce lines expressing asparagine synthetase A gene from *E.coli* at 3 different growth stages (Figure 1). Lettuce plants expressing asnA are characterized by an increased mass and leaf dry weight, an early flowering and a better assimilation of nitrogen. NMR-based surveys, coupled with multivariate analyses, allow one to observe metabolic changes in the transgenic lines monitoring metabolic profiles. Statistical analyses of NMR data showed that the P31 line significantly differed from P8 and P32 transgenic lines and from control line (Figure 2). This discrimination is due to amino acids more abundant in the P8 and P32 lines, to sucrose abundant in the P31 and control line and particularly to short chain inulins present in P31 linein an amount up to 30 times higher than in the other line, probably as an indirect effect of the transgene expression. Inulins are beneficial for human health, and they are usually extracted from plants and commercialized as long chain types, whereas the short forms are synthesized chemically. Hence, lettuce genotypes with high content of foliar short-chain inulin represent useful materials for breeding strategies and a potential source for low molecular weight inulins.

A.P. Sobolev, G.Testone, F. Santoro, C. Nicolodi, M. Iannelli, M.E. Amato, A. Iannello, E. Brosio, D. Giannino, L. Mannina, "Quality Traits of Conventional and Transgenic Lettuce (*Lactuca sativa L.*) at Harvesting by NMR Metabolic Profiling", *J. of Agriculture and Food Chemistry*, 58 (2010) pp. 6928-6936.

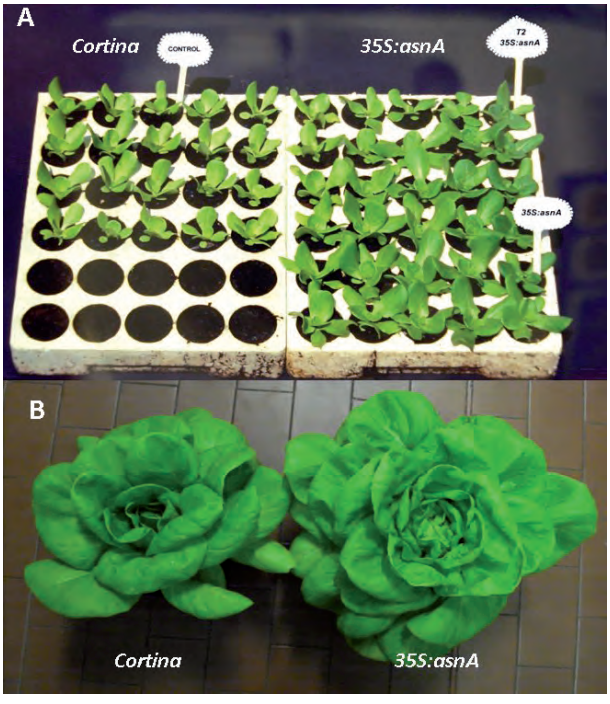


Figure 1. Control (Cortina) and transgenic (35S:asnA) lettuce plants at 24 (A) and 56 (B) days after sowing.

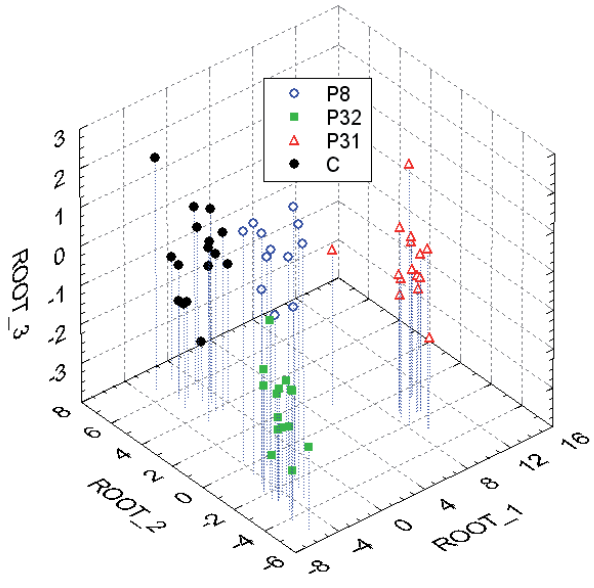


Figure 2. LDA of transgenic and control lettuce samples at 56 days after sowing. P8, P31, P32 transgenic lines. C control line.

GENETICS

Seed biofortification and manipulation of the phytic acid biosynthetic pathway

Phytic acid, the main storage form for phosphate in plant seeds, is poorly digested by monogastric animals and humans and decreases the nutritional value of the seeds by trapping phosphate and chelating nutritionally important minerals, such as iron, zinc, magnesium, and calcium. In order to improve micronutrient bioavailability and phosphorus utilisation by humans and non-ruminant animals, respectively, a major goal for grain crop improvement is the reduction of phytic acid content in the seed. One of the most used strategies to reduce phytic acid in the seed is the isolation of low phytic acid (*lpa*) mutants. However, any manipulation of phytic acid content in the seed requires knowledge of the key enzymes involved in its biosynthetic pathway.

Our main aim is to improve mineral bioavailability (biofortification) by lowering phytic acid amount in common bean (*Phaseolus vulgaris* L.) seed. Towards this goal we have undertaken a two-strategy approach: in a previous work we have isolated a bean *lpa* mutants by screening a mutagenised bean population, while in the current report we have identified, isolated and characterised the genes coding for candidate enzymes involved in inositol phosphate metabolism (Figure 1, boxes). The transcriptional analysis along seed development of these genes has revealed that some of them (Figure 1, red boxes) play a key role in the synthesis of phytic acid, thus representing good candidates for targeted mutant identification. In addition, using bioinformatic tools we have been able to map these genes on bean chromosomes, thus allowing the development of molecular markers.

In conclusion, this work will provide an important tool for the analysis and the study of the phytic acid pathway in plants and will provide useful tools for assisting bean breeders interested at improving seed quality traits.

M. Fileppi, I. Galasso, G. Tagliabue, M.G. Daminati, B. Campion, E. Doria, F. Sparvoli, "Characterisation of structural genes involved in phytic acid biosynthesis in common bean (*Phaseolus vulgaris* L.)", *Molecular Breeding* 25 (2010), pp. 453-470.

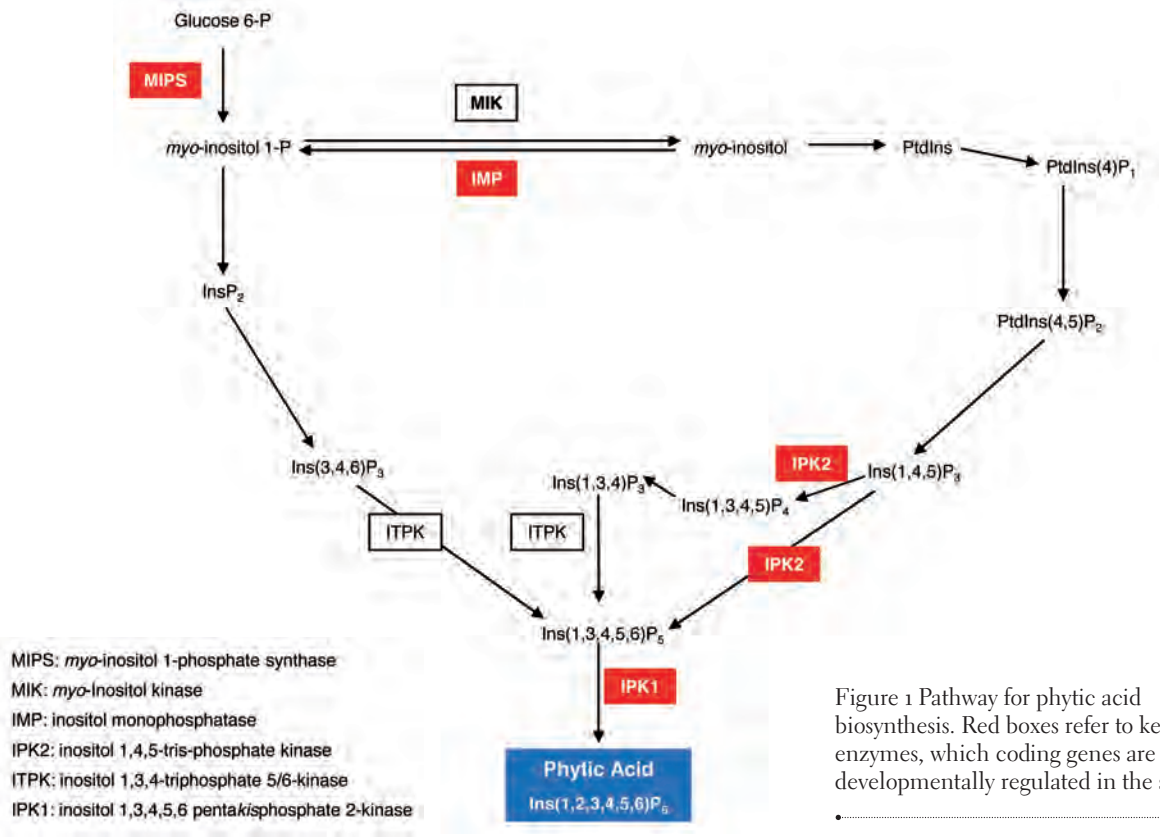


Figure 1 Pathway for phytic acid biosynthesis. Red boxes refer to key enzymes, which coding genes are developmentally regulated in the seed.

BIOLOGY

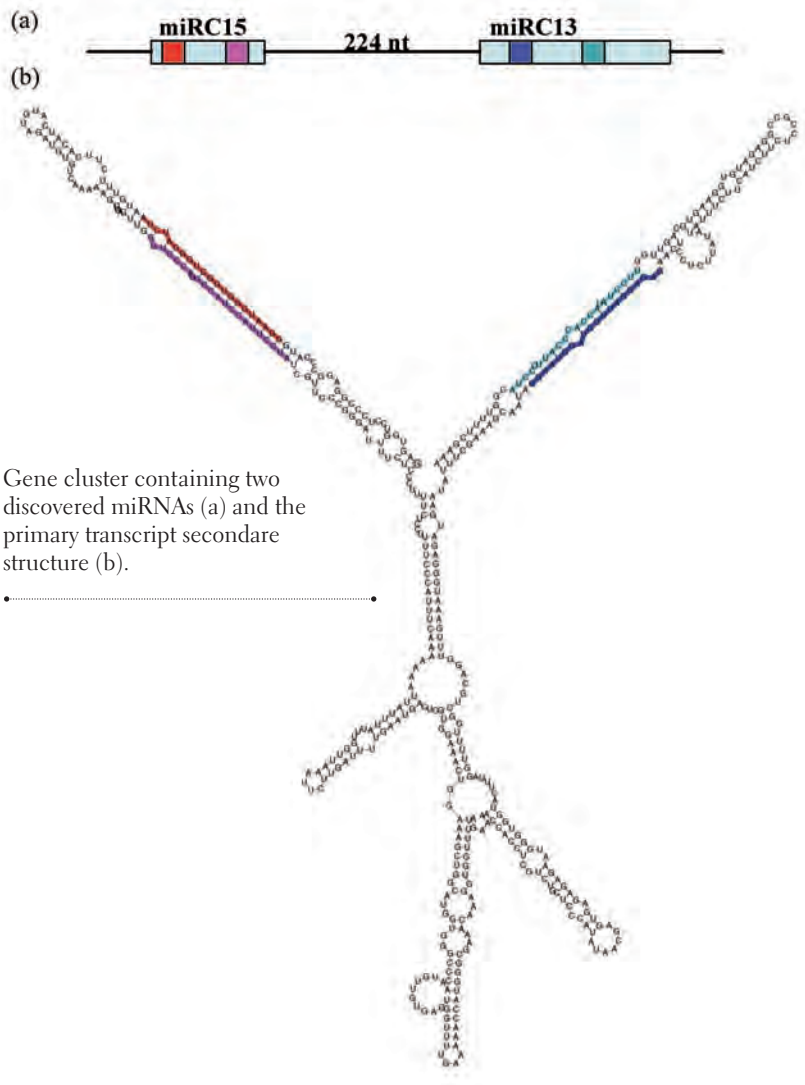
Genome-wide identification of plant microRNAs and their targets

In plants, small (s)RNAs (miRNAs and siRNAs) of 21-24 nucleotides influence gene expression during growth and development, in response to environmental stimuli at both the transcriptional and post-transcriptional levels. MiRNAs typically interact with complementary sequences in target mRNAs, leading to effector protein-dependent degradation or translational inhibition. siRNAs can act as guides for the methylation in complementary genomic DNA sequences.

The recent *Vitis vinifera* genome analysis endorses the hypothesis of involvement of ancestral rearrangement of different genomes in evolution of flowering plants and makes the grapevine system as unique as interesting from the point of view of RNA silencing-based gene regulation.

We have generated cDNA libraries of sRNAs from grapevine tissues and we have sequenced it with Illumina-Solexa high-throughput technology. Besides the conserved plant miRNAs, up to 43 novel grapevine-specific miRNAs were discovered. Some of the novel miRNA genes showed an unusual organization in tandem, revealing parallels with animal and human miRNA gene organization. Moreover, we have identified mRNA targets either for known and novel grapevine-specific miRNAs with genome wide degradome approach. We observed that miRNAs regulate different functional categories of genes and the apparent lack of cleaved target for some of them. Notably, mRNAs encoding proline- and leucine- rich proteins (likely involved in defence responses and in pathogen resistance) were targeted by some novel miRNAs. The list and the chromosomal location of 24-nt long heterochromatic siRNAs were also provided: these endogenous siRNA are likely to be involved in epigenetic marking of chromatin.

All these studies can ultimately lead to develop novel applicative strategies for improving plant fitness in response to adverse environmental stimuli.



Gene cluster containing two discovered miRNAs (a) and the primary transcript secondare structure (b).

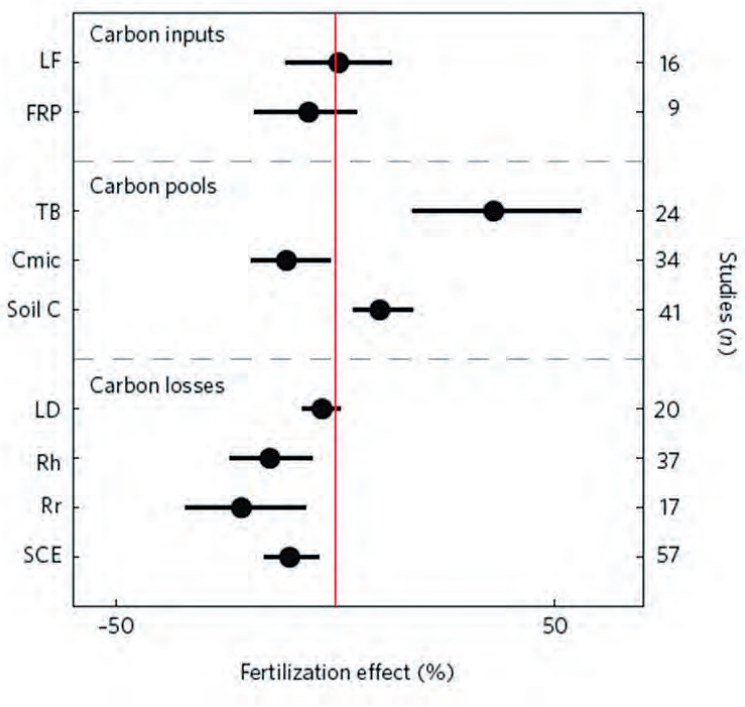
Pantaleo V., Szittya G., Moxon S., Miozzi L., Moulton V., Dalmay T., Burgyan J., "Identification of grapevine microRNAs and their targets using high-throughput sequencing and degradome analysis", *The Plant Journal.* 62(6) (2010), pp. 960-76.

ECOLOGY

Reduction of forest soil respiration in response to nitrogen deposition

The use of Fossil fuel and fertilizer has increased the amount of active nitrogen in the atmosphere over the past century. Some of this gets deposited in forests, leading to increased levels of nitrogen in soils. Excessive nitrogen deposition can harm forests, leading to soil acidification and nitrate leaching into groundwater. However, low levels of nitrogen deposition can have a positive effect, stimulating plant growth and thus increasing the amount of carbon that forests can remove from the atmosphere. Nevertheless, several studies report that nitrogen deposition is one of the main responsible of carbon sequestration in forests, stimulating photosynthesis and productivity. But does nitrogen deposition affects also organic matter decomposition in the soil?

Ivan Janssens and colleagues carried out an analysis of published experiments that added nitrogen to forest soils over years, and of field studies to determine the impact of nitrogen deposition on soil carbon release in temperate forests. The field studies made measurements of the net ecosystem exchange, the balance of CO_2 taken up by photosynthesis and released by respiration, that in those ecosystems is coming primarily from soils. These areas are located in temperate forests around the globe at nitrogen deposition levels ranging from low to high levels. The study suggests that nitrogen deposition slows the breakdown of soil organic matter, and thus increases soil carbon storage. As a result, CO_2 emissions from soil are substantially reduced. The reported results are from boreal and temperate forests. In this respect, it must be underlined that the future increase in nitrogen deposition expected in the tropics could have unforeseen consequences for carbon cycling in tropical forest soils.



Effect of experimental nitrogen addition on forest carbon pools and fluxes (meta-analysis).

Janssens I.A., Dieleman W., Luyssaert S., Subke J-A., Reichstein M., Ceulemans R., Ciais P., Dolman A.J., Grace J., Matteucci G., Papale D., Piao S.L., Schulze E-D., Tang J., Law B.E., "Reduction of forest soil respiration in response to nitrogen deposition", *Nature Geoscience*, 2010 3: 315-322.

ECOLOGY

Volatile isoprenoids help plants coping with oxidative stresses

Volatile isoprenoids (VIPs) are known to be involved in the communication between plants and their hosts (insects, fungi), and to interact with the chemistry of the atmosphere. Recent research highlighted that VIPs also protect plants against environmental stresses. Evidence is compiled that VIPs may generally act as antioxidants, directly scavenging reactive oxygen species that are formed when photosynthesis is inhibited by stresses, or indirectly mediating the presence of messenger molecules (NO and H_2O_2) that elicit hypersensitive response at cellular level. The evolutionary significance of the antioxidant function of VIPs is discussed, inferring that VIPs might be one of the first and most ancient mechanisms by which terrestrial plants achieved protection against high oxidative pressure. The idea that strong VIP emitters may be evolutionarily favored under a future warmer and more oxidant climate is however challenged, as other climate change factors, primarily rising CO_2, appear to inhibit VIP production.

Vickers C.E., J. Gershenzon, M.T. Lerdau, F. Loreto, "A unified mechanism of action for volatile isoprenoids in plant abiotic stress", *Nature Chem Biol.*, (2009), 5: 283-291.

REMOTE SENSING

Fluorescence remote sensing to retrieve vegetation photosynthesis

Vegetation plays a fundamental role in mediating carbon and energy exchange between the biosphere and the atmosphere, through key processes like photosynthesis and transpiration. Terrestrial Gross Primary Production (GPP) is an important parameter to quantify carbon fixation by plant ecosystems. Remote sensing (RS) offers a unique possibility to investigate GPP in a spatially explicit fashion; however, budgeting of terrestrial carbon cycle based on this approach still remains uncertain, and spatio-temporal variability of GPP needs a more detailed investigation on a local and regional scale. The overarching goal of this study was to find a linkage between environmentally induced changes of photosynthetic Light-Use Efficiency (LUE) and optical RS parameters. Diurnal courses of sun-induced fluorescence yield and the photochemical reflectance index of corn were derived from high-resolution spectrometric measurements and their potential as proxies for LUE was investigated. GPP was modelled using Monteith's LUE-concept and compared with eddy covariance flux data measuring carbon exchange of vegetation through micrometeorology techniques. It was found that the diurnal response of complex physiological regulation of photosynthesis can be tracked reliably with the sun-induced fluorescence. Considering structural and physiological effects, the research shows, for the first time, that including sun-induced fluorescence into modelling approaches improves the results in predicting diurnal courses of GPP. Such results support the hypothesis that satellite spaceborne quantification of sun-induced fluorescence yield may become a powerful tool to better understand spatio-temporal variations of fluorescence yield, photosynthetic efficiency and plant stress on a global scale.

Damm A., Elbers J., Erler A., Gioli B., Hamdi K., Hutjes R., Kosvancova M., Meroni M., Miglietta F., Moersch A., Moreno J., et al., "Remote sensing of sun induced fluorescence to improve modelling of diurnal courses of Gross Primary Production (GPP)", *Global Change Biology*, 16 (2010), pp 171-186.

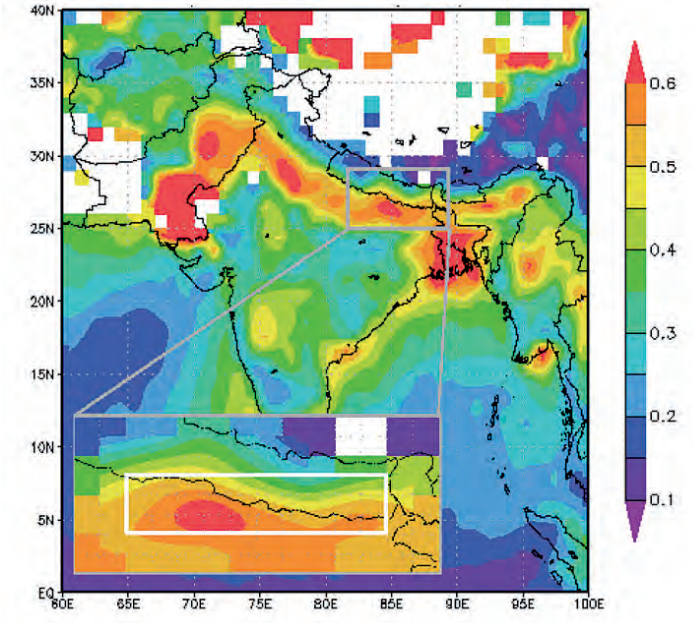
ATMOSPHERIC SCIENCES

Atmospheric Brown Clouds in the Himalayas: observations at Nepal-Pyramid

Over the last two decades, measurement campaigns performed in various areas of the planet, together with satellite observations, have highlighted the existence of thick clouds in the lower atmosphere, characterized by high concentrations of pollutants. These huge clouds have been named Atmospheric Brown Clouds (ABC): in 2003 the United Nations, aiming at evaluating their impacts on climate, mankind and environment, started the ABC project in the frame of their Environmental Programme (United Nations Environmental Programme – UNEP). The scientific evidence that the ABC can also affect the Himalayas has been surprisingly suggested by continuous observations of the atmospheric composition started in March 2006 at the EvK2-CNR Nepal Climate Observatory – Pyramid (NCO-P) located at 5079m of altitude, on the Everest Southern slope, in the upper Khumbu glacier valley. This experimental activity permitted to define the variability of climate-altering compounds like tropospheric ozone, aerosols, black carbon (BC), halogenated greenhouse gases, all linked to human and natural emissions. In this way it was also provided a first evaluation of the possible climate impacts linked to the transport of pollutants up to the Himalayan peaks. The ABC can extend from the Indo-Gangetic plan to the Himalayan foothills, where the pollutants eventually accumulate. During pre-monsoon season, 20% of days have been characterized by a strong influence of the ABC which, during afternoon hours, leads to a 5-fold increase in BC and PM_1 with respect to the seasonal means, thus confirming how, particularly during this season, the southern slope of the high Himalayan valleys represent a direct channel of ABC pollutant transport up to 5000 m altitude, thus strongly influencing local atmospheric conditions.

P. Bonasoni, P. Laj, A. Marinoni, M. Sprenger, F. Angelini, J. Arduini, U. Bonafè, P. Cristofanelli, et al., "Atmospheric Brown Clouds in the Himalayas: first two years of continuous observations at the Nepal Climate Observatory-Pyramid (5079 m)", *Atmos. Chem. Phys.*, 10, (2010), pp. 7515-7531.

Map of aerosol optical depth (AOD, MODIS) reaching the slopes of the Himalayas; the high values (red-orange colours) are related to ABC.



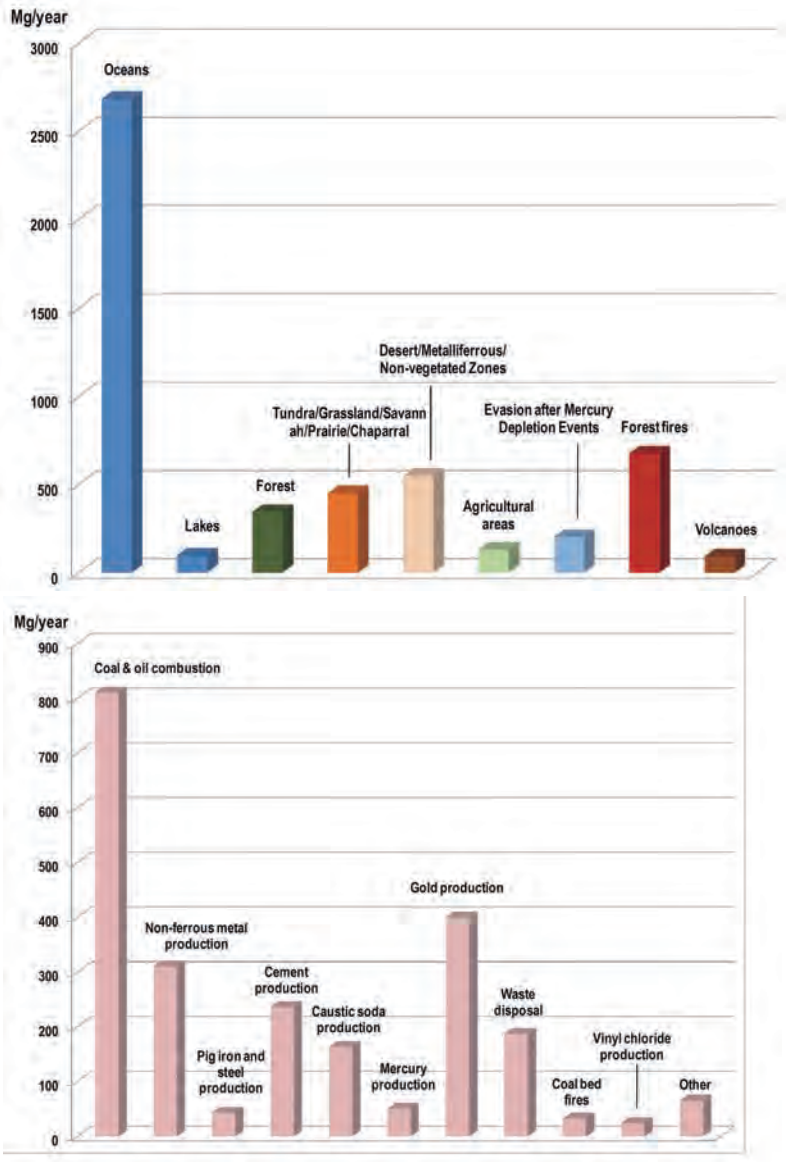
The Nepal Climate Observatory - Pyramid (5079 m) with the Lobuche Glacier on the backdrop.

Picture of the dense cloud of pollutants (the Atmospheric Brown Cloud) transported along the Khumbu valley up to NCO-P.

ATMOSPHERIC PHYSICS

Advances on mercury emissions to the atmosphere and policy implications

Mercury released to the atmosphere by major sources has gained growing attention for its effects on human health and ecosystems. In this framework the UNEP Mercury Programme has started a process for assessing to what extent contamination by mercury may affect human health and ecosystems and the Governing Council (UNEP-GC) urged to develop and implement partnerships as one approach to reducing the risks from mercury and its compounds release improving global understanding of international mercury emission sources, fate and transport. In this framework, the UNEP Global Partnership for Mercury Air Transport and Fate Research, started in 2005 and supported by the CNR-Institute of Atmospheric Pollution Research, prepared an assessment reporting on the relative contribution of anthropogenic and natural sources to the global atmospheric mercury budget and major patterns of atmospheric transport and deposition at continental and global scale. Results of the work have been published on Atmospheric Chemistry and Physics (Copernicus Publisher). On an annual basis, natural source emissions account for 5207 Mg (Fig. 1) of mercury whereas anthropogenic sources account for 2320 Mg (Fig. 2). The emission of mercury to the atmosphere driven by natural processes represents an important part of the global atmospheric mercury budget and is a dominant part of the global mercury cycle. However, while there is an on-going effort to quantify these fluxes, the magnitude of their extent, including both primary and secondary (recycled) sources, is still poorly constrained. The work has had a significant implication at policy level affecting the current preparation of the internationally treaty on mercury under development in the framework of the UNEP-GC which will be discussed in its plenary session in February 2013.



Pirrone N., Cinnirella S., Feng X., Finkelman R., Friedli H.R., Leaner J., Mason R., Mukherjee A.B., Stracher G., Streets D.G., Telmer K., "Global mercury emissions to the atmosphere from anthropogenic and natural sources", *Atmospheric Chemistry and Physics*, 2010, 10: 5951-5964.

Figure 1. Mercury emissions from natural sources.

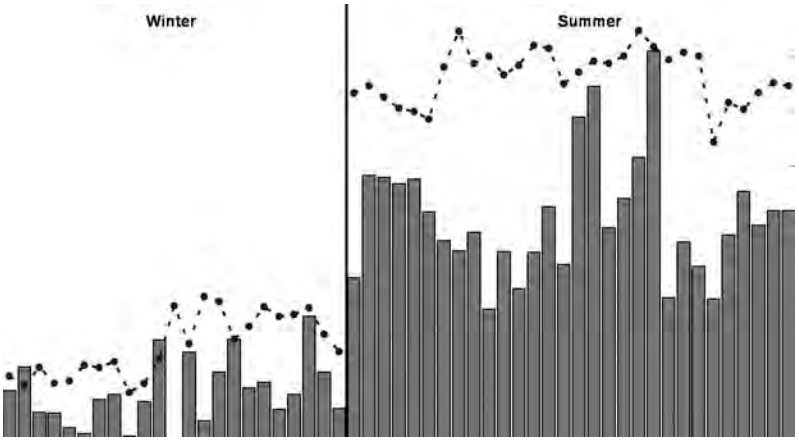
Figure 2. Mercury emissions from anthropogenic sources.

ATMOSPHERIC PHYSICS

Occurrence of gas phase ammonia in the area of Beijing (China)

A. Ianniello, F. Spataro, G. Esposito, I. Allegrini, E. Rantica, M.P. Ancora, M. Hu, T. Zhu, "Occurrence of gas phase ammonia in the area of Beijing (China)", *Atmospheric Chemistry and Physics*, 10 (2010), pp. 9487-9503.

Ammonia (NH_3) contributes to several environmental problems, including toxic effects on vegetation, atmospheric nitrogen deposition, leading to eutrophication and acidification of ecosystems. The importance of ammonia is linked to its ability to form fine particulate matter ($PM_{2.5}$) impacting on human health, atmospheric visibility, global radiative balance and transboundary air pollution. This complex role of ammonia makes the identification of its manifold emission sources a significant task in the field of atmospheric pollution. Ammonia emissions are increasing rapidly, especially in China where the ammonia emissions are three times higher than European and US emissions. Although the main source of ammonia is agriculture, the contribution of vehicles may be an important and unregulated source in urban areas. It is well known that there are large uncertainties in estimated emission rates for ammonia due to the lack of reliable atmospheric measurements. A critical aspect is the discrimination between gaseous ammonia and particulate ammonium. In order to improve the air quality and to determine the contributions of local and regional sources to air pollution in Beijing (Blue Sky of Beijing Project), the IIA-CNR of Rome carried out ammonia measurements in winter and summer 2007 using the denuder technique which is an accurate method to separate gaseous and particulate ammonia. High ammonia levels were measured and associated with air masses from the highly industrialized areas to the south of Beijing indicating the strong impact of regional sources and meteorology. Ammonia was also correlated with pollutants emitted by vehicles showing that the traffic was an important source. These measurements have provided useful information to develop abatement strategies for ammonia.



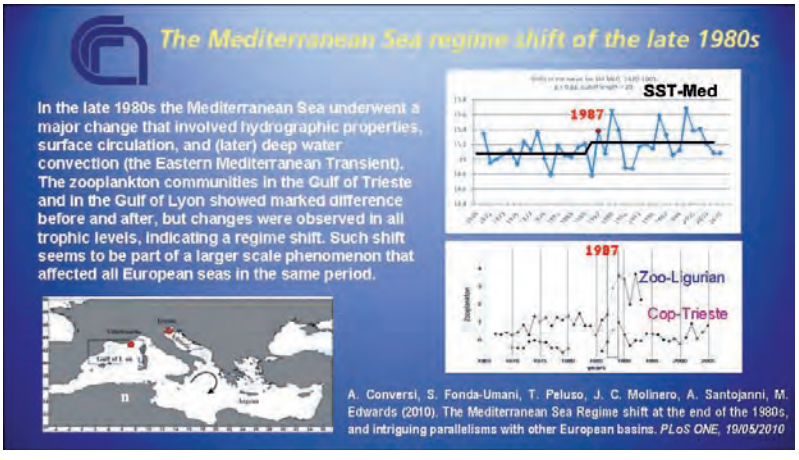
Temporal trend of ammonia during the winter and summer campaigns at Beijing.

CLIMATE CHANGE

The Mediterranean Sea regime shift at the end of the 1980s

Regime shifts are abrupt changes encompassing a multitude of physical properties and ecosystem variables, which lead to new regime conditions. Recent investigations focus on the changes in ecosystem diversity and functioning associated to such shifts. Of particular interest, because of the implication on climate drivers, are shifts that occur synchronously in many basins.
Long-term records of Mediterranean ecological and hydro-climate variables were analysed and reviewed and it was found that all of them point to a synchronous change in the late 1980s. A quantitative synthesis of the literature (including observed oceanic data, models and satellite analyses) shows that these years mark a major change in Mediterranean hydrographical properties, surface circulation, and deep water convection (the Eastern Mediterranean Transient). The analyses suggest that local, regional and basin scale hydrological properties are linked with two major indicators of large scale climate, the North Atlantic Oscillation index and the Northern Hemisphere Temperature index, suggesting that the Mediterranean shift is part of a large scale change in the Northern Hemisphere. The possible impacts of changes in circulation vs. temperature on pelagic ecosystems have been described. The hypothesis derived from these results is that the shifts that affected the North, Baltic, Black and Mediterranean (this work) Seas at the end of the 1980s, so far only partly associated, are likely linked as part of a northern hemisphere change. These findings bear wide implications for the development of climate change scenarios, as synchronous shifts may provide the key for distinguishing local (i.e. basin) anthropogenic drivers, such as eutrophication or fishing, from larger scale (hemispheric) climate drivers.

Conversi A., S. Fonda-Umani, T. Peluso, J.C. Molinero, A. Santojanni, M. Edwards, 2010, "The Mediterranean Sea Regime shift at the end of the 1980s, and intriguing parallelisms with other European basins", *PLoS ONE* 5(5): e10633. doi:10.1371/journal.pone.0010633



Synchronous changes in zooplankton in both Mediterranean basins, and identification of shift in average SST.

REMOTE SENSING

A remote sensing technique to monitor phenological cycle in the Alps

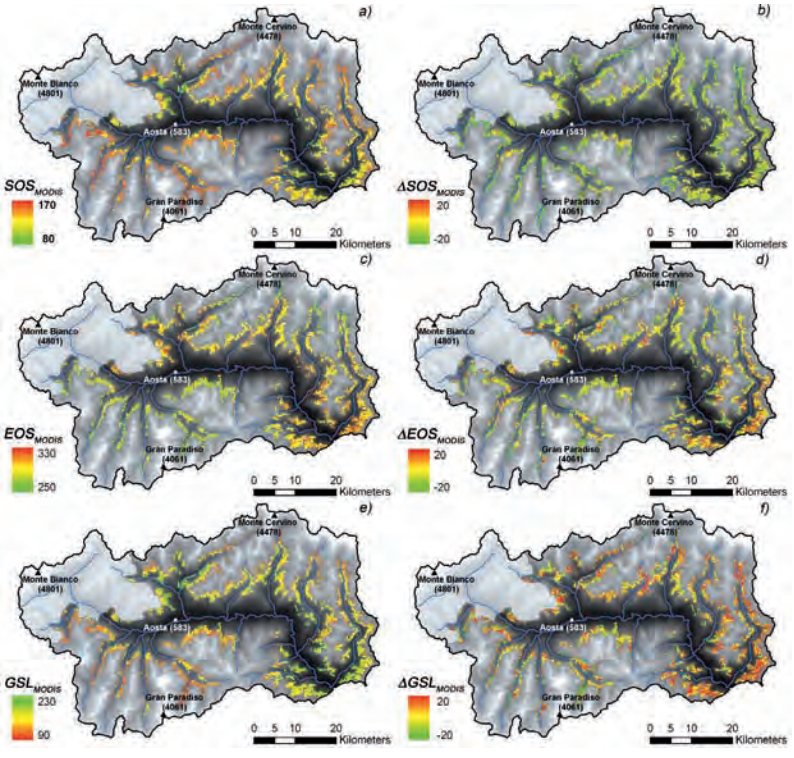
L. Busetto, R. Colombo, M. Migliavacca, E. Cremonese, M. Meroni, M. Galvagno, M. Rossini, S. Siniscalco, U. Morra di Cella, E. Pari, "Remote sensing of larch phenological cycle and analysis of relationships with climate in the Alpine region", *Global Change Biology*, 16 (2010), pp. 2504–2517.

Phenological studies analyze the timing of vegetation main seasonal events (e.g., leaf unfolding, leaf coloring). Since this timing is related to the relationships between vegetation development and climatic drivers, the analysis of its variations is an important tool to evaluate the effect of climatic change on forest ecosystems in Alpine regions, which are highly sensitive to climate change.

Satellite data allow the monitoring of spatial and temporal variations of the phenological cycle over large areas, and are therefore being increasingly used in phenological studies conducted at regional or continental scales. In this research a novel technique for monitoring the phenological cycle of European larch in the Aosta Valley from satellite data developed and evaluated in terms of accuracy. The response of the start and end dates of larch growing season to climate variability was also assessed, through a comparison of interannual temperature anomalies and satellite-derived phenological anomalies.

A comparison with field data showed that the methodology was suitable to estimate the season start and end dates of larch with a mean error of less than a week, and that the strong interannual variability of phenological dates was clearly related to interannual variability of spring and autumn air temperatures.

Such results highlight the suitability of satellite data for phenological monitoring in Alpine forests, where field data are rarely available. Moreover, the close correlation between the interannual variability of satellite-derived phenological dates and regional climate suggests that satellite phenological maps may provide very useful information for analyzing the impacts of global change on forest ecosystems in the Alps.



Maps of 2003 larch start and end of season dates and growing season length (a, c, e) and their anomalies with respect to the 2000-2007 mean (b, d, f).

PALEOCLIMATE

Hyperthermal events: global implications and environmental effects

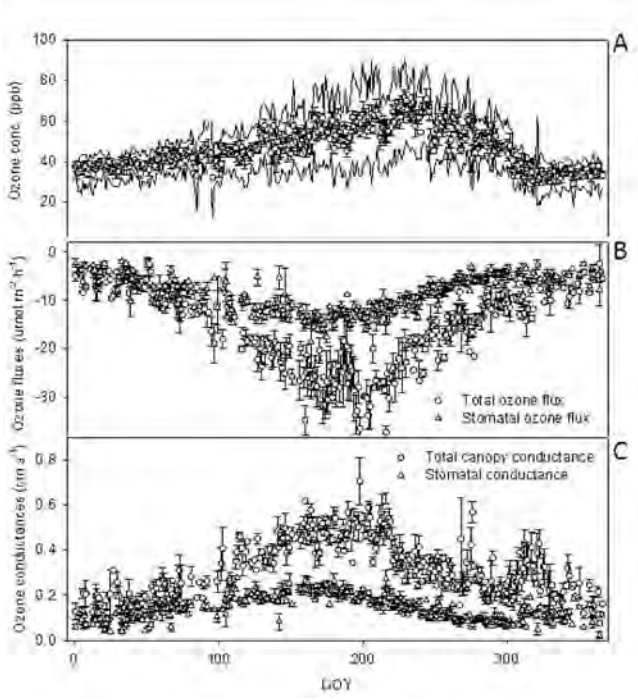
The Paleocene epoch has been punctuated by a series of transient warming events. These short-lived hyperthermals are correlated with abrupt negative carbon isotope excursions (CIEs), as well as drops in carbonate content, enhanced carbonate dissolution, and pronounced peaks in magnetic susceptibility. This is commonly ascribed to massive additions of 13C-depleted carbon to the ocean–atmosphere system from an external carbon reservoir that is associated, among other things, with increasing atmospheric pCO_2 and temperature. The Dan-C2 event is an early Danian (Paleogene) transient (~100 kyr) hyperthermal episode centred at ~65.2 Ma, which records shift in carbon reservoirs and ocean warming in the north-western and south-eastern sectors of the Atlantic Ocean. The presented high-resolution information from the western Tethyan Contessa Highway section (Gubbio, Italy), provide the first direct evidence of the Dan-C2 event beyond the Atlantic Ocean. In the studied sedimentary succession the Dan-C2 event exhibits stressed ecological responses among calcareous Nanoplankton and foraminifera, which highlight marked environmental perturbation affecting the geobiosphere and resulting in enhanced eutrophication of the sea surface waters and carbonate dissolution, as well as lowered oxygen content along the water column and at the sea bottom. As for other early Paleogene hyperthermal events, the cause of the Dan-C2 event might likely be found in changes, potentially astronomically paced, in the distribution of carbon within surface biosphere reservoirs. However, the role played by the concurrent third and last phase of Deccan volcanism would be also taken into account. In addition it was provided the first evidence of a further short-lived hyperthermal event not known up to now.

R. Coccioni, F. Frontalini, G. Bancalà, E. Fornaciari, L. Jovane, M. Sprovieri, "The Dan-C2 hyperthermal event at Gubbio (Italy): Global implications, environmental effects, and cause(s)", *Earth and Planetary Science Letters* 297 (2010) 298-305.

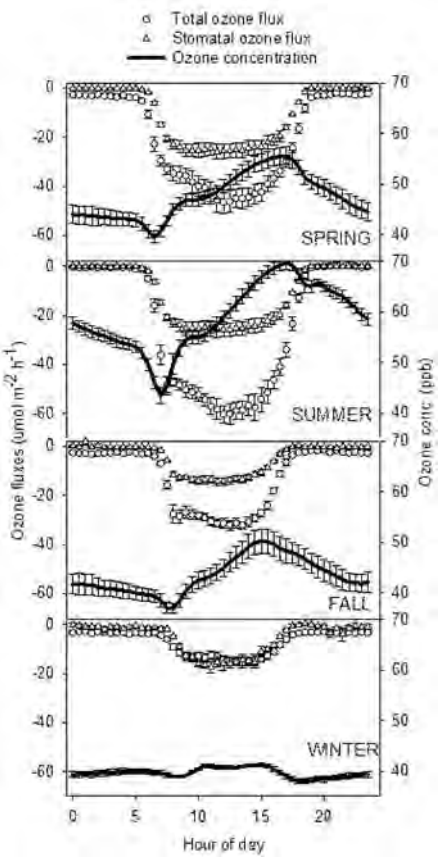
BIOMETEOROLOGY

Ozone fluxes in a pine ecosystem are dominated by non-stomatal processes

Ecosystems remove ozone from the troposphere through both stomatal and non-stomatal deposition. The portion of ozone taken up through stomata has an oxidative effect causing damage. It was used a multi-year data set to assess ozone deposition to a ponderosa pine plantation near Blodgett Forest, Georgetown, California. Environmental parameters, water and ozone concentration and fluxes were measured continuously from January 2001 to December 2006. High levels of ozone concentrations were observed during the spring-summer period, with corresponding high levels of ozone fluxes. During the summer season, it was calculated that, in agreement with previous studies, a large portion of the total ozone flux was due to non-stomatal processes, suggesting that chemical reactions with Biogenic Volatile Organic Compounds (BVOC) emitted by the ecosystem are mainly responsible for this ozone flux. In the study it was also reported the first direct measurement of BVOC+ozone oxidation products, confirming that ozone loss process is occurring below the flux measurement height. The analysis of correlations between common ozone exposure metrics based on accumulation of concentrations (AOT40 and SUM0) and ozone fluxes (total, stomatal and non-stomatal), showed that stomatal flux, which is considered responsible for ozone damage, was weaker correlated with ozone concentrations than non-stomatal flux during summer and fall seasons. On the other hand, non-stomatal flux was more strongly correlated with ozone concentration because BVOC emission and ozone concentration both increase with temperature. As result of the study it



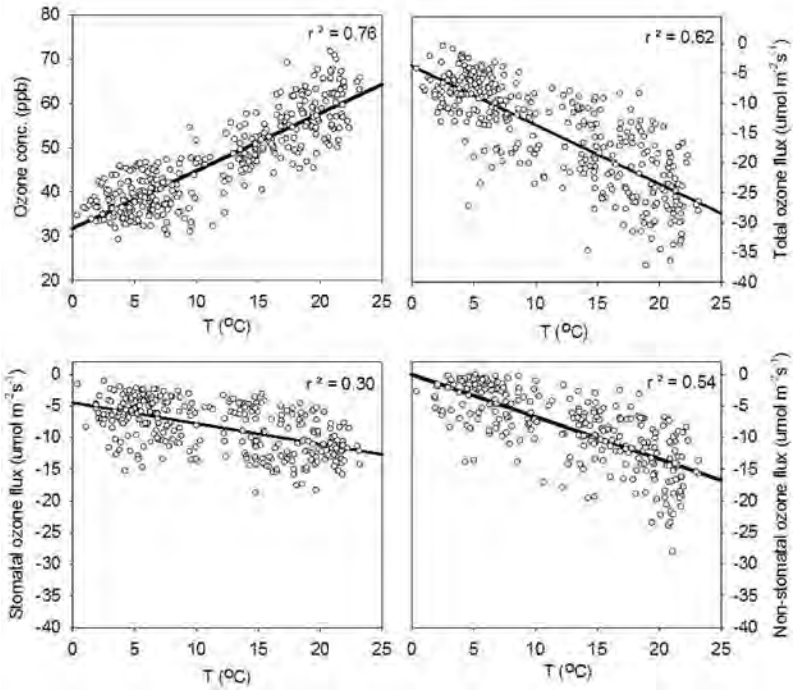
A: daily averages of ozone concentration. B: daily averages of total and stomatal ozone fluxes. C: daily averages of total and stomatal ozone conductance.



Ozone concentration, total ozone flux and stomatal ozone flux reported for the four seasons and shown as hourly means and averaged for 2001-2006 period.

was found that AOT40 and SUM0 are poor predictors of stomatal ozone uptake, and that a physiologically based metric would be more effective.

S. Fares, M. McKay, R. Holzinger, A.H. Goldstein. "Ozone fluxes in a Pinus ponderosa ecosystem are dominated by non-stomatal processes: evidence from long-term continuous measurements". *Agricultural and Forest Meteorology*, (2010), 150: 420-431.



Correlation of ozone concentration, total ozone fluxes, stomatal ozone fluxes and non-stomatal ozone fluxes with temperature.

FOOD FARMING

A natural method to remove ochratoxin A from contaminated red wines

Red wines produced in certain vintages in high-risk regions could be highly contaminated by ochratoxin A (OTA), a naturally occurring mycotoxin with nephrotoxic and carcinogenic properties. Corrective measures are therefore necessary to reduce the toxin in contaminated wines below the maximum permitted level of 2 μg/Kg. Insoluble oenological fining agents, such as activated carbon, can remove OTA from contaminated wine but produce negative effects on organoleptic parameters. It was found that activated carbon reduces up to 11% of colour intensity and 60-70% of antioxidant health benefits compounds such as resveratrol and quercetin. For this reason it was developed an innovative corrective measure to remove the toxin from wine without altering its quality parameters. The idea arose after finding that grape pomaces have a high affinity for OTA. In fact it was discovered that, during maceration of grapes contaminated with OTA, the distribution of the toxin between must and pomaces is 4 and 96%, respectively. A single repassage (mixing wine with pomaces) of contaminated wine through uncontaminated pomaces removed up to 65 % of OTA from wine. Time course experiments showed that OTA adsorption by pomaces is a rapid process and is not affected by the tested toxin concentrations. Grape pomaces maintained a good efficacy in removing the toxin after being reused four times. Unlike oenological fining agents the use of grape pomaces to remove OTA from red wines did not affect wine quality parameters, including colour intensity and health-promoting components. It is currently being studied a prototype to automate and improve the decontamination process based on repassage in continuous of contaminated musts/wines through uncontaminated grape pomaces.

M. Solfrizzo, G. Avantaggiato, G. Panzarini, A. Visconti, "Removal of Ochratoxin A from Contaminated Red Wines and Musts by Repassage over Grape Pomaces", *Journal of Agricultural and Food Chemistry*, 58, (2010) 317-323.

GENETICS

The genetic signatures of 100 years of age

Following over ten years of analysis, a study published in *Science* by the Institute of Biomedical Technology of the CNR in Milan, in collaboration with Boston University, has demonstrated the longevity relationship with the possession of specific "genetic profiles". Researchers have not identified a single variant of hereditary longevity but combinations of genetic variants which influence both the probability of contracting certain diseases and the resistance against them. In a sample of a thousand American individuals between 95 and 119 years old, 150 variants were identified which, simultaneously analyzed, can predict with an accuracy of about 80% if an individual will reach 100 years of age. In particular, 19 "genetic signatures" were identified that were shared by people of similar age for survival and delay in contracting Alzheimer's disease, cardiovascular diseases, and hypertension. A step towards personalized genomics and predictive medicine.

FOOD FARMING

Polyphenols from pea root exudates stimulating orobanche seed germination

Maximization of food production requires pest control, one of the major problems in agriculture. The conventional approach relies almost completely on chemicals, but many of them bring about severe toxicological and environmental problems. On the contrary, natural product-based pesticides offer very low environmental risks, high target selectivity, novel mechanism of action, and show reduced risks for humans and nontarget organisms. *Orobanche* and *Phelipanche* spp. (broomrapes) are holoparasitic plants causing severe yield reduction of many important crops, including tomato (Figure 1), cabbage (Figure 2), sunflower and leguminosae. Very few chemical herbicides are able to selectively control broomrapes, therefore calling for natural product-based pesticides. Using the alternative approach of "suicidal germination" (*i.e.*, germination induction in the absence of a host plant), germination of *Orobanche* species was blocked by testing both microbial and plant exudates metabolites. Three different classes of plant secondary metabolites, dihydrosorgoleone, sesquiterpene lactones, and strigolactones are known to induce seed germination of these parasites, with strigolactones showing the strongest activity. From pea root exudates, were isolated and characterized peagol and peagoldione metabolites, closely related to strigolactones, and three polyphenols, named peapolyphenols A-C, together with the well-known polyphenol (-hydroxyDHP) and a chalcone. They showed a selective stimulation of *Orobanche* seed germination, in particular *O. foetida*, whose germination is not induced by the widely-used synthetic strigolactone GR24.
In conclusion, it was found that peapolyphenol A, -hydroxyDHP and the chalchone are natural herbicides with practical application in agriculture for pest control.

A. Evidente, A. Cimmino, M. Fernandez-Aparico, A. Andolfi, D. Rubiales, and A. Motta (2010), "Polyphenols, including the new Peapolyphenols A-C, from pea root exudates stimulating *Orobanche foetida* seed germination", *Journal Agricultural Food Chemistry* 58, 2902-2907.

Figure 1 *Orobanche ramosa* infesting tomato field.

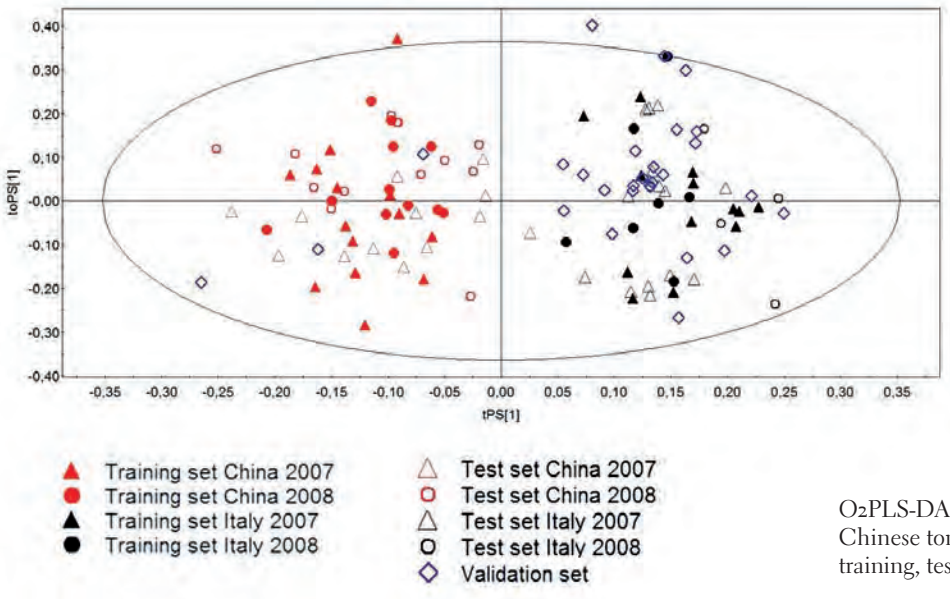
Figure 2 *Orobanche ramosa* infesting cabbage field.

FOOD FARMING

R. Consonni, L.R. Cagliani, M. Stocchero, S. Porretta, "Evaluation of the Production Year in Italian and Chinese Tomato Paste for Geographical Determination Using O2PLS Models", *J. Agric. Food Chem.*, 58 (2010), pp. 7520-7525.

Tomato paste from Italy and China: effects of the production year

In the last years, several tons of triple-concentrated tomato paste have been imported in Italy mainly from China. Actually Italian law requires tomato sauce producers to indicate the grown origin of tomato fruits on the label. In this context, many potential frauds regarding the real geographical origin of tomato products could be made. It was demonstrated the possibility to clearly differentiate Italian and Chinese triple-concentrated tomato paste samples produced in 2007 analyzing the metabolic water-soluble content by ^{1}H Nuclear Magnetic Resonance (NMR) and chemometrics. The metabolic content represents a sort of a fingerprint of the analyzed food matrix, reflecting different characteristics like soil, climate, ripening and cultivar, and constitutes a very useful tool in food authenticity assessment even if it could also be affected by the production year. To face this effect, the metabolic content of 119 Italian and Chinese tomato paste samples at different concentration rates of two production years (2007 and 2008) was investigated by combining NMR data and bidirectional orthogonal projection to latent structures discriminant analysis (O2PLS-DA). O2PLS-DA is well-suited for noisy and correlated variables, and allows to obtain robust classification models and clear interpretation of the systematic variation of data useful to characterize each class. The O2PLS-DA model obtained by considering only tomato paste samples of 2007 demonstrated a high predicting capability for all analyzed samples, independently from the concentration rate (double- and triple-concentrated tomato paste) and the year of production. NMR then confirmed to be a very useful tool in food characterization and authentication.



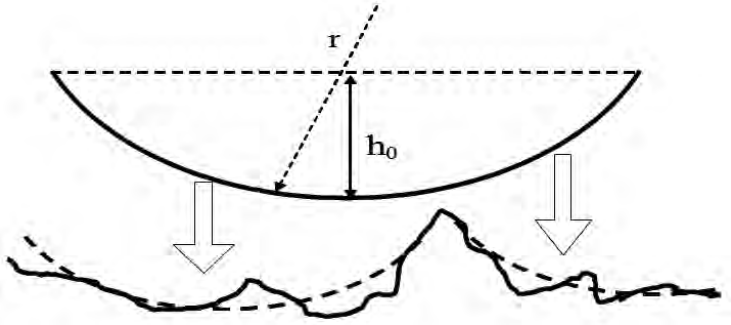
O2PLS-DA score plot of Italian and Chinese tomato paste samples of training, test and validation sets.

HYDROLOGY

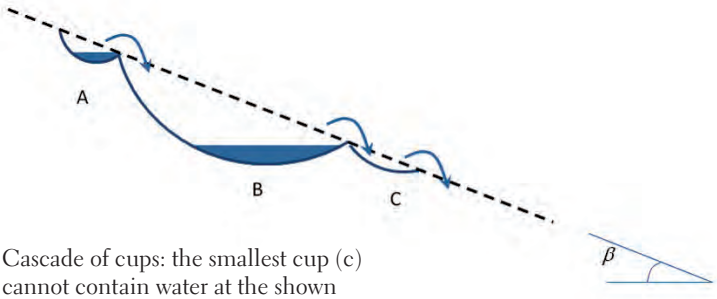
Determination of surface water storage on pervious and impervious areas

Surface Water Storage is the maximum volume of water that can be retained in depression (ponds) and irregularities of a pervious or impervious soil surface. Surface Water Storage is a parameter extremely difficult to be measured. Since 70's various empirical or approximate relationships tried to establish a correct assessment of this value. The study of the relationships between surface roughness, local slope gradient and maximum volume of water storage in surface depressions is a fundamental element in hydrological models development; it can be used in soil and water conservation strategies, in particular for water harvesting in arid environments. Good estimates of the maximum volume of water storage are important for runoff assessment during rainfall events and in models and projects for hydraulic risk mitigation and protection against floods. The amount of water volume that can be stored in surface depression depends on the geometrical and statistical properties and irregularities of depression (ponds), and on the local slope gradient of the surface. Generally the water storage decrease as local slope gradient increase. An example that exemplifies the concept is given by the progressive inclination of a tea spoon full of water. The aim of the study was to develop such a relation for predicting/estimating the maximum volume of water that a soil surface (with given roughness characteristics and local slope gradient) can store. Using a spherical cup geometry approximation, a general physical model was derived and tested for immediate and practical application. The intrinsic merit of the cup approximation is to identify where roughness elevation comes in and how it relates to slope gradient in defining depression volume.

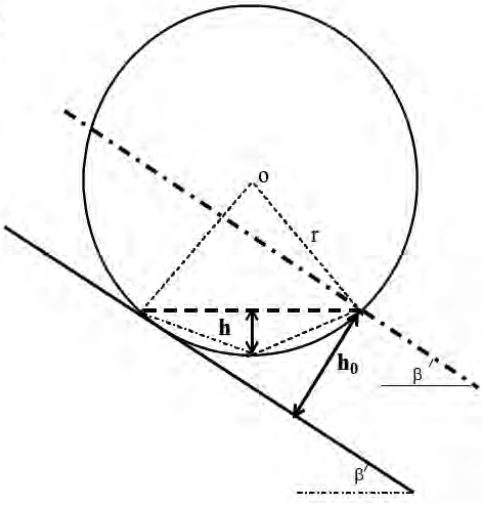
Borselli L., Torri D. 2010. "Soil roughness, slope and surface storage relationship for impervious areas", *Journal of Hydrology* 393 (2010): 389-400. doi:10.1016/j.jhydrol.2010.09.002



Spherical cup approximation for surface roughness.



Cascade of cups: the smallest cup (c) cannot contain water at the shown gradient.



Spherical cup on a sloping surface: relation with water depth (h) and roughness height (h_o).

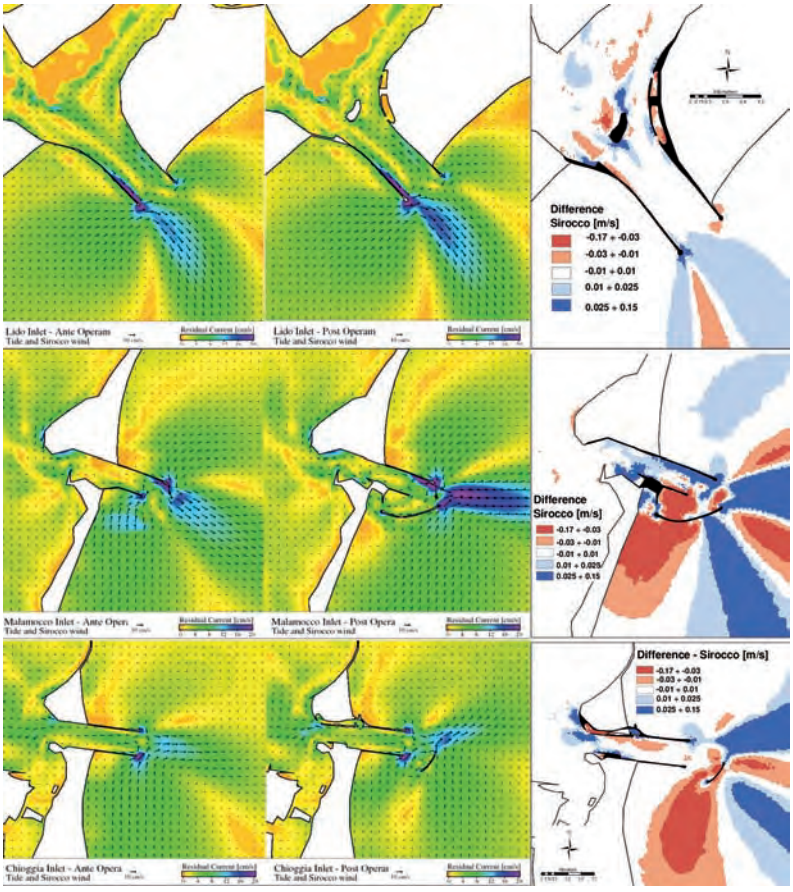
HYDRODYNAMICS

How the Mo.S.E. Project is changing the Venice lagoon dynamics

The Mo.S.E project is a long-debated project to safeguard the city of Venice and its lagoon from "high water" events. The project is still under implementation and it entails changing the configuration and bathymetries of the three lagoon inlets. After the project will be completed, the new installed structures will cause changings in the configuration of the seaward inlets, while they are not yet in operation.

In order to predict the effects of the proposed alterations of the hydrodynamics of the lagoon, a well-tested hydrodynamic-dispersion model was applied. The results show that, with the new structures, the Lido sub basin tends to increase its extension at the expense of the Chioggia sub basin. Changes in the instantaneous currents and in the sea-lagoon interaction are both responsible for those effects. In fact, the new breakwaters in front of Malamocco and Chioggia inlets modify the length and direction of the outflowing jet and the patterns of the currents around the inlets and the nearby coast. The new artificial island inside the Lido inlet changes the current pattern and increases the current velocity on the southern side of the channel propagating this effect up to Venice city. This implies that the Lido sub basin can improve its renewal time but a more intense current speed can be a risk for habitat and infrastructure conservation. The Chioggia sub basin water quality can worsen because of the weakening of hydrodynamic exchanges. Finally the microcirculation between the breakwater and the shore in Chioggia and Malamocco inlets can be a trap for pollutants and suspended sediments.

Ghezzo M., Guerzoni S., Cucco A. and Umgiesser G., "Changes in Venice Lagoon dynamics due to construction of mobile barriers", *Coastal Engineering*, 57 (2010) 694-708.



Residual current velocity maps for real tide plus Sirocco wind scenario. Ante operam, Post operam and difference between the velocity and scalar fields.

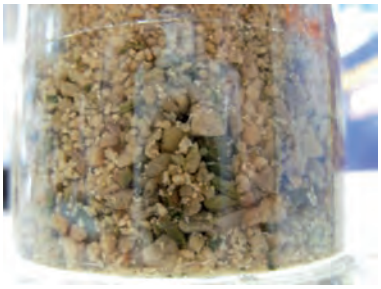
WATER TREATMENT

A new system for lowering sludge production in biological processes

Treatment and final disposal of the sludge produced during municipal wastewater treatment may account for 50-60% of total plant operating costs. In Europe, sludge production has not only continuously increased over recent decades (from 5.5 million tonnes dry solids in 1992 to 8 million in 1998 and 10 million in 2007) but also have disposal costs (now estimated at between 350 and 750 Euros per tonne of dry solids). Unfortunately, these figures are expected to increase further as a result of progressively more stringent effluent regulation criteria together with the growing number of wastewater treatment plants. Therefore, in the near future, the possibility of reducing excess sludge production will be one of the most challenging tasks involved in wastewater treatment. Among the new technologies recently proposed to comply with this request, one of the most promising is the system developed by the Water Research Institute (IRSA) of the CNR whose acronym is SBBGR (Sequencing Batch Biofilter Granular Reactor). SBBGR is a "time oriented" submerged biofilter in which all the steps of the biological treatment take place, one after the other, in the same tank instead of moving to a second tank for the continuation of the treatment as in conventional treatment systems. In addition, this technology boasts a unique feature: the microorganisms present in the system grow as granules characterised by a very high density. This allows higher biomass concentration in the reactor to be obtained. In comparison with the conventional treatment systems, SBBGR technology is able to reduce the surface requirement of the treatment plant (up to 60 %), the sludge production (up to 80 %) and the treatment costs (up to 40%).

C. Di Iaconi, M. De Sanctis, S. Rossetti, R. Ramadori, "SBBGR technology for minimising excess sludge production in biological processes", *Water Research*, 44 (2010), pp. 1825-1832.

Photo of SBBGR prototype used for the experimentation.



Granules of microorganisms in SBBGR technology.

In 2010, the project received from European Commission the award of "Best Life Environment Projects".

WATER TREATMENT

Arsenic removal by membrane processes

A. Figoli, A. Cassano, A. Criscuoli, M.S.I. Mozumder, M.T. Uddin, M.A. Islam, E. Drioli, "Influence of operating parameters on the arsenic removal by nanofiltration", *Water Research*, 44 (2010) pp. 97-104.

Arsenic is a natural tasteless and odourless element existing in the earth's crust at average levels of about 2000–5000 mg/l. Groundwater and surface contamination by arsenic is one of the main environmental problems in the present millennium, as many people are exposed to excessive amounts through contaminated drinking water. Arsenic contamination of surface and groundwater is a worldwide problem in a large number of countries (Bangladesh, Argentina, Italy, USA, etc.). In order to meet the new Maximum Contaminant Level (MCL) standard (10 mg/l) recommended by the World Health Organization (WHO), a continuous investigation of the available arsenic removal technologies is essential to develop economical and effective methods for removing arsenic.

In nature arsenic occurs in several chemical forms and oxidation states, among which, the most important two, occurring in water environment, are trivalent (AsIII) and pentavalent (AsV).

The removal of AsV from synthetic water was studied on lab scale by using two commercial nanofiltration (NF) spiral-wound membrane modules (N30F and NF90). The influence of the main operating parameters such as feed concentration, pH, pressure and temperature on the As rejection and permeate flux, was investigated. An increase in pH and a decrease in operating temperature and As feed concentration led to higher As removal for both membranes, whereas higher transmembrane pressure values reduced the removal achievable with the N30F membrane. In both cases, the permeate flux increased with temperature and pressure and reached its maximum value at a pH of 8.

Among the parameters affecting the As rejection, feed concentration plays a key role for the production of a permeate stream respecting the limits imposed by WHO.

NEUROSCIENCES

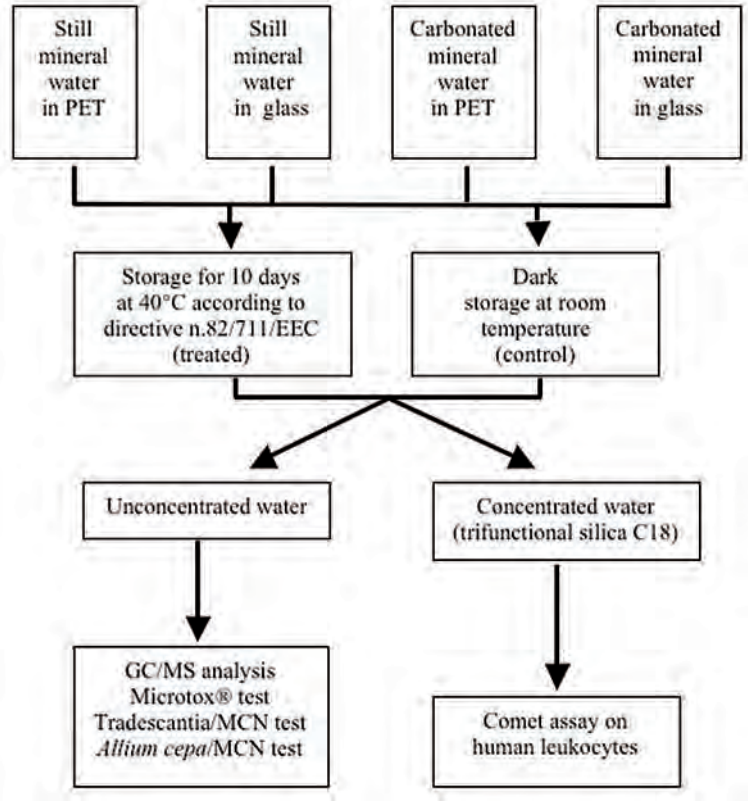
Neural plasticity and sensory integration in perception

From the Institute of Neuroscience of the CNR in Milan and Pisa, a study published in *Current Biology* refocuses on the traditional concepts regarding the physiology of perception. The cerebral integration of sensory information does not occur only in the "secondary areas": it is already realized in the primary areas where the information is analyzed by the individual senses. According to researchers, the sensory information can be integrated even in the primary cortex, on an unconscious level, in the early stages of preparation prior to their conscious perception. For the demonstration of this, an experiment was set up of "binocular rivalry" in which the team of researchers observed that a tactile signal might interact with a visual even when the latter is out of conscious awareness. The clinical applications are important: if the connections between the somatosensory cortex and vision are not created ex novo, but they are naturally supplied by our brain, it could lead to a better understanding of the mechanisms of neural plasticity that is established after a sensory loss. In the blind, for example, the visual cortex primarily processes tactile information.

WATER RESEARCH

Genotoxic assessment of mineral water packed in PET or glass bottles

The potential migration of genotoxic compounds into mineral water stored in polyethylene terephthalate (PET) bottles was evaluated by an integrated chemical/biological approach, using short-term toxicity/genotoxicity tests and chemical analysis.
Six commercial brands of still and carbonated mineral water bottled in PET and in glass were stored at 40 °C for 10 days according to the standard EEC migration test (82/711/EEC) or at room temperature in the dark (control).
After treatments, the samples were analyzed using gas-chromatography/mass spectrometry (GC/MS) to detect volatile and non-volatile compounds, with the *Vibrio fischeri* test to evaluate potential toxicity of the samples, and with three mutagenicity tests (*Tradescantia* and *Allium cepa* micronucleus tests and the Comet assay on human leukocytes) to detect their genotoxic activity. GC/MS analysis did not detect phthalates or acetaldehyde in the water samples. The test with *Vibrio fischeri* found no toxic effects. Mutagenicity tests detected genotoxic properties of some samples in both PET and glass bottles.
Statistical analyses showed a positive association between mineral content and mutagenicity (micronuclei in *A. cepa* and DNA damage in human leukocytes). No clear effect of treatment and PET bottle was found.
These results suggest the absence of toxic compounds migrating from PET in the test conditions (10 days at 40°C). In conclusion, the tested bottle materials and the stored treatment were not associated with genotoxic properties of the water; on the contrary the genotoxic effects detected in bottled water may be preferentially related with the water characteristics (i.e. mineral and CO_2 content).



Scheme of the study carried out on bottled mineral water samples.

E. Ceretti, C. Zani, I. Zerbini, L. Guzzella, M. Scaglia, V. Berna, F. Donato, S. Monarca, D. Feretti, "Comparative assessment of genotoxicity of mineral water packed in polyethylene terephthalate (PET) and glass bottles", *Water Research*, 44 (20 10), pp. 1462-1470

EARTH SCIENCE

A way to track mantle heterogeneity

The terrestrial mantle is chemically heterogeneous, and the nature and scale of this heterogeneity are of primary importance to understand the evolution of the Earth. A way to track such heterogeneity is to analyze the basalts produced by the mantle partial melting in the different tectonic contexts.
The studies rely on the division between "compatible" elements (that have the tendency to remain in the minerals of the residual rock) and "incompatible" ones (that have a preference for the melt). The modelling relies on the degree to which these elements remain in the solid and the used parameter is the mineral/melt "partition coefficient".
The nowadays available data on the partitioning of lithium (Li) and boron (B) for the upper mantle show a relatively large scatter. The research carried out within the European project EUROMELT (HPRN-CT-2002 -00211) has allowed to improve the experimental and analytical techniques for the determination of the very low (ppb-ppm) contents of Li and B in the mantle minerals (olivine and pyroxene) and in the basaltic melt. The experiment, performed at a pressure of 1 GPa and a temperature of 1330°C at the Lab. Magmas et Volcans (Clermont-Ferrand) produced the equilibrium between a synthetic basalt and an olivine powder from a spinel lherzolite xenolite. Lithium and boron were analyzed in the run products by means of the Cameca IMS 4F ion microprobe installed at the Secondary Ion Mass Spectrometry (SIMS) Lab. of the CNR-Institute of Geosciences and Earth Resources (IGG), Section of Pavia. The SIMS methodological development allowed to get accurate measurements of Li and B in the minerals and in the melt, besides in the mineral phases of the starting xenolite. Li resulted to be moderately incompatible, and B much more incompatible than generally known from literature.

L. Ottolini, D. Laporte, N. Raffone, J.L. Devidal, B. Le Fèvre, "New Experimental Determination of Li and B Partition Coefficients During Upper Mantle Partial Melting", *Contributions to Mineralogy and Petrology*, 2009, IF 2008: 3,853.

MEDICINE

The antitumoral processes of quercetin

A study conducted by researches at the Institute of Food Sciences at the CNR in Avellino (Isa-Cnr), published by the *Journal of Cancer*, demonstrated the efficiency of quercetin in the treatment of leukemia. This molecule of the class of phytochemicals present in foods such as onions, capers, celery, apples, eggs, green tea, and red wine makes cancer cells isolated from patients affected by Chronic Lymphocytic Leukemia (LLC) helpless with pharmacological treatment with chemotherapy. The molecule can block the transformation of a normal cell into that of a cancerous cell and reverse this process. LLC affects about 1-6 people out of 100,000 and represents the most common form of leukaemia in adults (22-30% of cases). The researchers warn that the quantity of quercetin taken in on a diet (25-30 milligrams) is too small to play a significant role in anti-cancer formation.

EARTH SCIENCE

Evolution of the roman magmatic province in southern Italy

The Roccamonfina volcano belongs to the Roman Magmatic Province, a volcanic belt located along the Italian peninsula made up by active and quiescent volcanoes through the emplacement of magmas extremely enriched in Potassium. The magmas were produced by partial melting of the upper mantle during the collision between the Adria and Italian microplates caused by the convergence between Africa and Eurasia. The enrichment in potassium is thought to be related to the introduction of melted sediments within the upper mantle through the subduction of the oceanic slab beneath the Italian peninsula prior to collision. This volcano is a key element for understanding the evolution of the collision between the microplates; its activity can be divided in two stages separated by volcano-tectonic caldera collapses. Ultrapotassic leucite-bearing rocks are confined to the pre-caldera stage. After the major sector collapse of the volcano, occurred at ca. 400 ka, leucite-free shoshonitic rocks erupted from cinder cones and domes both within the caldera and on the external flanks volcano. The last phases of volcanic activity erupted sub-alkaline magmas as enclaves in trachytic domes, and as lavas within the Monte Santa Croce dome. During the final activity high-K calc-alkaline lavas have been erupted. It is argued that ultrapotassic magmas were generated in a modified lithospheric mantle after crustal-derived metasomatism. Interaction between the metasomatic agent and lithospheric upper mantle produced a low-melting point metasomatised veined network. The partial melting of the veins alone produced pre-caldera leucite-bearing ultrapotassic magmas. Shoshonitic magmas were generated by further melting, at higher temperature, of the same metasomatic assemblage with addition 10 to 20 % of OIB-like asthenospheric mantle material. We suggest that addition of asthenospheric upper mantle material from foreland mantle, flowing through slab tearing after collision, was achieved.

S. Conticelli, S. Marchionni, D. Rosa, E. Boari, G. Giordano and R. Avanzinelli, "Shoshonite and sub-alkaline magmas from an Ultrapotassic Volcano: Sr-Nd-Pb isotope data on the Roccamonfina volcanic rocks, Roman Magmatic Province, Southern Italy", Contributions to *Mineralogy and Petrology*, 2009, volume 157, Number 1/January, 2009, 41-63. doi: 10.1007/s00410-008-0319-8.

EARTH SCIENCE

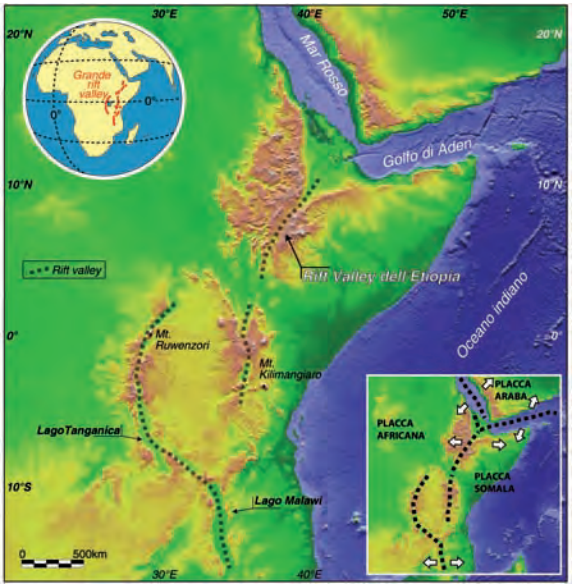
Continental rift evolution: from rift initiation to incipient break-up in the main Ethiopian rift

Rifting and break-up of continental plates and the opening of new oceanic basins represent one of the most important aspects of Earth Sciences. Besides the scientific importance, these processes present a high social impact, related to the associated seismic and volcanic risks, and an economic relevance, connected to the presence of natural resources such as mineral deposits, hydrocarbons and geothermal power.

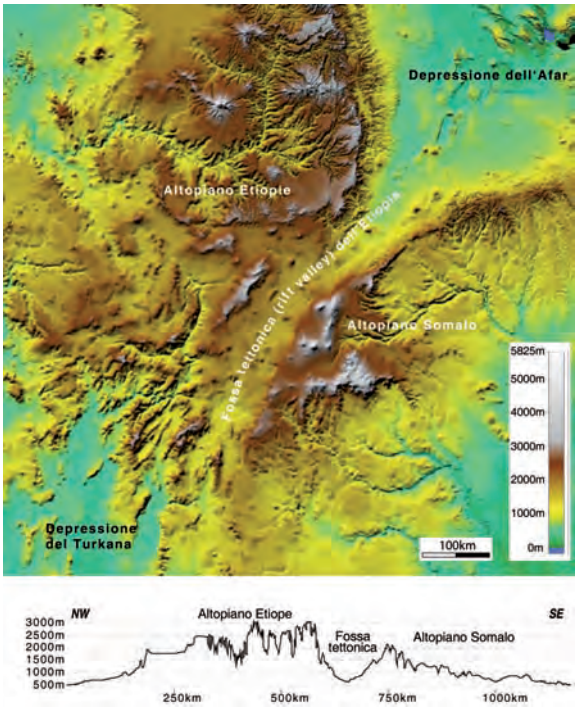
The rift valley of Ethiopia, in East Africa, which results from extension between the African and Somalian plates, represents an ideal place to analyze the dynamics of continental rifting and break-up: indeed, it records and exemplifies all the different stages of continental separation, from the initial application of extensional stresses to continental plates, to their eventual rupture and development of a new oceanic basin in between. Recent geophysical-geological data acquired in the frame of international scientific projects have evidenced that the first stages of rifting, at around 11 Ma ago, have been characterized by development of a rift valley in which deformation, associated to strong volcanic and seismic activity, was mostly localized at the major tectonic escarpments that separate the rift floor from the surrounding uplifted plateaus. With increasing plate separation, deformation has migrated from the rift margins to the centre of the rift floor, giving rise to narrow regions of localized strong volcanic and seismic activity. The upwelling of hot magmas in these narrow regions resulted in a strong heating of the continental lithosphere, with a consequent re-

duction of its resistance. This in turn facilitated the rupture of the continental plates in the centre of the rift depression giving rise to new incipient mid-ocean ridges as observed in the northern Ethiopian rift.

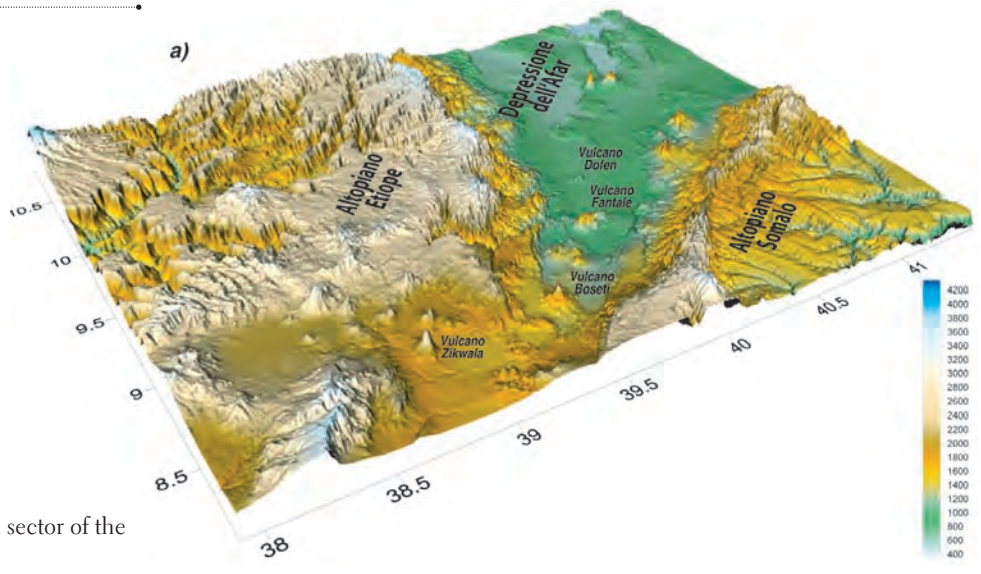
Corti G., 2009, "Continental rift evolution: from rift initiation to incipient break-up in the Main Ethiopian Rift, East Africa", *Earth Science Reviews*, 96, 1-53.



Topographic expression of the Great Rift Valley of East Africa, with indicated the location of the Ethiopian rift valley. Inset in the bottom-left corner shows a schematic plate kinematic setting of the area.

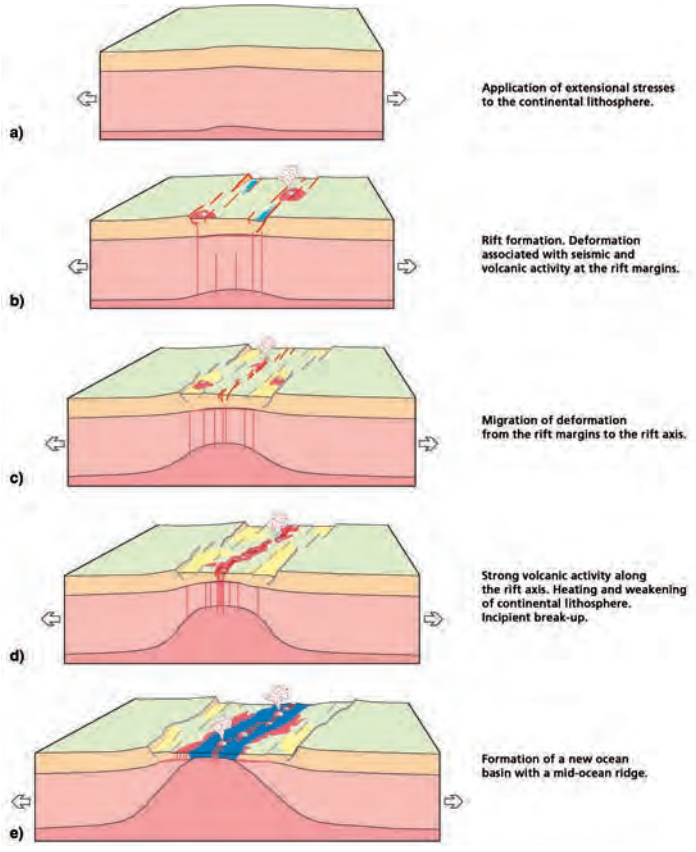


Digital elevation model of the Ethiopian Rift showing the topography of the rift valley and the surrounding Ethiopian and Somalian Plateaus. The bottom panel illustrates a topographic profile across the rift valley.



3D view of the northern sector of the Ethiopian rift valley.

Characteristics of the tectonic deformation in Ethiopia. Top panel: Asela normal fault; bottom panel: Wonji normal faults.



Typical evolutionary scheme of a continental rift as exemplified by the evolution of the Ethiopian rift valley.

EARTH SCIENCE

The quest for the Africa-Eurasia plate boundary west of the Strait of Gibraltar

The present-day plate boundary between Northwest Africa and Southwest Eurasia (Fig. 1) has been a matter of debate since the birth of the plate tectonic theory, in the early sixties. The solution to this puzzle has important implication in terms of both plate theory and in the understanding of earthquake and tsunami hazards for the countries around the Gulf of Cadiz: Morocco, Portugal and Spain.
This portion of Atlantic Ocean was the source area of the 1755 Great Lisbon Earthquake, with a hypothesized M=8.5 to 8.7, which caused the largest tsunami ever experienced in Western Europe. The population of Europe was shocked to learn that the capital of one of the most powerful maritime empire of the eighteenth century had been destroyed within minutes. Thanks to the "Euro-Margins" Project of European Science Foundation, named SWIM (Earthquake and Tsunami hazards of active faults at the SouthWest Iberian Margin: deep structure, high-resolution imaging and paleoseismic signature) 14 Scientific Institutions, belonging to 7 European Countries, put together 19 Marine Surveys carried off in the Gulf of Cadiz between the years 2000 and 2006. The result of this effort is a new high-resolution bathymetry map (Fig. 1) that allowed the identification, for the first time, of a series of tectonic lineaments striking WNW-ESE, named the "Swim Lineaments" (Fig. 2). The SWIM Lineaments are 600 km long, almost half the length of the San Andreas Fault of California that is 1500 km long.
The SWIM Lineaments probably represent the long looked for plate boundary.
This discovery opens new perspectives to mitigate earthquake and tsunami risk in the Gulf of Cadiz; this area will possibly be monitored in a very close future.

Zitellini, N., Gracia E., Matias L., Terrinha P., Abreu M.A., DeAlteriis G., Henriet J.P., Danobeitia J.J., Masson D.G., Ramella R., Somoza L., Diez S, "The quest for the Africa-Eurasia plate boundary west of the Strait of Gibraltar", *Earth and Planetary Science Letters*, 2009, 280, 13-50.

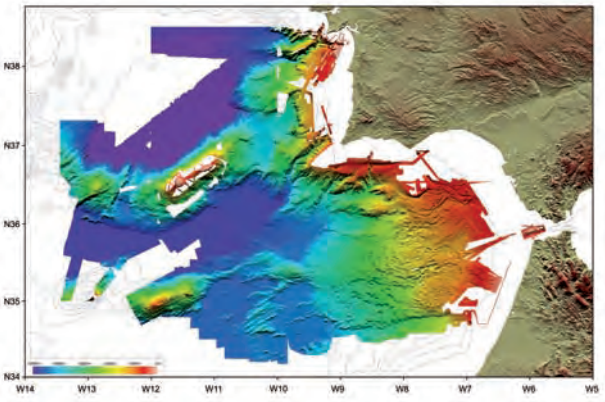


Figure 1 High resolution Bathymetry map of the ESF "SWIM" Project, from Zitellini et al. 2009.

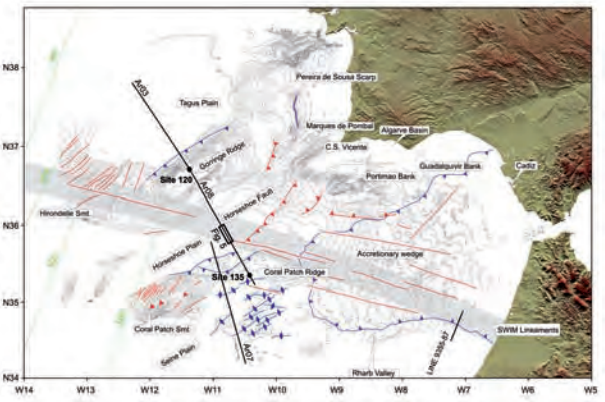


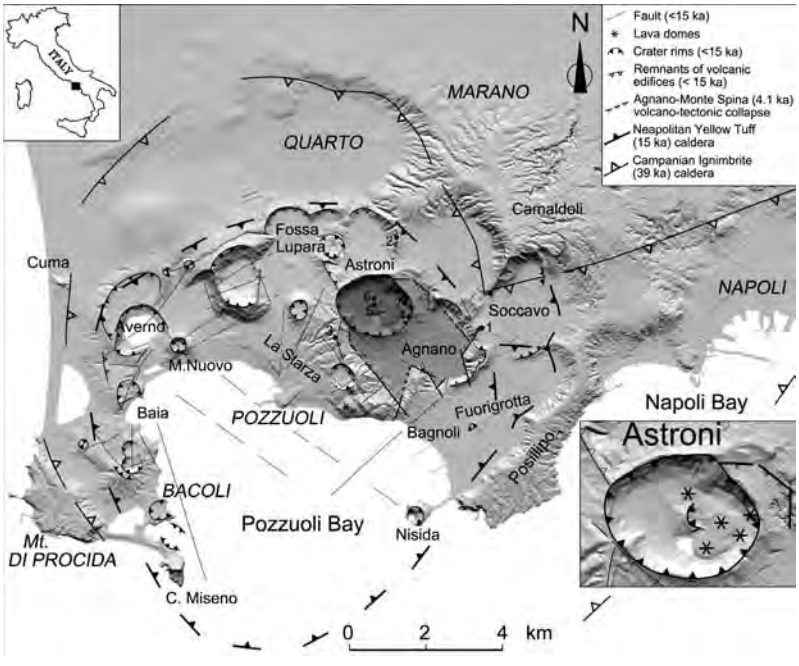
Figure 2 Tectonic map derived from the bathymetry. Gray area represents the possible plate boundary, from Zitellini et al., 2009.

VOLCANOLOGY

New deep magma in the feeding system of the Astroni Volcano (Campi Flegrei)

M. D'Orazio, F. Innocenti, S. Tonarini e C. Doglioni, Reply to the Discussion of: «Carbonatites in a Subduction System: The Pleistocene alvikites from Mt. Vulture (Southern Italy)», *Lithos*, 98 (2008), pp. 313-334 e by F. Stoppa, C. Principe e P. Giannandrea, *Lithos*, 103 (2008), pp. 557-561.

Campi Flegrei is a Quaternary supervolcano in the Neapolitan area. Volcanic activity at Campi Flegrei started more than 60 ka ago and culminated in two high-magnitude, caldera-forming eruptions, which generated the Campi Flegrei caldera: the Ignimbrite Campana (39 ka, more than 200 km3 of produced emesis) and the Neapolitan Yellow Tuff (15 ka). After the Neapolitan Yellow Tuff event the volcanic activity continued with at least 72 smaller eruptions within and along the structural boundary of the caldera. Campi Flegrei is still an active structure, as testified by the eruption of Monte Nuovo (1538 AD) and by the recent unrest episodes of 1969-72 and 1982-84 at the Pozzuoli harbour. Due to high volcanic hazard and intense urbanization, (close to 1.5 million people live within the entire caldera, with about 350 000 in its active portion) the volcanic risk is extremely high. The Astroni volcano formed between 4.1 and 3.8 ka B.P., in a period of intense volcanic activity during which were built many volcanic edifices (see figure). The volcanological, geochemical and isotopic data collected in the study allow recognizing the arrival of a new deep magma in the feeding system of the volcano. The post-Neapolitan Yellow Tuff magmatic activity has been feeded mainly by shallow reservoirs of residual magma remained in magma chambers after the great explosive eruptions, thus the ascent of deep magmas, recognized at Minopoli (10 ka) and Astroni, is particularly important because the arrival of new deep, warmer and fluid-rich magma in the shallow feeding system, could increase temperature and pressure triggering new magmatic and phreatomagmatic eruptions.



Structural sketch map of the Campi Flegrei caldera, showing the location of Astroni volcano. The studied samples were collected at: Monte Sant'Angelo; Contrada Romano; Celle; Cratere Astroni; Colle Imperatrice; Rotondella; Caprara.

VOLCANOLOGY

Degassing, crystallization and eruption dynamics at Stromboli volcano

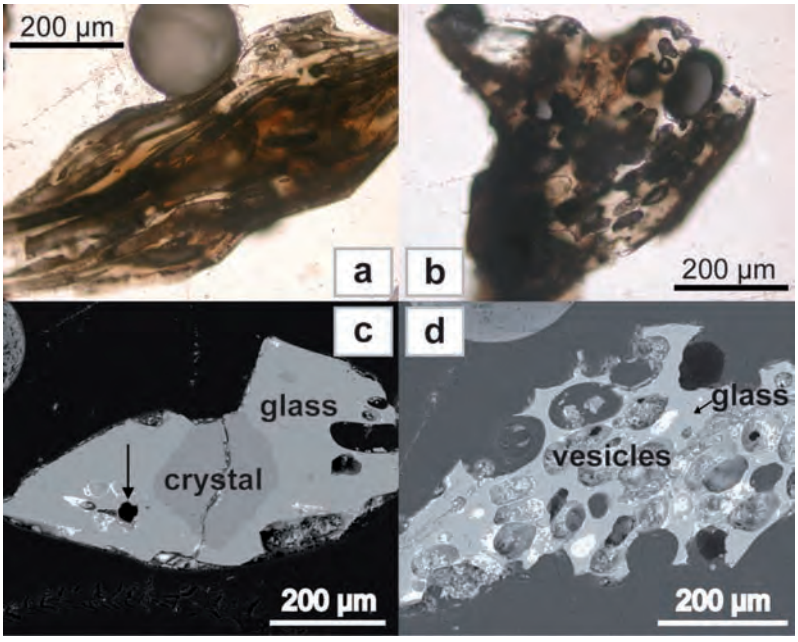
Understanding magma evolution processes and ascent dynamics is important to improve monitoring and hazard assessment strategies at active volcanoes. Particular attention must be paid to the processes controlling the physico-chemical evolution of magmas rising through volcanic conduits as they especially affect the eruptions style and intensity.

A typical case study is the Stromboli volcano (Aeolian Islands, Italy). During its recent persistent activity it has erupted two different types of magma with distinct physico-chemical features: i) a dense scoriaceous, degassed, crystal-rich magma (typical of mild explosive activity); ii) a hotter pumiceous, volatile-rich, crystal-poor magma (typical of more energetic paroxysms).

Textural and micro-chemical investigations with the most innovative analytical techniques for in situ trace element and isotope (δ^7Li) determinations were carried out on scoriaceous- and pumiceous-like glassy ashes erupted before and after the paroxysm of April 5th 2003. This allowed to unravel the origin, dynamics and relationships between these two magmas associated with dramatically different eruptive styles.

The study indicates a common origin for the two types of magma: the volatile-rich pumiceous magma evolves after ponding in the upper conduit by continuous degassing-induced crystallization towards a volatile-poor, scoriaceous melt. It was highlighted the potentiality of lithium isotopes as tracers of degassing processes within the shallow plumbing system. The study reveals the presence of pumiceous-like ashes in pre-paroxysm samples, which indicates the early ascent of small volumes of undegassed deep-seated magma blobs that behaved as a herald of a larger volume of pumiceous magma that ascended fast on April 5th triggering the paroxysm.

F. Schiavi, K. Kobayashi, T. Moriguti, E. Nakamura, M. Pompilio, M. Tiepolo, R. Vannucci, "Degassing, crystallization and eruption dynamics at Stromboli: trace element and lithium isotopic evidence from 2003 ashes", Contributions to *Mineralogy and Petrology*, 159 (2010), pp. 541-561.



1-Optical microscope and BSE images of scoriaceous(a–c) and pumiceous(b–d) glassy ashes. Arrow indicates a crater of trace element analyses by LA-ICPMS

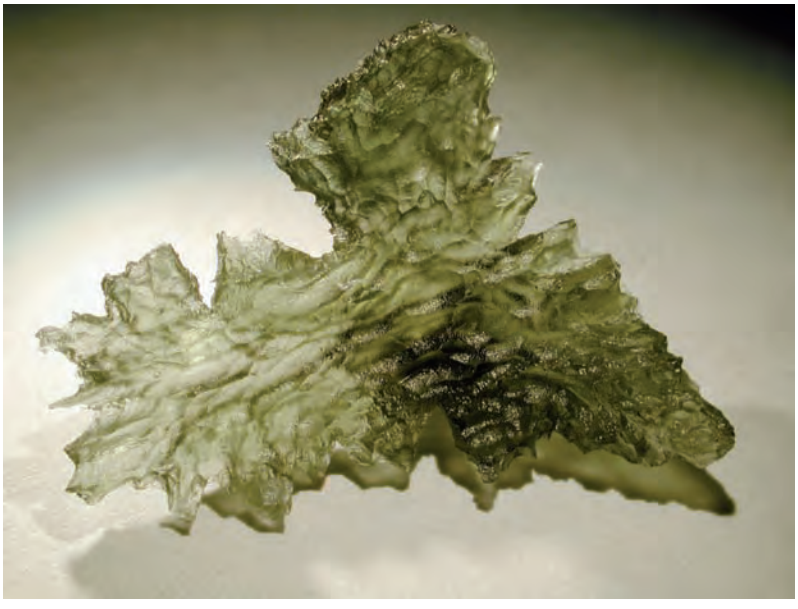
2-Simplified model for Stromboli 2003 activity showing the relationships between the scoriaceous (dark grey) and the pumiceous (light grey) magmas.

GEOCHEMISTRY

A 15 million year old impact crater

Hypervelocity impacts of asteroids and comets with Earth have become an accepted geological process that played an important role in the early evolution of the Earth and the solar system in general. These catastrophic events may induce sudden major environmental and climate changes, causing mass extinctions on Earth, such as that occurred about 65 million years ago that led to the extinction of dinosaurs. Accurate dating of hypervelocity impacts of extraterrestrial bodies with Earth is therefore important because it can be used to constrain the impact flux on Earth and to establish a causative link between impact events and sudden mass extinctions of life. There are as much as 174 known impact structures on Earth, most of which produced catastrophic climate changes, but only for a small number ages are known with a high level of confidence.
Tektites are impact glasses which can be found up to a few hundred kilometres from the source crater and whose radioisotopic dating, through the ^{40}Ar-^{39}Ar method (based on the natural decay of parent ^{40}K to the daughter ^{40}Ar over geological time and analysis through mass spectrometry after irradiation of the sample in a nuclear reactor), allows to establish the time of an impact. Central European tektites, i.e., moldavites, are thought to be genetically related to the meteorite impact event that produced, about 15 million years ago, the 24-km diameter Ries crater in Germany. Moldavites can be up to a few centimetres in size and are known from several localities of the Czech Republic, Germany and Austria. This work through the setting up for the first time in Italy of a new calibration procedure of the ^{40}Ar-^{39}Ar method and more that 200 radioisotopic analyses of sub-millimetre moldavite fragments from different localities, has allowed to estimate that the Ries impact formed 14.68±0.11 million years ago, with a relative precision <1%.

G. Di Vincenzo, R. Skála, "Ar^{40}-Ar^{39}-Ar Laser Dating of Tektites from the Cheb Basin (Czech Republic): Evidence for Coevality with Moldavites and Influence of the Dating Standard on the Age of the Ries Impact", *Geochimica et Cosmochimica Acta*, vol. 73 (2009), pp. 493-513.



Moldavites from Czech Republic.

REMOTE SENSING

Soil moisture (SM) variations monitoring by AMSU-based soil wetness indices

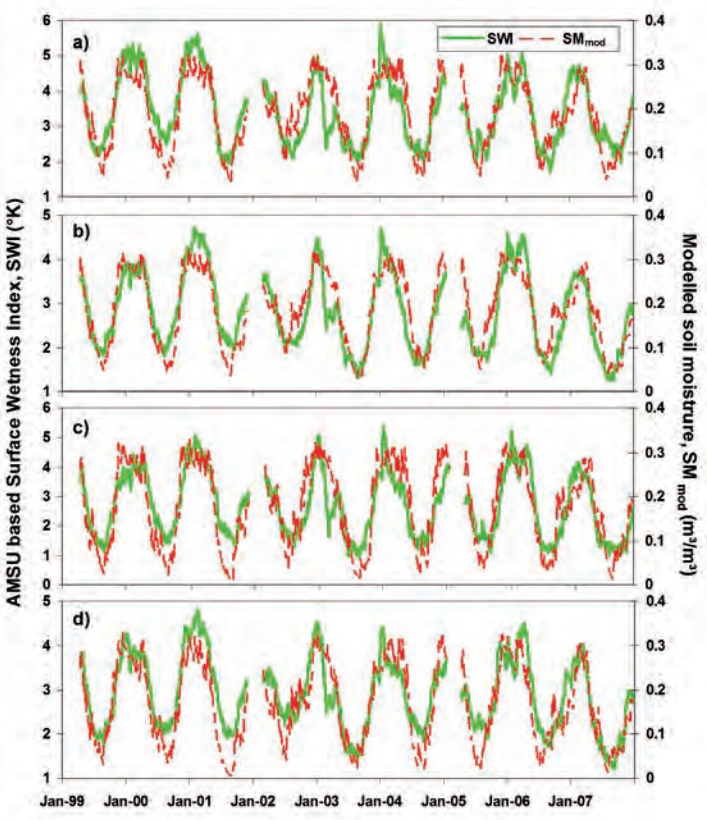
The amount of water held in the soil (SM) is a fundamental variable in several applications including flood forecasting, numerical weather predictions, agricultural drought assessment, water resources management, etc. In the last thirty years, the possibility of using satellite observations for SM monitoring has been widely investigated, with particular attention to active and passive microwave sensors. The topic is of great interest, as demonstrated by the launch in November 2009 of SMOS (Soil Moisture and Ocean Salinity), the first ESA (European Space Agency) mission specifically dedicated to SM measurement and monitoring on a global scale. In such a context, the potential for the assessment of soil wetness variations of the Advanced Microwave Sounding Unit (AMSU), radiometer on board the NOAA satellites since 1998, has been investigated. In particular, AMSU SM products have been compared to in situ measurements as well as to outputs of a continuous rainfall-runoff model applied to four catchments located in the Upper Tiber River. In order to characterize signal behavior corresponding to unperturbed soil condition, a dense data set of AMSU imagery collected over a nine years period has been used. On this basis a robust indicator of soil wetness variations (SWVI) has been introduced and compared with the SWI (Surface Wetness Index) – both computed on the basis of AMSU radiances – that were found to be highly correlated both with the in-situ and modeled SM. Overall, the root mean square error was found to be less than 0.05 m^3/m^3 for both the comparisons, thus assessing the potential of the AMSU sensor to quantitatively retrieve frequently updated SM estimates, thanks even to its high revisiting time.

T. Lacava, L. Brocca, G. Calice, F. Melone, T. Moramarco, N. Pergola, V. Tramutoli, "Soil moisture variations monitoring by AMSU-based soil wetness indices: a long-term inter-comparison with ground measurements", *Remote Sensing of Environment*, 114(10), (2010), pp. 2317-2325.

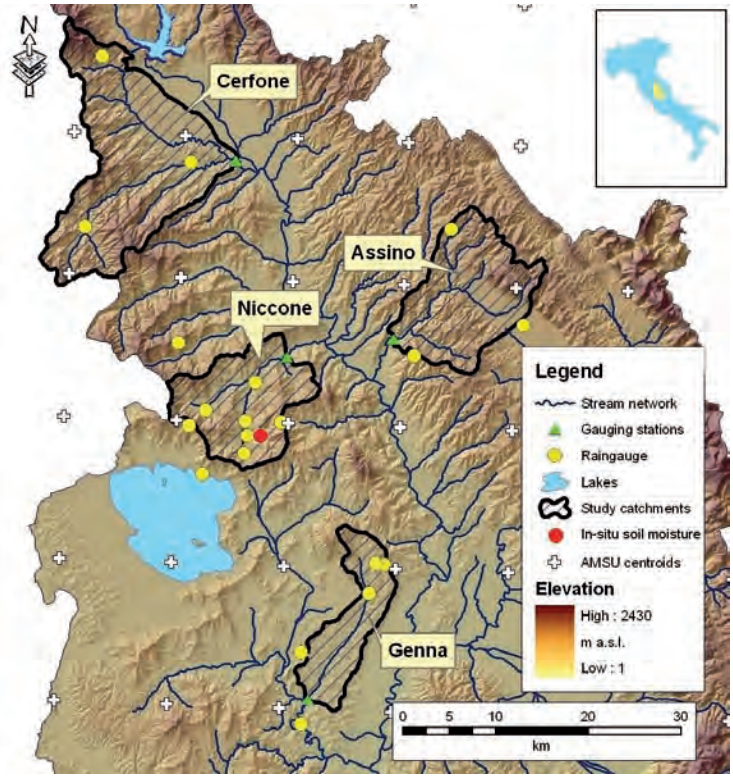
ECOLOGY

Composting beached Posidonia

Following years of research on the re-use of the waste of *Posidonia oceanica* which pours onto the beaches in Puglia, the Institute of Sciences of Food Production of the CNR in Bari (Ispa-Cnr) has launched a project for the composting of the biomass of these plants and their use as fertilizer, soil conditioner or substrate for cultivation without soil. Achieve in collaboration with the city of Mola di Bari and several private companies from Puglia, *Prime* (Posidonia residues integrated management for ecosustainability) is one of the 56 Italian projects that receives funds from the European foundation of the program Life+. Posidonia is not an algae but an aquatic plant with important functions: the oxygenation of water, determination of fishing grounds, protection of the beach from erosion, shelter, food, and breeding zones for marine fauna. Periodically, however, it produces beach waste, above all on the coasts of Puglia, Sardinia, Tuscany, and Lazio. From this waste arrives the necessity for a system of re-use because the disposal in landfills results in the production of leachate, groundwater pollution, and greenhouse gases.



Temporal pattern of modeled soil moisture, SMmod, and filtered AMSU based SWI for: a) Assino, b) Niccone, c) Cerfone, and d) Genna catchment.



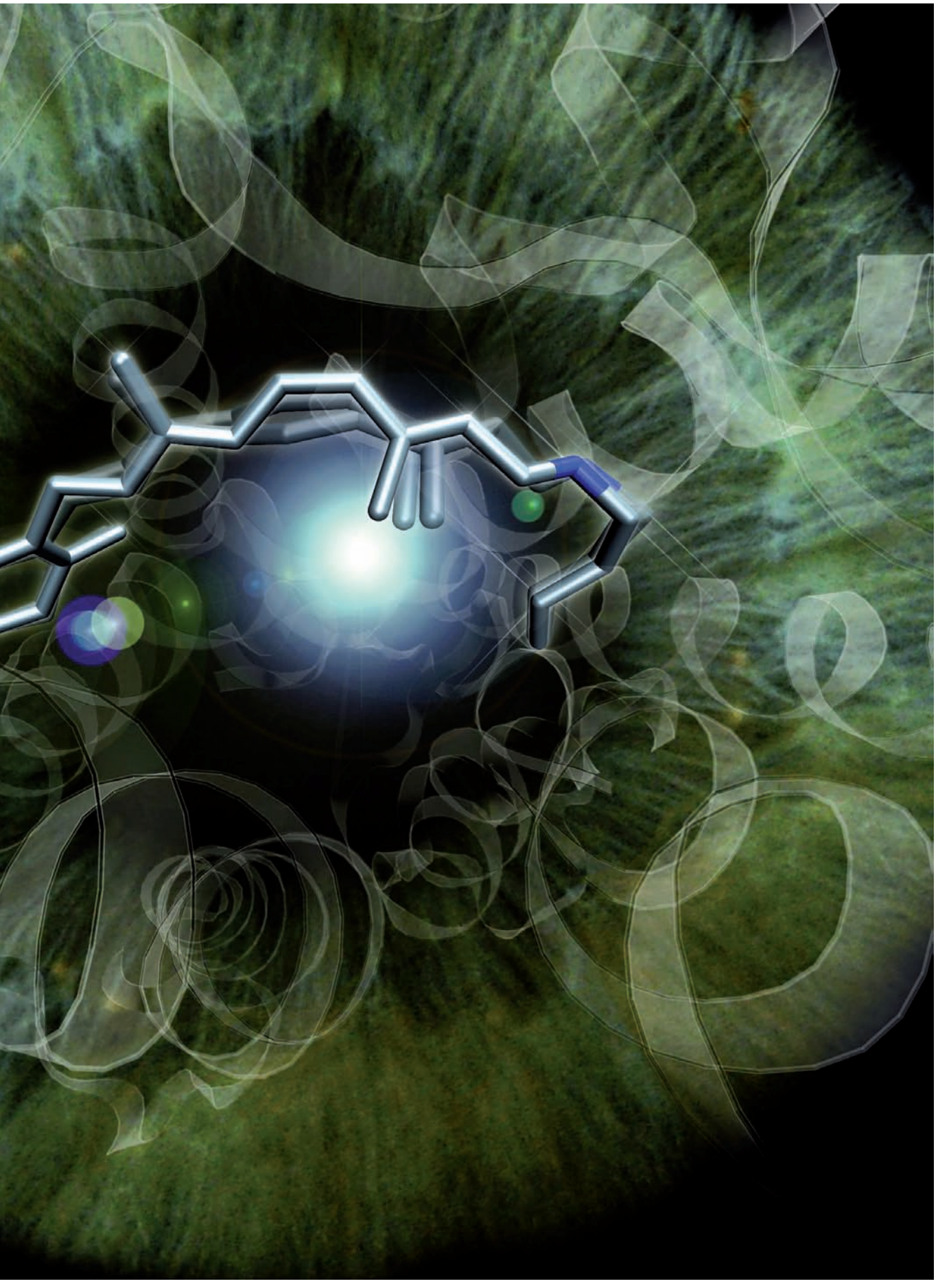
Morphology and hydro-meteorological network of the study area (Upper Tiber basin); in-situ soil moisture sensors and AMSU pixel centroids locations.

Energy & Matter

Highlights

Biology – Biophysics, Biochemistry, Green technologies, Photovoltaics, Energy, Nuclear Fusion, Materials, New Materials, Biomaterials, Colloids, Molecular physics, Microscopy, Spectroscopy, Catalysts, Electrocatalysts, Biosensors, Sensors, Nanosciences, Nanotechnologies, Nanomedicine, Nanoelectronics, Superconductivity, Superconductors, Piezoelectricity, Magnetic fields, Magnetism, Space science, Optical imaging, Optics, Optofluidics, Hydrodynamics, Quantum gases, Quantum information, Quantum systems, Computational chemistry, Computational Physics, Statistical Physics, Measurement, Cultural Heritage, Art Conservation

Ultrafast isomerization of rhodopsin as the first event of vision.

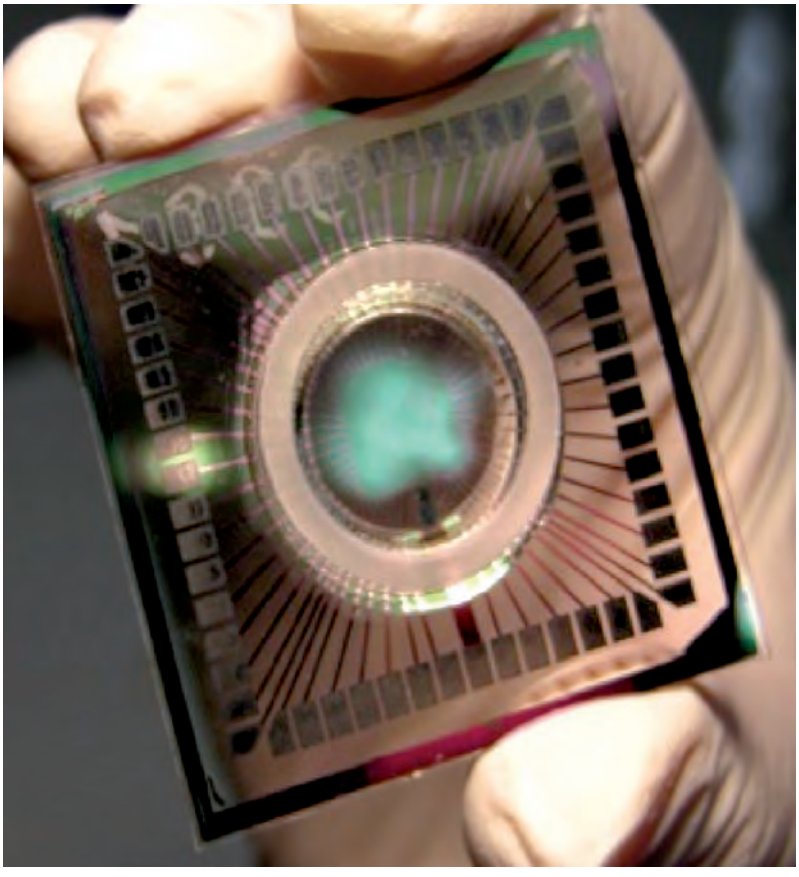


BIOPHYSICS

A deeper insight on the plants

It will be possible now to look with a different perspective on the world of plants, until now seen as less intelligent than animals. The cells located in the root apexes of the plants communicate with each other through electrical signals and have characteristics similar to those observed in neuronal cells of animals. This evidence is the result of research held in the National Institute of Optics at the CNR, by Dr. Marzena Ciszak and Prof. F. Tito Arecchi in collaboration with the Ortoflorifrutticoltura Department at the University of Florence.
The data were obtained using, for the first time on plants, a typical technique of neurobiology, the MEA (multi electrode arrays) device that is applied to roots to measure electrical signals from small groups of individual cells. Plant cells, apart from the generation of electrical impulses, exhibit also another property, the synchronization phenomena, i.e. the ability to emit signals in unison, leading to a collective processing of information coming from the outside world. These studies are the result of an interdisciplinary work, which collects physicists and agronomists, and apply the dynamical systems theory to the plant biology. The combination of different areas of science has led to a deeper vision of plants, revealing aspects not explored before and that require further investigation. It is expected that the application of physics to plant biology will provide mathematical models to characterize the operation of plants on cellular level, but also will lead to useful models for the development of Agriculture.

E. Masi, M. Ciszak, G. Stefano, L. Renna, E. Azzarello, C. Pandolfi, S. Mugnai, F. Baluska, F.T. Arecchi, S. Mancuso, "Spatiotemporal dynamics of the electrical network activity in the root apex", *Pnas* mar, (2009).



60-electrode array (MEA).

BIOCHEMISTRY

The first real-time movie of the chemical reaction that allows vision

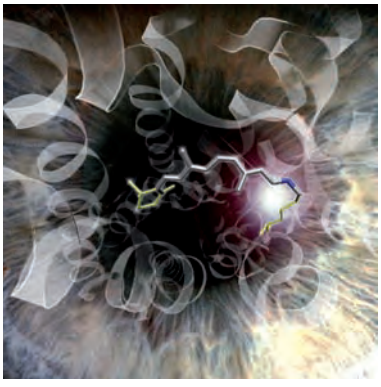
Vision is based on one of the fastest photo-chemical processes ever known in nature. In fact, from the moment a photon hits the retina of the eye (or rather one of its molecules called rhodopsin), the first reaction is concluded in much less than a millionth of a millionth of a second. Such process is so quick that it defied experimental observation until now. Scientists from the CNR and Politecnico di Milano, in collaboration with University of Bologna, University of Berkeley (USA), University of Oxford (UK) and Max Planck Institute in Mülheim (Germany), have finally succeeded in the enterprise of "photographing" the very first events of the chemical process responsible for human vision.

Using a special camera that picks up the individual frames using ultrafast laser flashes of light (lasting a few billionths of a millionth of a second), it was possible to record a movie of this process in real time. The combination of this information with theoretical simulations, carried out using advanced and efficient computers with complex algorithms, enabled reconstructing the fast conformational change of the molecule responsible for human vision.

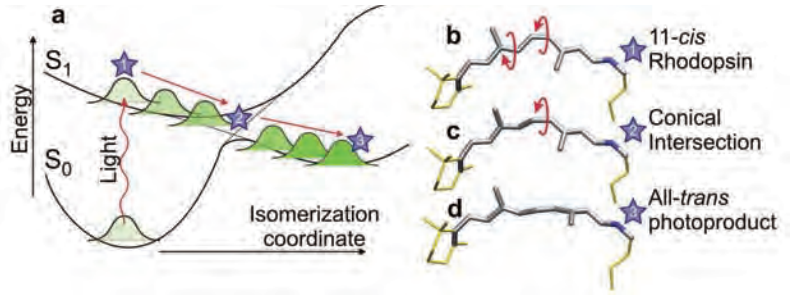
The experiment provided the most convincing evidence so far for the existence of a phenomenon known as conical intersections, which can be seen as 'chemical black holes': singularities that connect different electronic states of the matter. These are points which capture molecules, dramatically accelerating the chemical reaction and making it extremely efficient. Until now, these features were predicted only theoretically, resisting any attempt to their direct observation. In this research conical intersections have been observed experimentally for the first time, demonstrating the validity of theoretical predictions.

This ultrafast process constitutes the first step of the complex biochemical mechanism that leads to the propagation of an electrical stimulus to the brain, which ultimately allows human vision. Natural evolution has engineered this mechanism in order to make it so efficient -many animals, including humans, can detect even the faintest light in the darkness- because it constitutes a key factor for the survival of the species. This extraordinary sensitivity of the eye has been made possible thanks to the extreme rapidity of the photo-chemical reaction, which has been recorded here for the first time.

D. Polli, P. Altoè, O. Weingart, K.M. Spillane, C. Manzoni, D. Brida, G. Tomasello, G. Orlandi, P. Kukura, R.A. Mathies, M. Garavelli, G. Cerullo, "Conical intersection dynamics of the primary photoisomerization event in vision", *Nature*, 467 (2010), pp. 440-443.



Ultrafast isomerization of rhodopsin as the first event of vision.



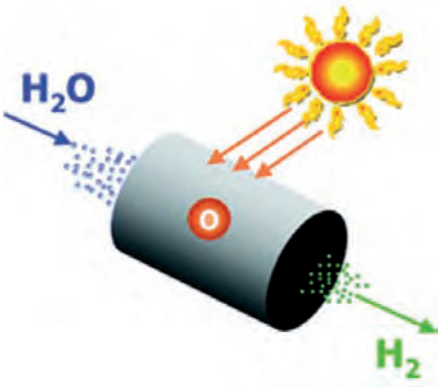
(a) Sketch of the potential energy surfaces of rhodopsin as a function of the isomerization coordinate. Averaged structures of the chromophore at the initial (b), the conical intersection (c) and final (d) configurations.

GREEN TECHNOLOGIES

Solar hydrogen: fuel of the near future

Renewable hydrogen produced using solar energy to split water is the energy fuel of the future. Accelerated innovation in both major domains of solar energy (photovoltaics and concentrated solar power) has resulted in the rapid fall of the solar electricity price, opening the route to a number of practical applications using solar H_2. New thermochemical water splitting using concentrated solar power (CSP) coupled to nanocatalysis has the potential to convert and store solar energy into clean hydrogen using a tiny fraction of the world's desert area to meet our present and future global energy needs. Photovoltaics, in turn, has the versatility required for supporting the creation of a distributed energy generation infrastructure in wealthy as well as in developing countries especially now that the price of PV solar electricity has fallen to unprecedented low levels. In all these cases, solar H_2 will be used to store energy and release it on demand either for fuel cells (to power homes and boats) or internal combustion engines and turbines (for powering cars, trucks and in thermoelectric power units). Referring to several examples as well as to new technologies, this article provides insight into a crucial technology for our common future.

M. Pagliaro, A.G. Konstandopoulos, R. Ciriminna, G. Palmisano, "Solar hydrogen: fuel of the near future", *Energy & Environmental Science*, 3 (2010) pp. 279-287.



Water splitting with hydrogen generation occurs as steam crosses cheap nanocatalyst activated by solar power.

PHOTOVOLTAICS

Nanostructured materials for solar energy conversion

The photovoltaic technologies – born in order to find an alternative solution to the growing energy demand – do not allow to fully exploit the solar energy: the response of the commonly used cells, silicon-based, does not completely fit the spectral distribution of the solar energy. Only a technology able to convert the solar spectral distribution without energy loss would be able to give a full exploitation of the solar energy.

The Institute for the Study of the Macromolecules (ISMAC) of CNR has developed nanostructured materials that can cover large areas with low cost technology and are able to convert energy without dissipation. Those materials self-assemble in highly ordered structures at the nanometric scale, where highly emissive molecules with large extinction coefficient are inserted into parallel nanochannels of organic crystals (perhydrotriphenylene and deoxycholic acid). The intermolecular distances (1-2 nm) and relative orientation (collinear) of the emissive molecules are optimal for resonant energy transfer processes from one molecule to the other, that take place without any energy loss. By properly choosing the molecules, it is possible to shift the energy in any region of interest by avalanche processes.
Another advantage of these materials is their low cost, due to the easy fabrication, that makes them very interesting for small and medium industries that can not afford large financial investments but are at the base of the Italian industrial environment.

J. Moreau, U. Giovanella, J.P. Bombenger, W. Porzio, V. Vohra, L. Spadacini, G. Di Silvestro, L. Barba, G. Arrighetti, S. Destri, M. Pasini, M. Saba, F. Quochi, A. Mura, G. Bongiovanni, M. Fiorini, M. Uslenghi e C. Botta, "Highly emissive nanostructured thin films of organic host-guests for energy conversion", *ChemPhysChem*, (2009), 10, 647-653.

PHOTOVOLTAICS

Nanocrystalline silicon matrix for low-cost photovoltaics

Quantum confinement (QC) can occur in semiconductors when charge carriers (electrons or holes) are restricted within regions as small as few nanometers. QC effectively increases the electronic gap of the semiconductor as the size of the confining regions is reduced.

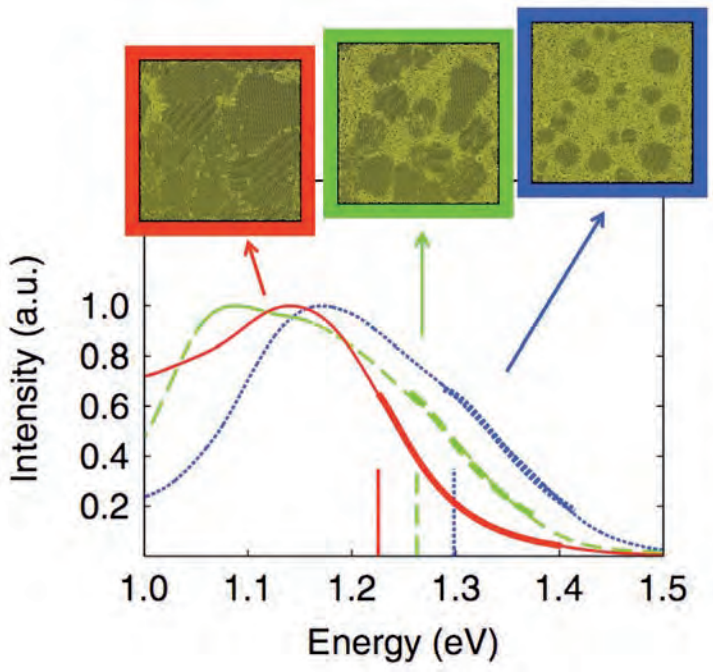
This phenomenon has large technological impact since it controls the optoelectronic properties of the pristine material (e.g. luminescence, absorption coefficient) by changing the morphology and size of the nanoparticles. QC of both electrons and holes can be achieved in crystalline nanoparticles embedded into dielectric matrices or in vacuo.

In this work we report a new type of confinement occurring only for positively charged carriers. Such a phenomenon is observed and demonstrated in a mixture of Silicon nanocrystals (nc-Si) embedded into a disordered hydrogenated silicon matrix.

To this aim we calculated the electronic properties of large atomistic models of nc-Si silicon within the tight-binding approximation, demonstrating that holes are confined within the grains while electrons are rather delocalized within the embedding matrix. We validated the theoretical results by photo- luminescence experiments on samples grown by plasma-enhanced chemical vapor deposition.

According to this study nc-Si could represent an environmentally clean and low-cost material with strong impact in photovoltaics. For example, by varying the size of the nanoparticles within the material, it is possible to improve selectively the absorption of photons of different colors and to manufacture silicon-based solar cells with novel architecture and improved efficiency (e.g. third generation tandem solar cells).

L. Bagolini, A. Mattoni, G. Fugallo, L. Colombo, E. Poliani, S. Sanguinetti, E. Grilli, "Quantum confinement by an order-disorder boundary in nanocrystalline silicon", *Phys. Rev. Lett.* 104 (17), 176803 (2010)



The photoluminescence spectra of three different nanocrystalline silicon samples (top panels) depend on the average grains size (dark yellow regions). Red, green and blue colors correspond to samples with decreasing average grain size and increasing confinement effects. Superimposed thick bands and vertical lines are the theoretical predictions.

ENERGY

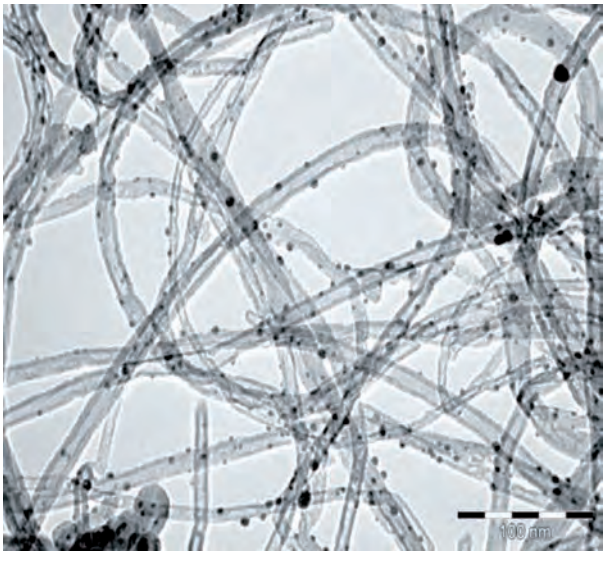
Clean energy from vegetable biomasses

The selective production of chemicals from renewables with contemporaneous release of energy is perhaps the most desired target of sustainable chemistry. Researchers at ICCOM-CNR have discovered that such a target can be accomplished for a variety of renewable alcohols and carbohydrates, including ethanol, glycerol, ethylene glycol and sugars, by means of two electrochemical devices: *direct fuel cells* and *electrolyzers*. In either case, an aqueous solution of the fuel in the anode compartment is oxidized on a nanostructured electrocatalyst that is appropriately designed to promote selectively the partial oxidation of the anolyte with high stability and fast kinetics.

When the oxidation process is carried out in a direct alcohol fuel cell (DAFC), the solid electrolyte is an anion-exchange membrane and electrical energy is released, while the alcohol is selectively converted into the corresponding carboxylic acid, isolated as alkali metal carboxylate. In an electrolyzer, containing an anode electrocatalyst similar to that employable in a DAFC, the electrolyte may be either an anion exchange-membrane or a solution of an alkali metal hydroxide (NaOH or KOH, for example) and the alcohol is converted into the corresponding alkali metal carboxylate, while hydrogen gas is produced at the cathode upon water reduction. The DAFCs developed at ICCOM-CNR are able to provide power densities up to 60 mW cm^{-2} at room temperature and up to 200 mW cm^{-2} at 80°C, yielding proportional amounts of carboxylates. As for the electrolyzers developed at ICCOM-CNR, the production of 1 Kg of hydrogen from aqueous ethanol occurs with one third of the energy required by a traditional electrolyzer by virtue of the much lower oxidation potential of ethanol to acetate vs. water to oxygen (E° 0.10 V vs. 1.23 V) and the relatively low anodic polarizations. Moreover, up to 25 Kg of potassium acetate are contemporaneously produced, if the promoting hydroxide is KOH. This new technology may pave the way to the massive production of electrolytic hydrogen also in those countries where nuclear energy is not available to carry out traditional water electrolysis or where the use of fossil fuels imposes too severe environmental and economical constraints.

V. Bambagioni, C. Bianchini, J. Filippi, W. Oberhauser, A. Marchionni, F. Vizza, J. Teddy, P. Serp, M. Zhiani, "Pd and Pt-Ru anode electrocatalysts supported on multi-walled carbon nanotubes and their use in passive and active direct alcohol fuel cells with an anion-exchange membrane (alcohol = methanol, ethanol, glycerol)", *J. Power Sources*, (2009), 190, 241.

Top: Flashlight and mobile-phone battery charger realized with fuel cells fed with water solutions of either glycerol or ethanol and equipped with the electrocatalysts described in the article.



Left: TEM (Transmission Electron Microscopy) image of the nanostructured catalyst Pd/MWCNT. The average dimensions of the palladium nanoparticles are around 2 nm.

ENERGY

Titanium dioxide-based photocatalysts for solar energy conversion into hydrogen

The photocatalytic production of hydrogen by water splitting induced by solar radiation represents one of the most important current scientific tasks, because of its potential to transform and store solar energy under a clean and totally renewable energy form. This photosynthesis-mimicking process, however, proceeds with low yield, because the presently available photocatalytic materials are able to absorb only a minor fraction of the solar light and transform it into chemical energy (*i.e.*, into hydrogen).

In collaboration with the *Institute of molecular science and technologies (ISTM)*, a series of titanium dioxide-based photocatalysts, produced either by the innovative flame spray pyrolysis technique, allowing for the single step synthesis of oxides and mixed oxides powders, also containing metal, e.g. gold, nanoparticles, or by more traditional techniques, such as the deposition of noble metal nanoparticles from micellar systems or photodeposition, were prepared and structurally characterized. Such photocatalytic materials were tested either in water photosplitting, or in the low temperature photoreforming reaction of alcohols, employed as 'sacrificial reagents' in hydrogen production from water solutions, in an expressly set up recirculation system allowing for the on-line analysis of the gas phase composition. The photocatalysts were employed either dispersed in stirred aqueous suspensions, and a stirring rate-dependent hydrogen evolution rate was observed, or adsorbed on quartz grains in contact with vapor phase reactants, with a re-usable photocatalytic set up leading to a higher hydrogen yield. Both the presence of metal nanoparticles on the oxide surface, facilitating photoproduced charges' separation, and the presence of alcohols contribute in increasing the rate of photocatalytic hydrogen production, up to solar energy conversion values appearing very promising for the scale up of the process.

G.L. Chiarello, E. Selli, L. Forni, "Photocatalytic hydrogen production over flame spray pyrolysis-synthesised TiO_2 and Au/TiO_2", *Applied Catalysis B: Environmental*, 84 (2008) pp. 332-339;
G.L. Chiarello, L. Forni, E. Selli, "Photocatalytic hydrogen production by liquid - and gas - phase reforming of CH_3OH over flame-made TiO_2 and Au/TiO_2", *Catalysis Today*, 144 (2009), pp. 69-74.

ENERGY

Inside the nature of ultrafine particles in atmosphere: is it possible to reduce their emission?

Ultrafine particulate in urban polluted areas consists mainly of ultrafine carbonaceous particles produced from combustion sources such as engine or domestic boiler. The abatement of ultrafine carbonaceous particles is of special interest due to their high health impact strictly related to their nanometric size.
A study performed by IRC-CNR has been focused on the development of advanced analytical techniques for a broad description of the fuel effects on the carbonaceous particles characteristics. The pollutants emitted from a controlled combustion system have been deeply studied. Fuels as methane, ethylene, cyclohexane and benzene, representative of commercial fuels components, have been used. A detailed description of the length and organization of the particles carbonaceous structures has been obtained by high resolution transmission electron microscopy (TEM). The results show that the particles nanostructure is strictly related to the aromatic content of the fuel, particularly benzene, and to the combustion conditions. The ultrafine particles produced from benzene combustion are smaller with respect to the particles produced from aliphatic fuels and, for this reason, cause an enhanced health effect. Up to now the complex chemical mechanism devoted to the formation of ultrafine particulate and the relationships between chemical properties (including radiation absorption, relevant for green house effect) and nanostructure are not perfectly well understood. To fill this gap means to have a chance to reduce their emission.

M. Alfe, B. Apicella, R. Barbella, J.N. Rouzaud, A. Tregrossi, A. Ciajolo, "Structure-property relationship in nanostructures of young and mature soot in premixed flames", *Proceedings of the Combustion Institute*, 32 (2009) 697-704.

ENERGY

Materials chemistry for clean energy applications

Major worldwide challenge is the development of cleaner, sustainable sources of energy to deal with the environmental threat of global warming and the finite nature of fossil fuel reserves. There is, however, no single solution. Promising energy conversion and storage technologies, including fuel cells and lithium batteries, are being developed to help cutting carbon dioxide emissions. The performance of these energy systems depends crucially on the properties of their component materials, thus requiring the development of innovative materials chemistry. One leading technology for future power generation is the solid oxide fuel cell (SOFC). An SOFC is an electrochemical device which converts chemical energy into electricity and, in the simplest case, is based on the chemical reaction between hydrogen (at the anode) and oxygen (at the cathode) to produce water. The two electrode compartments are separated by the electrolyte, which serves as a barrier to gas diffusion but allows ion transport of either oxide ions or protons. Schematics of a SOFC utilizing oxide-ion conducting electrolytes is shown in Fig. 1. The role of materials science is fundamental for discovering and developing electrolyte materials that support high ion conductivities (and negligible electronic conductivities) at lower temperatures, together with good chemical stability and sinterability for fabrication. Such breakthroughs underpin applied research, and depend simultaneously upon exploring new classes of compounds. In this work we highlighted the most relevant and recent discoveries in the field of materials chemistry applied to the development of SOFC electrolytes giving particular emphasis to the structural and mechanistic features of the ion transport.

L. Malavasi, C. Fisher, S.M. Islam, "Recent developments in oxide-ion and proton conducting materials for clean energy applications: structural and mechanistic features", *Chem. Soc. Rev.* (2010) 39, 4370.

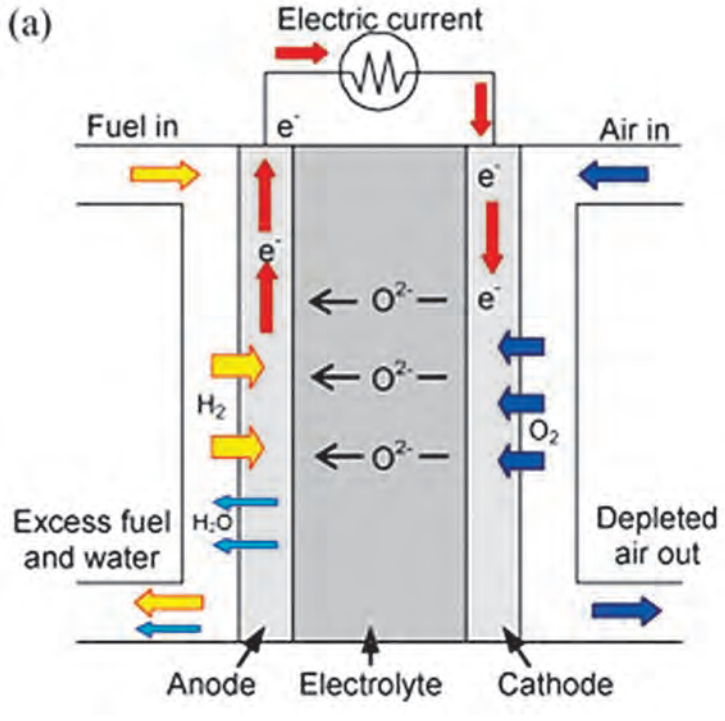


Figure 1. Schematic diagram of the processes taking place in a solid oxide fuel cell (SOFC) during operation using an oxide-ion conducting electrolyte. A key advantage of SOFCs is that they also allow hydrocarbons to be used as a fuel source.

NUCLEAR FUSION

A step forward in understanding plasma turbulence

In controlled thermonuclear fusion reactors, a key problem in order to achieve ignition is the optimization of thermal energy confinement, in particular of the ion main species. To reach the high ion temperatures required for fusion power production in the plasma core, it is mandatory to reduce the transport processes that carry thermal energy from core to edge. The main transport mechanism in a tokamak – the most widespread magnetic confinement configuration, also adopted for the international project Iter – is turbulence. Instabilities are excited by the presence of an ion temperature gradient and limit the attainment of high gradients, thereby anchoring the temperature profile to a critical gradient value. As a consequence, the only way to achieve high central temperatures would be to have high edge temperatures, which creates serious problems of interactions with first wall materials.
Theory predicts that an efficient tool to stabilize ion turbulence is to create in the plasma a rotational shear, which would induce an increase in the critical gradient. Experiments – presently the only ones in the world – conducted under the coordination of the Institute of Plasma Physics of CNR - Milano on JET (the tokamak operated by EFDA in UK which is the nearest to ITER in size and parameters) have shown rather surprisingly that rotation does not only increase the critical gradient, but lowers strongly the turbulence growth rate in the plasma core. This allows reaching ion temperature gradients up to 3 times above the critical ones.
These results suggest that a sizeable rotational shear should be induced also in Iter, in order to reach steady-state regimes with high core ion confinement and low edge temperatures.

P. Mantica et al., "Experimental Study of the Ion Critical-Gradient Length and Stiffness Level and the Impact of Rotation in the JET Tokamak", *Physical Review Letters*, 102, 175002 (2009).

NUCLEAR FUSION

A scaled tokamak to study plasma instability

In the future the energy supply will focus on different alternatives, including controlled thermonuclear fusion, which aims to get energy from the fusion of nuclei of deuterium and tritium, isotopes of hydrogen in the plasma state. Soon ITER (International Thermonuclear Experimental Reactor) machine, built to demonstrate the feasibility of a reactor based on magnetic confinement of plasma in a toroidal structure called tokamak, will start to operate. For the success of ITER, scaled experiments are necessary, in order to prepare operation regimes in smaller and more flexible tokamaks.
The Italian Association EURATOM ENEA, of which CNR is part, has proposed to build the Tokamak FAST (Fusion Advanced Studies Torus) to provide a machine capable to reproduce high energy confinement ITER scenarios, with similar conditions of plasma-wall interaction, and to study confinement of fast ions in situations close to the break-even point from which the reaction is self-maintaining.
The IFP-CNR research on simulations of the main plasma scenarios shows the importance of the FAST project for ITER. Electromagnetic waves at a frequency of 170 GHz are foreseen among the FAST heating systems. This power, injected into the plasma, is able to produce an increase in electron temperature. These waves are also used for the control and suppression of magnetohydrodynamic (MHD) instabilities, one of the possible causes of the loss of energy confinement in tokamaks. For this work the study of stabilization of MHD modes was carried out with theoretical models developed in IFP.

G. Calabrò, F. Crisanti, G. Ramogida, R. Albanese, A. Cardinali, A. Cucchiaro, G. Granucci, G. Maddaluno, M. Marinucci, S. Nowak, A. Pizzuto, V. Pericoli Ridolfini, A. Pironti, A.A. Tuccillo e F. Zonca, "FAST Plasma Scenarios and Equilibrium Configurations", *Nucl. Fusion*, 49 (2009), 055002 Iop Publishing (UK).

LASER FUSION

Ultraintense lasers to unlock the secrets of giant planets

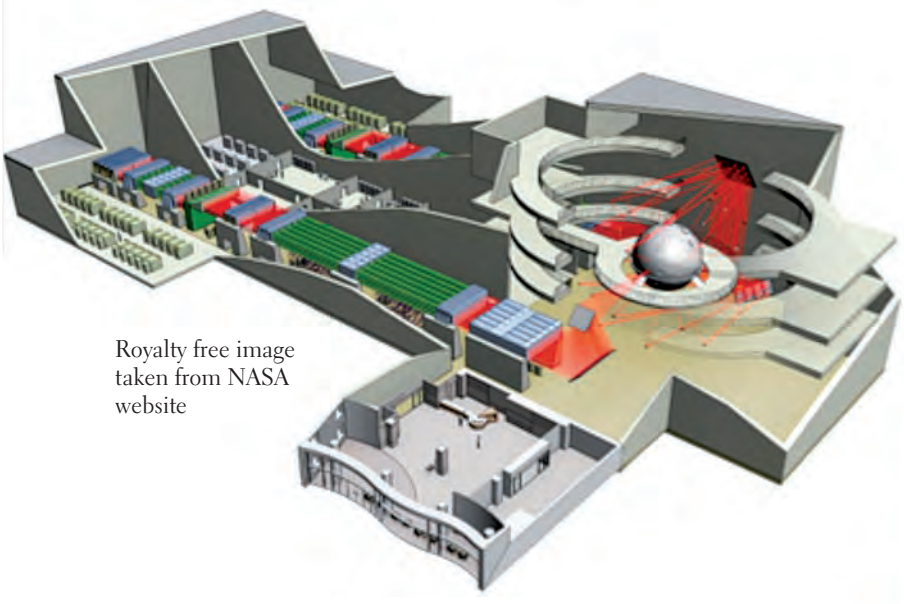
Interaction of ultraintense laser light with matter is currently under intense investigations, both in the laboratory and via theory and numerical modeling, due to the potential for a wide range of practical applications and the possibility of exploring astrophysical processes in the laboratory. Among the key applications, laser fusion and novel radiation and particle sources are developing at an impressive pace. In fact, two large laser infrastructures named HiPER [http://www.hiper-laser.org] and ELI [http://www.extreme-light-infrastructure.eu] have been proposed in Europe to advance in these areas.

In high intensity laser-matter interactions, a significant fraction of energy carried by the laser pulse is transferred to extremely intense fluxes of energetic (fast) electrons that activate huge magnetic fields and give rise to bright X-ray emissions. The description of how such uniquely large currents propagate in matter is poorly understood and new measurements are needed.

A new X-ray measurement technique developed and established at the Intense Laser Irradiation Laboratory at INO-CNR (Pisa) was used to identify the role of different X-ray emission mechanisms. The contribution of the directional (bremsstrahlung) emission could therefore be separated from the non-directional (fluorescence) emission, typical of this class of experiments.

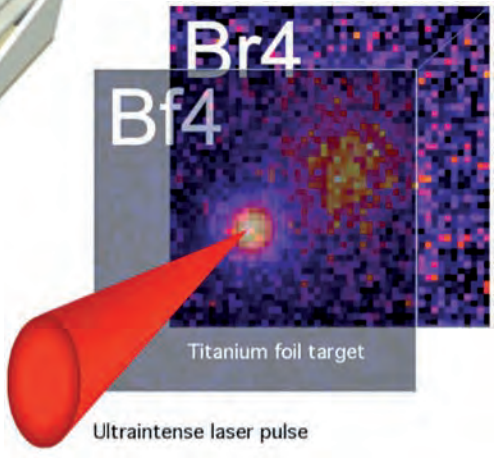
These new results open the possibility of implementing new investigation techniques and conceiving new radiation sources for material sciences and bio-medical applications.

The experiment was carried out by researchers of INO-CNR (Pisa), in collaboration with the Institute of Optics and Quantum Electronics of the Friedrich-Schiller-Universität di Jena in the framework of the LASERLAB access scheme to EU laser facilities.



Royalty free image taken from NASA website

F. Zamponi, A. Lübcke, T. Kämpfer, I. Uschmann, E. Förster, A.P.L. Robinson, A. Giulietti, P. Köster,L. Labate, T. Levato, and L.A. Gizzi, "Directional Bremsstrahlung from a Ti laser-produced X-ray source at relativistic intensities in the 3-12 keV range", *Physical Review Letters* 105, 085001 (2010).



Warm dense matter conditions in the core of Jupiter can be reproduced in the laboratory using ultraintense laser interaction with solids. False color view of the X-ray emission from laser-irradiated titanium foil target.

MATERIALS

New connections between nanotech and molecular sciences

Technologies based on catalytic chemical processes are nowadays of the utmost importance: it is estimated that almost 60% of the total amount of the commercial chemicals requires catalysts to be produced at some step of their synthesis. As a consequence, understanding the molecular mechanism of such processes is fundamental in order to improve the present technologies, thus opening a new scenario. The CNR Institute of Science and Molecular Technologies of the University of Milan has put an insight in the comprehension of the oxygen activation mechanism by heterogeneous catalysis: it has been observed the activity decay of a catalyst made up of gold nanoparticles while progressively adding proper probe molecules (selective poisoning), thus understanding the molecular mechanism of the process which sees the main actors - oxygen and glucose – reacting on the catalytic surface, where they undergo the positive effect (promoter) or negative effect (poison) caused by the added compounds (secondary actors) on the basis of their chemical nature (hard and soft). The model is based on a catalyst constituted by gold spheroids similar to metallic macromolecules (i.d. the macromolecule Au_{800} contains 800 atoms and has a diameter of ca. 3 nm) having chemical, physical and catalytic properties affected by their dimension: the electronic transfer among the reagents is mediated by the entire gold macromolecule and, by perturbing the catalyst with minimum aliquots of molecules which are able to increase or decrease the electronic density, also the catalytic performance increases or decreases. Beside innovatively describing the catalytic mechanism, the study finds new connections between nanotechnologies and molecular sciences which can help to project materials with particular electronic properties.

C. Della Pina, E. Falletta, M. Rossi, A. Sacco, "Selective Deactivation of Gold Catalyst", *Journal of Catalysis*, Vol. 263, Issue 1, 1 April 2009, pp. 92-97.

MATERIALS

Microspheres for immunosensing applications

An important goal in current biomedical research is to develop sensing devices capable of indicating the presence of specific markers for early diagnosis of degenerative diseases or cancer. An innovative approach to the development of optoelectronic sensors is the use of properly functionalized glass microspheres. A sphere is, in fact, a resonator, in which light propagates for very large times and lengths, limited only by the absorption of the material that forms the sphere or the light scattering caused by surface imperfections. This ability to trap light for a long time is numerically expressed by the quality factor of the resonator. A glass microsphere (diameter 50 to 200 microns, or about a hair thickness) is a miniaturized device with an extremely high quality factor, much higher than other conventional optical resonators. A microresonator is an ideal sensor, because any change on its surface and in the surrounding material causes a decrease of quality factor, and the sensitivity to these changes is very high, potentially capable of detecting a single molecule adsorbed onto the surface. In this work the group at IFAC-CNR, which has already developed efficient techniques for microsphere manufacturing and the coupling of light, as well as for other optical biosensors, has demonstrated the real potential of a microspherical biosensor, testing the possibility of coating a microsphere - without limiting its quality factor - with polymeric films bearing the appropriate elements for molecular markers recognition.

S. Soria, F. Baldini, S. Berneschi, F. Cosi, A. Giannetti, G. Nunzi Conti, S. Pelli, G.C. Righini, e B. Tiribilli, "High-Q polymer-Coated Microspheres for Immunosensing Applications", *Optics Express*, Vol. 17 (2009), Issue 17, pp. 14694-14699.

MATERIALS

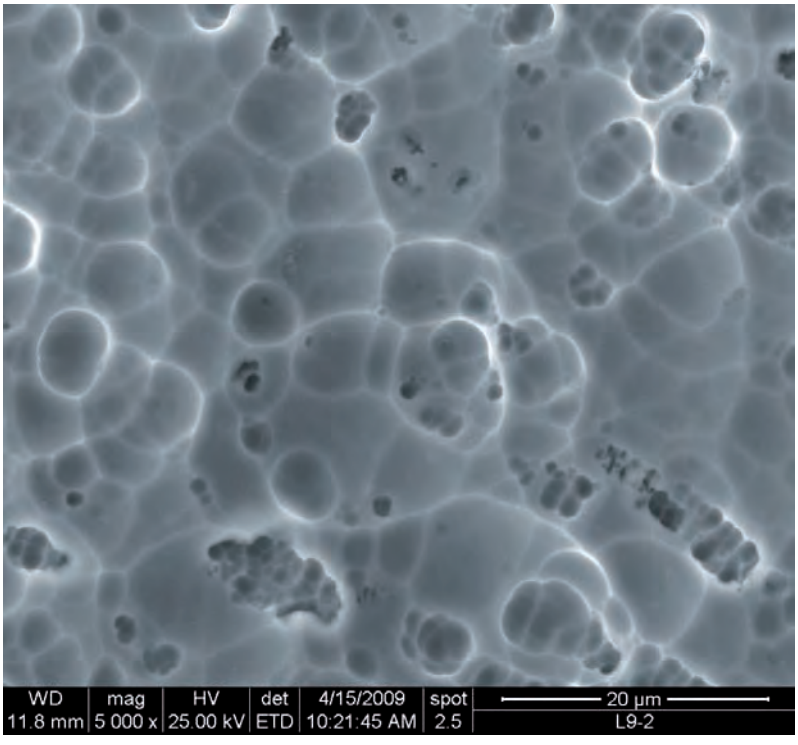
Superelastic alloys for biomedical applications: a novel and safer surface treatment of Nitinol

The NiTi alloy (Nitinol) is of great technological interest for its outstanding thermomechanical properties, shape memory and superelasticity; the latter is widely applied in the biomedical field to produce components like vascular stents, orthopedic and orthodontic implants, chirurgical instruments. These applications require accurate surface treatments to remove oxides and processing defects and to induce peculiar properties in the surfaces. Treatments often include etching, performed by using solutions containing hydrofluoric acid, a colorless and volatile substance (boiling point 19.5°C), very dangerous for the operator. Neutral pH fluoride solutions are less dangerous but, at the same time, much less effective.

The Institute for Energetics and Interphases and the Institute of Inorganic and Surface Chemistry of CNR have proposed an electrochemical etching treatment, based on anodic polarization of the NiTi object in a fluoride solution pH 6-7. The anodic oxidative process causes acidification of the solution in contact with the electrode surface, a local increase of undissociated HF and the sustained alloy dissolution proceeding with intermediate oxide formation. The process of water reduction at the counter electrode produces hydroxyl ions that avoid the progressive acidification of the overall solution.

The resulting surface shows a low roughness with a microscopic morphology reflecting the polycrystalline material structure, suitable for applications in implantology. The proposed procedure reduces drastically the risk for the operator and the environmental impact of the used chemicals as compared to traditional procedures.

S. Cattarin, P. Guerriero, M. Musiani, A. Tuissi, L. Vázquez-Gómez, "Electrochemical etching of NiTi alloy in a neutral fluoride solution", *Journal of the Electrochemical Society* 156 (2009) C428-C434.



SEM image of the surface of a NiTi sheet electrode polished by anodic electrodissolution in a neutral fluoride solution.

MATERIALS

Single-component organic crystals go ferroelectric

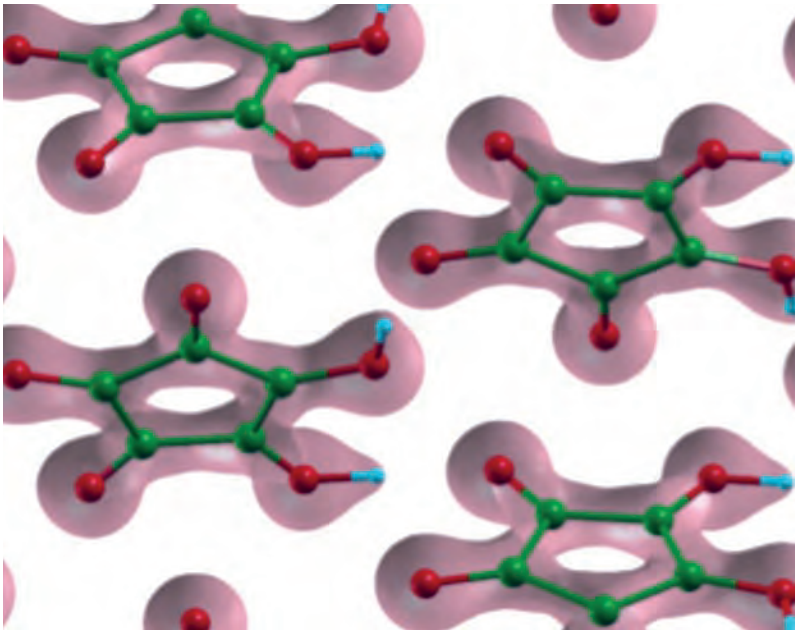
Plastics and other organic materials hold great promise for future flexible and cheap electronics. A fruitful collaboration between Japanese researchers - at the Advanced Industrial Science and Technology, Tsukuba and Univ. Tokyo - and Italian researchers – at CNR-SPIN L'Aquila - brings now into play another appealing property, i.e. ferroelectricity, so far rather unexplored in the organic arena. Ferroelectricity denotes the presence of a spontaneous and switchable electric polarization, below a certain ordering temperature. Technologically, ferroelectrics (and related piezoelectrics and pyroelectrics) are successfully used in a variety of applications, including nonvolatile memories, mechanical actuators or sensors. Traditional ferroelectrics are inorganic materials (like $BaTiO_3$, Barium Titanate), but the discovery of performing organic ferroelectrics would indeed avoid the use of expensive and toxic heavy-metals and allow the synthesis at low temperatures. So far, ferroelectric organic polymers (mostly acid-base binaries) had either low polarization with high operating voltage or high polarization with low operating temperatures. The croconic acid, the compound at the basis of the researchers' discovery, is found to have superior properties, as outlined below.

A five-membered carbon ring, with oxygen and hydroxyl (OH) groups attached to each carbon, form a molecule called "croconic acid", $H_2C_5O_5$. Synthesized in crystalline form, with molecules held together via a network of hydrogen bonds, the croconic acid shows high ferroelectric polarization (of the order of 20 μC/cm2, comparable to $BaTiO_3$) persisting up to above room-temperature, along with low operating voltage. From the microscopic point of view, the molecular stacking is such that hydrogens can easily hop between oxygens on one molecule and on its nearest neighbor. Supposing each hydrogen to lie closer to one molecule rather than halfway between (see figure), it is easy to guess that an electric field can shift the H atoms along the hydrogen bonds to positions on either side of the molecules, therefore switching the ferroelectric polarization.

From first-principles, CNR researchers in L'Aquila have shown that the hydrogen off-centering is indeed energetically favored and have predicted ferroelectric polarization in excellent agreement with experiments.

In summary, the results on croconic acid enrich the field of organic electronics and constitute a paradigm that can be hopefully optimized in other materials.

S. Horiuchi, Y. Tokunaga, G. Giovannetti, S. Picozzi, H. Itoh, R. Shimano, R. Kumai & Y. Tokura, "Above-room-temperature ferroelectricity in a single-component molecular crystal", *Nature* 463, (2010), pp. 789-792.



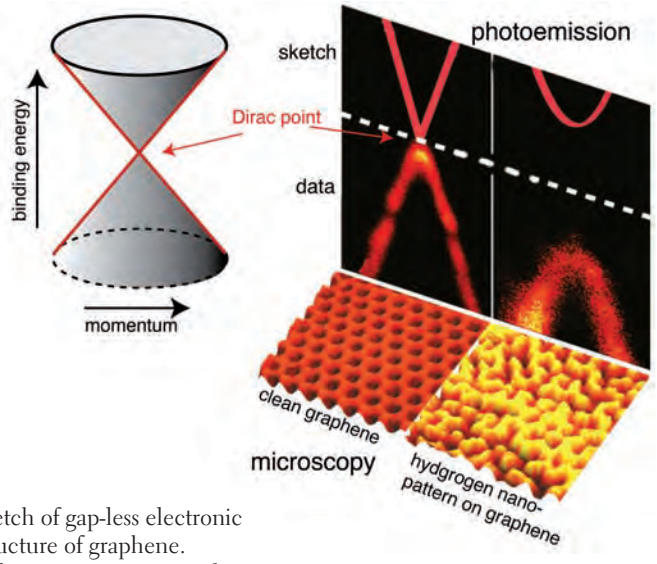
Valence charge density for the croconic acid crystal (from first-principles). Green, red and cyan balls denote C, O and H respectively.

MATERIALS

Towards the application of graphene in nanoelectronics

Graphene, a single layer of graphite, has recently attracted considerable attention due to its remarkable electronic and structural properties and its possible application in the emerging area of graphene-based electronic devices. The charge carriers in graphene behave like Dirac fermions, i.e. as relativistic massless particles, and graphene exhibits ballistic charge transport, turning it into an ideal material for circuit fabrication. It lacks, however, an energetic band gap around the Fermi level as in semiconductor materials, which is essential for controlling the conductivity by electronic means. Theory predicts that a tunable band gap may be engineered by periodic modulations of the graphene lattice, but experimental evidence for this is so far lacking. Our work demonstrates the existence of a bandgap opening in graphene induced by the patterned adsorption of atomic hydrogen onto the Moiré superlattice positions of graphene grown on a (111) iridium surface. To show this, information on the electronic structure is obtained by synchrotron radiation-based angle resolved spectroscopy and this is combined with details on the atomic structure determined by scanning tunnelling microscopy and with ab initio calculations.

R. Balog, B. Jørgensen, L. Nilsson, M. Andersen, E. Rienks, M. Bianchi, M. Fanetti, E. Lægsgaard, A. Baraldi, F. Besenbacher, S. Lizzit, Z. Sljivancanin, B. Hammer, T.G. Petersen, P. Hofmann and L. Hornekær, "Bandgap opening in graphene induced by patterned hydrogen adsorption", *Nature Materials*, 9, (2010) pp. 315.



Left: Sketch of gap-less electronic band structure of graphene.
Right: Electronic structure and structure for clean and hydrogen-covered graphene.

MATERIALS

Multiple glasses in repulsive systems

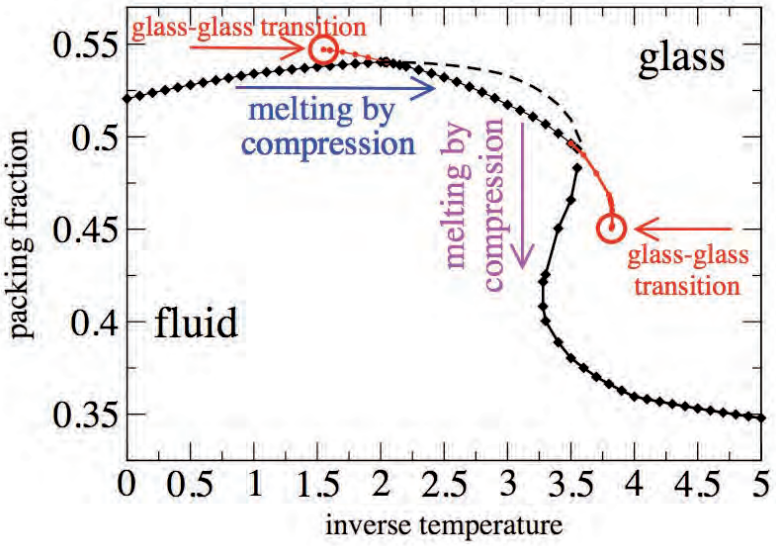
The glass transition in soft matter systems has become the subject of intense investigation in recent years. Soft matter includes a very large class of materials, whose common characteristic is that they are composed of mesoscopic "colloidal" particles, i.e. particles with sizes ranging from 1 nm to a few microns, normally dispersed in a solvent.

When colloidal particles interact via short-range attractions (e.g. through depletion interactions), a reentrant glass-liquid-glass transition happens. Glasses are non-ergodic states of matter, which display a liquid-like disorder, but are kinetically arrested, i.e. they do not flow. Multiple glasses, which are differentiated for example by their elastic properties, arise in these systems due to the competition of attractive interaction and hard-core repulsion.

In this work we show that it is not necessary to have attraction in order to observe multiple glasses. To this aim, we have studied the simplest model of a purely repulsive potential, i.e. the square shoulder model, in which the hard-core is complemented by a soft core. Using the mode-coupling theory (MCT) of the ideal glass transition, we have observed a novel topology of the arrested states: not only multiple glassy states exist, but also two glass-glass transition lines are found, each terminating in a higher-order singularity.

Moreover, one of the two glassy states is found to be buried within the first glass, a scenario that was not previously found in attractive models. Upon changing the width of the shoulder, this disconnected glass-glass line merges with the liquid-glass line giving rise to two reentry phenomena: melting by cooling and melting by compression as well as associated diffusion anomalies, similar to the ones observed in water. These results should be relevant for soft colloidal particles, like microgel particles and vesicles, but also for metallic glasses like cerium or cesium, micellar and granular materials.

M. Sperl, E. Zaccarelli, F. Sciortino, P. Kumar, H.E. Stanley, "Disconnected Glass-Glass Transitions and Diffusion Anomalies in a Model with Two Repulsive Length Scales", *Phys. Rev. Lett.* 104, 145701 (2010).



Phase diagram of a square shoulder potential, showing reentrant melting (by compression and by cooling) and multiple glassy states.

MATERIALS

Modelling defects in semi-conductors and insulators

The study of defects in semi-conductors and insulators is one of the oldest and most productive branches in materials science. Since the early 1930's it has been clear that defect control opens the way to reliable electronics manufacturing. With the birth of silicon-based Field-Effect Transistor (MOSFET) technology, silicon dioxide (SiO_2) has become the prototypical gate oxide. Among the vast defect fauna that SiO_2 exhibits, oxygen defects play the major role in many of the degradation processes that affect the functionality of silica-based components. Despite extensive research efforts, a global understanding of oxygen self-diffusion at the atomic scale has remained elusive. The mechanism of oxygen migration has been unravelled, thanks to the long-standing expertise of CNR-IOM DEMOCRITOS in the development and implementation of advanced theoretical methods in collaboration with CNR-NANO S3 and with the CEA (France). We proved that, at experimental conditions, standard theoretical approximations predict oxygen diffusion via negatively charged interstitials, in strong disagreement with available data. A reasonable picture of oxygen kinetics is only recovered if the charge-capture energetic includes explicit many-body effects.

L. Martin-Samos, G. Roma, P. Rinke and Y. Limoge, "Charged oxygen defects in SiO2: going beyond Local and Semilocal Approximations to Density Functional Theory", *Physical Review Letters*, 104 (2010) 075502.

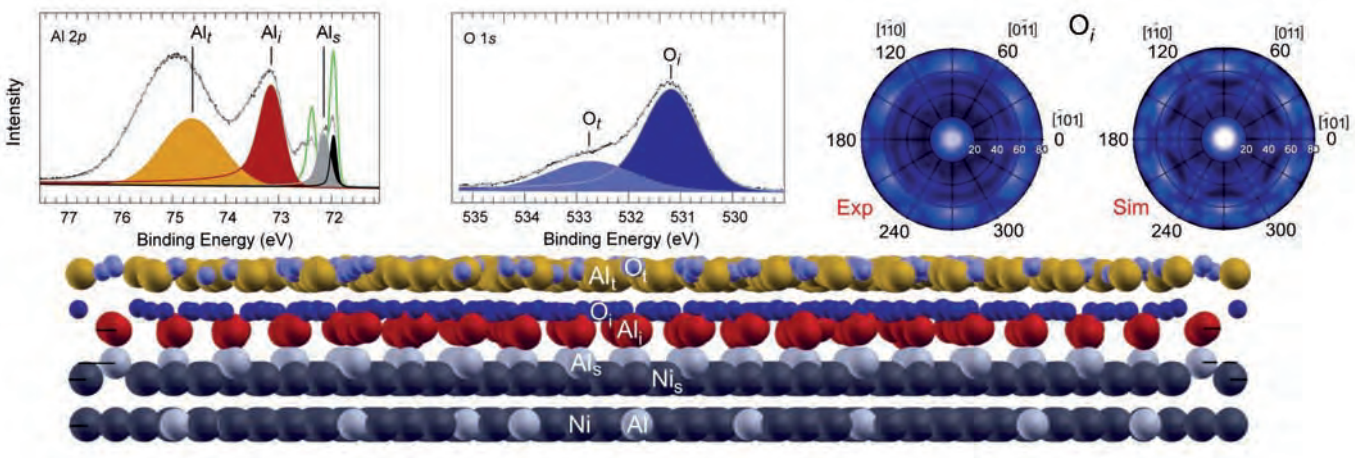
MATERIALS

Probing the interlayer relaxation at the metal-oxide interfaces

The knowledge of the atomic positions at metal-oxide junctions is a prerequisite for the rational design of ultrathin oxide films. Determination of atomic arrangement at the interfaces is a key feature for the use of oxide coatings as protective layers and for tuning the electronic properties of the oxide supported active metal clusters, which is a very important issue in order to engineer new catalysts. However, the breaking of the bulk periodicity often results in a large atomic rearrangement, confined within few Ångströms from the interface, which is extremely difficult to characterize experimentally. Because of the large lattice mismatch, the periodic structural modifications extend laterally over few nanometers, thus strongly limiting the applicability of diffraction techniques based on long-range order due to the large dimensions of the unit cells. The possibility to separate nonequivalent chemical species in x-ray photoelectron diffraction measurements allowed us to unveil a large modification of the alumina ultrathin epitaxial oxide film grown on nickel-aluminum Ni_3Al (111). In order to determine the alumina structure we have compared the experimental photoelectron diffraction modulation functions of chemically nonequivalent Al and O species with multiple-scattering simulations. The remarkable outcome of this study is the ejection of the alloy first-layer Al atoms towards the ultrathin oxide layer: Al atoms are lifted, yielding a first-to-second metal layer distance relaxation of +35%.
Our findings provide the evidence for the formation of a new Al intermediate metallic layer at the metal-oxide interface. The formation of this new interface structure is crucial for the explanation of several properties of the aluminum oxide films.

E. Vesselli, A. Baraldi, S. Lizzit, G. Comelli, "Large Interlayer Relaxation at a Metal-Oxide Interface: the case of a Supported Alumina Ultrathin Film", *Physical Review Letters* 105 (2010), 046102.

Al2p and O1s core level spectra, measured and simulated O1s diffraction pattern and structural model of the relaxed ultra-thin alumina oxide layer.

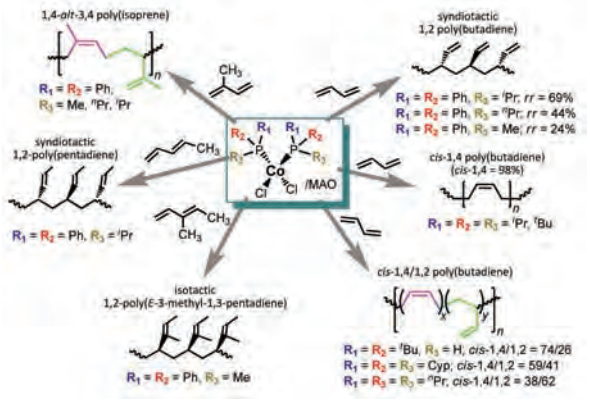


MATERIALS

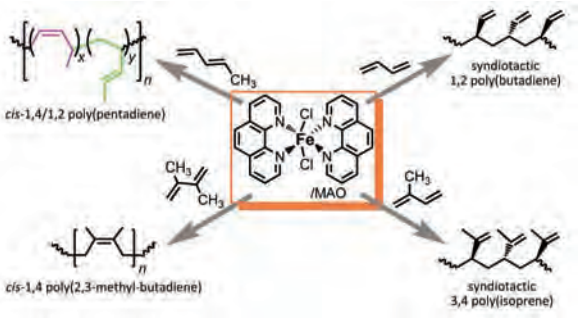
Butadiene and isoprene polymers for tires manufacturing

Polybutadienes and polyisoprenes properties and applications strongly depend on the polymer structure. These polymers may in fact exhibit different structures: *cis*-1,4; *trans*-1,4; 1,2; 3,4. Moreover, 1,2 and 3,4 polymers can in turn be iso- or syndiotactic. Of course, alongside these regular polymers, polymers with a mixed structure can be obtained (*e.g.*, *cis*-1,4/1,2). *Cis*-1,4 polybutadiene and polyisoprene are elastomers and their main use is in the manufacture of tires; syndiotactic 1,2 polybutadiene and 3,4 polyisoprene are crystalline polymers and are predominantly used in the manufacture of shoe soles (Italy is the greatest world consumer). The best method for preparing the above polymers is the stereospecific polymerization through catalysts obtained by combining transition metal or lanthanide compounds with aluminium-alkyls (*Ziegler-Natta catalysts*). The article describes the discovery of novel, extremely active and stereospecific catalysts based on transition metal complexes with amine or phosphine ligands, able to produce polymers with controlled microstructure from butadiene and isoprene. For instance, catalysts obtained by combining phosphine cobalt complexes with methylaluminoxane provided polybutadienes with different structure by simply varying the type of phosphine on the cobalt atom. These results were worthwhile from the industrial point of view, being butadiene and isoprene polymers of commercial interest. In addition, the catalysts described were also able to polymerize substituted butadienes, giving polymers with different structure from different monomers. These results were very interesting from a scientific point of view, since they permitted to improve the knowledge on the diene polymerization mechanism, in particular as regards the influence of catalyst and monomer structures on polymerization chemo- (*formation of 1,4 or 1,2 polymers*) and stereoselectivity (*formation of iso- or syndiotactic polymers*).

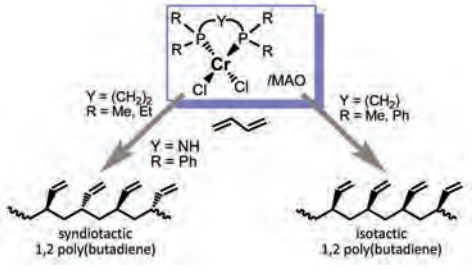
G. Ricci, A. Sommazzi, F. Masi, M. Ricci, A. Boglia, G. Leone, "Well Defined Transition Metal Complexes with Phosphorus and Nitrogen Ligands for 1,3-Dienes Polymerization", *Coord. Chem. Rev.*, 254 (2010), pp. 661-676.



Polydienes by cobalt phosphine complexes based catalysts: influence of catalyst and monomer structures on polymerization chemo- and stereoselectivity.



Diene polymers by iron phenantroline complex based catalyst: influence of monomer structure on polymerization chemoselectivity.



Polybutadienes by chromium phosphine complexes based catalysts: influence of the catalyst structure on polymerization stereoselectivity.

NEW MATERIALS

An innovative route to nanosystems

The international scientific community is extremely interested in the development and optimization of sustainable synthetic routes to copper oxide nanosystems (Cu2O and CuO). In fact, the latter are attractive candidates for various technological applications, from pollutant detection up to their conversion into products with reduced environmental impact. The Institute of Molecular Science and Technologies (ISTM) has provided a significant contribution by developing an innovative preparation strategy based on Chemical Vapor Deposition (CVD) starting from a novel molecular precursor never utilized in similar processes, $Cu(hfa)_2$•TMEDA (hfa = 1,1,1,5,5,5- hexafluoro- 2,4- pentanedionate; TMEDA = *N*,*N*,*N*',*N*'-tetramethylethylenediamine).

CVD process consists in the deposition into a solid substrate of a thin film from the target molecular precursor, initially introduced in vapor phase and subsequently decomposed over the substrate surface, obtaining thus high deposition rates, homogeneity and purity of the deposited systems. The obtained results have shown that controlled variations in the growth temperature from 250 to 550°C enable an accurate control on the material phase composition (from Cu_2O, to Cu_2O+CuO, to CuO) – an important pre-requisite for functional performances. A parallel morphological evolution has also been observed, from films with a variable porosity as a function of the synthesis conditions to an array of interconnected nanowires with a high length-to-diameter ratio.

D. Barreca, A. Gasparotto, C. Maccato, E. Tondello, O.I. Lebedev e G. Van Tendeloo, "CVD of copper oxides from a diketonate diamine precursor: tailoring the nano-organization", *Crystal Growth & Design*, (2009), 9 (5), 2470-2480.

CHEMISTRY

The discovery of soft matter

A study published in *Nature Materials*, developed by the Institute for Chemical and Physical Processes (Ipfc-Cnr) and the Institute of Complex Systems (Isc-Cnr), has provided the first experimental evidence of the so-called equilibrium gel, a new state of soft matter where the colloidal particles get stuck in a state of low-density gel consisting of very little matter, occupying only a small fraction of the available space. The work, realized in collaboration with the Sapienza University of Roma and with the European Synchrotron Radiation Facility (Esrf) in Grenoble, confirms the above-mentioned theory in recent years work carried out by a research team at La Sapienza, and it was conducted on Laponite, a synthetic clay used in scientific applications for the construction on nanocomposites which is used as a thickening agent such as in paints, cosmetic products and for household cleaning supplies. The characteristics of this clay are suitable for technological applications, such as lightweight and biocompatible materials which are used for the transport of medications.

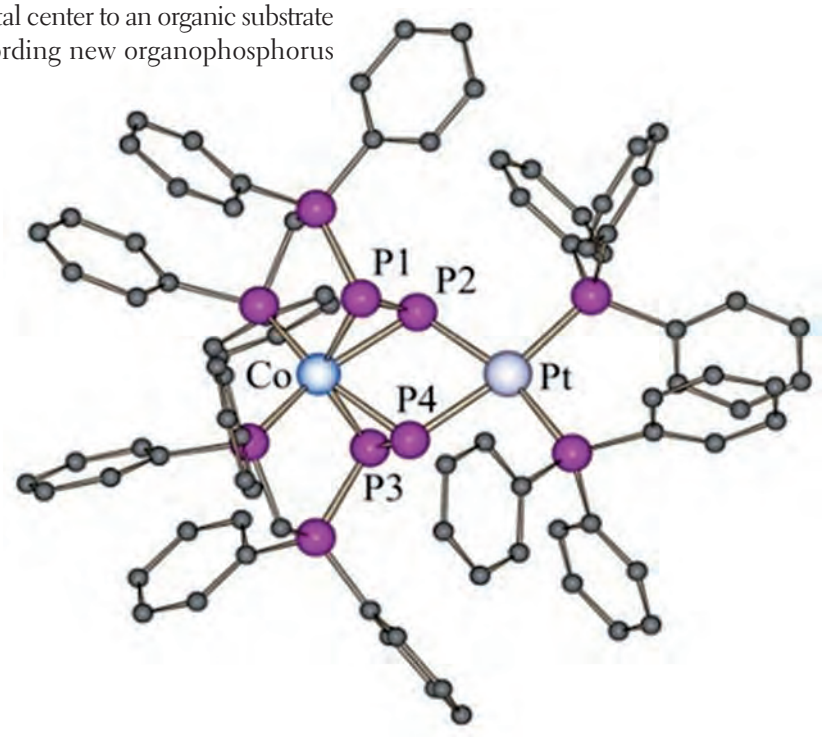
NEW MATERIALS

Playing with phosphorus atoms and metals to produce new molecules and materials

Phosphorus is an ubiquitous element, being present for example in living organisms and fertilizers. Phosphorus compounds are widely produced worldwide for use in pharmaceuticals, pesticides, additives for food, plastics and special steels, lubricants and flame retardants, just to mention a few. The current technology is still based on the reaction of P_4 (white phosphorus) with chlorine gas. This process has a high environmental impact, therefore the direct activation and functionalization of P_4 under mild conditions avoiding toxic reagents would be highly desirable. The discovery of possible processes carried out in the presence of metal catalysts is therefore attracting increasing interest both in academia and industry.

Many transition metals can activate P_4 either by direct coordination of the intact molecule or by cleavage of one or more P-P bonds forming a large variety of polyphosphorus ligands P_n (n = 1 - 24). The ideal goal is to transfer catalytically the P_n moiety from the metal center to an organic substrate affording new organophosphorus derivatives. A comprehensive summary of the fascinating work carried out in the last 40 years on the activation of P_4 mediated by late-transition metals is the subject of our job. Among the many outstanding results in this area, it is worth mentioning the mechanistic breakthrough recently reported by CNR researchers at ICCOM, who showed that cooperative effects between two metal ions are active to bring about P_4 activation and functionalization. Figure 1 shows the solid state structure obtained by X-ray diffraction of a Co/Pt complex (bimetallic cobalt/platinum cation) bearing the unique *catena*–phosphonium(+)diphosphenide(-) ligand that might be used as a platform for organophosphorics and phosphorus-based materials.

M. Caporali, L. Gonsalvi, A. Rossin, M. Peruzzini, "P4 Activation by late-transition metal complexes", *Chem. Rev.* 110 (2010), pp. 4178-4236.



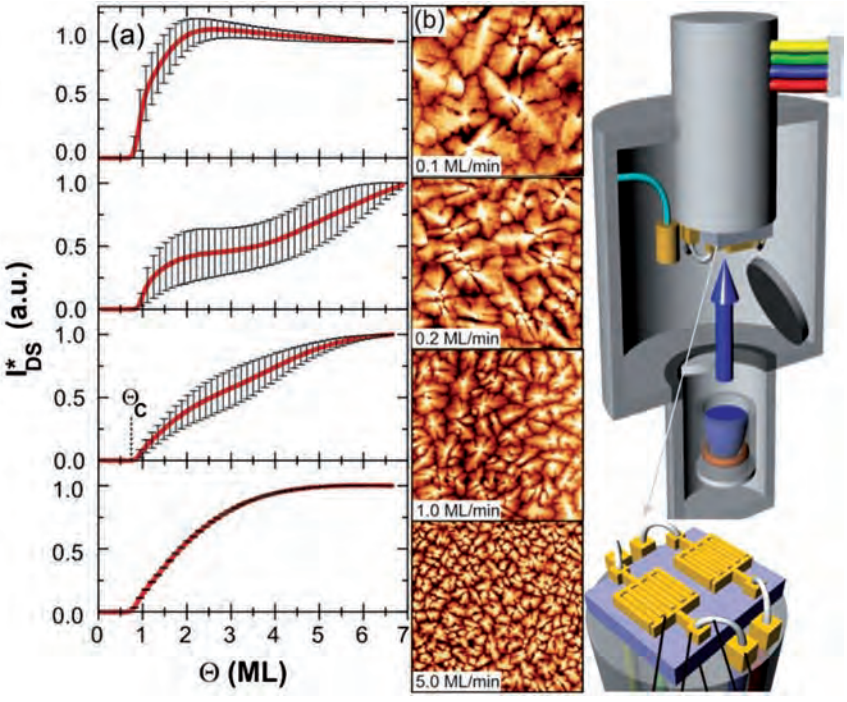
X-ray crystal structure of the heterobimetallic complex cation $[Co(\mu,\eta^{1:2:1}\text{-}P{=}P\text{-}PPh_2CH_2PPh_2)_2\{Pt(PPh_3)_2\}]^+$.

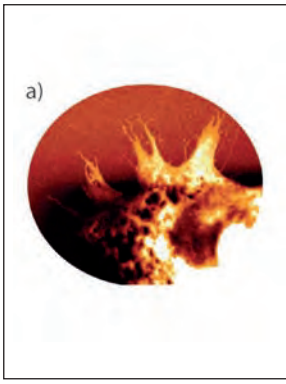
NEW MATERIALS

Ultra-thin film organic field effect transistors: fundamentals and applications to living matter

Ultra-thin film organic transistors are low-dimensional devices where charge transport takes place at the organic semiconductor/gate dielectric interface. We systematically investigated how the growth rate of the organic thin film affects both the surface morphological features and the device response. We designed and built a high-vacuum sublimation setup to monitor the transistor current *in situ* and in real-time during the deposition of the organic semiconductor, pentacene, on the test pattern. At the percolation threshold below one monolayer (ML), the current rapidly increases vs thickness Θ and saturates upon the deposition of 2 to 7 MLs, viz. for Θ ranging from 3 to 10 nm. The quantitative analysis of the current yields a detailed correlation between the charge transport parameters and the growth mode of the pentacene thin film. We demonstrate that the carriers are distributed and move across 2-3 monolayers. The apparent thickness of the active layer is limited by the occurrence of layer-by-layer to island growth transition. Earlier controversial results were unified within this framework [1].

Because of the proximity of the charge carriers to the surface, ultra-thin film transistors are extremely sensitive to charged or polarisable adsorbed species. They are emerging as a new class of label-free transducers and sensors for biomolecules, cells and tissues. Our aim was to understand how the morphological properties (roughness σ, correlation length

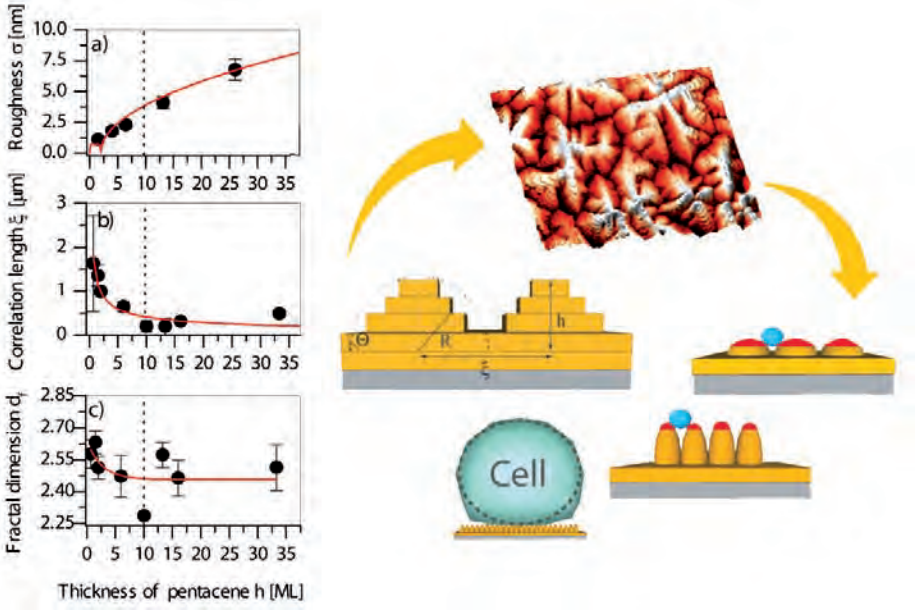




(a) Drain-source current in pentacene transistors acquired in real time in situ for different deposition rates. (b) AFM evolution of pentacene morphology for 7 ML films. In scheme experimental setup.

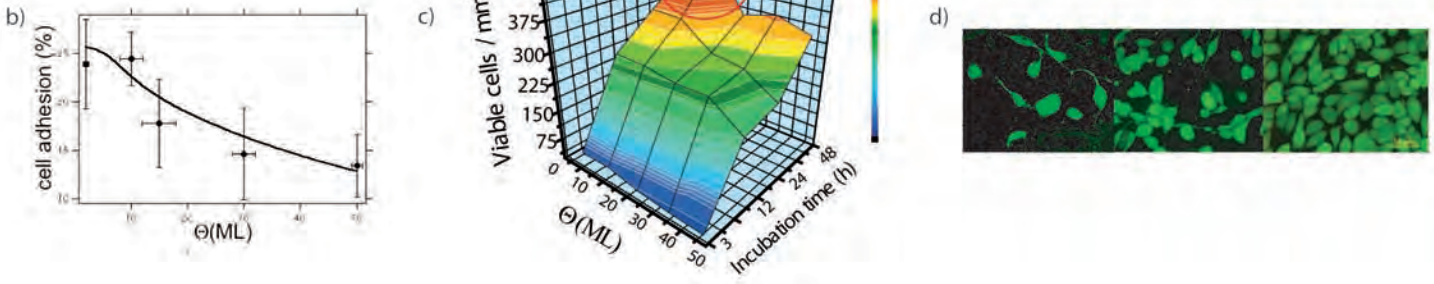
ξ, fractal dimension d_f) of pentacene thin films affect adhesion and viability of human neural cells, astrocytoma 1321N1, *in vitro*. We finely tune the surface morphology of pentacene thin films by Θ. By combining fluorescence and atomic force microscopies, we detect a transition in cell adhesion at Θ≈10 ML. Its origin is ascribed to the pentacene local curvature exceeding the maximum curvature attained upon the elastic deformation of the cell membrane, causing the loss of conformal contact. Optimum morphology range for cell deployment and proliferation is identified [2]. Our work demonstrates that the biocompatibility of pentacene ultra thin film depends on a combination of multiscale morphological features.

[1] A. Shehu, S. D. Quiroga, P. D'Angelo, C. Albonetti, F. Borgatti, A. Scorzoni, P. Stoliar and F. Biscarini, "Layered distribution of charge carriers in organic thin film transitors", *Physical Review Letters*, 104 (2010), pp. 246602-1-246602-4.
[2] Tonazzini I, Bystrenova E, Chelli B, et al., "Multiscale Morphology of Organic Semiconductor Thin Films Controls the Adhesion and Viability of Human Neural Cells", *Biophysical Journal*, 98 (2010), pp. 2804-2812.



Left: Thickness dependent morphological properties of pentacene ultra-thin films.

Right: AFM image. Schematic drawings of the islands and model for local pentacene curvature. Effective contact (red) of cell membrane and islands depends on local curvature.



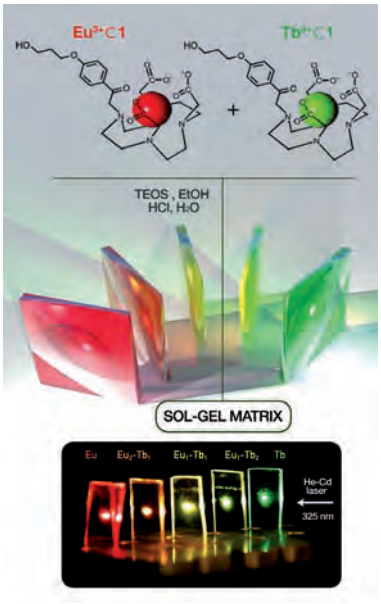
a) AFM image of human astroglial cell on pentacene thin film. b) Cell adhesion vs thickness. c) Cell viability and proliferation characteristics vs thickness and culture time d) Fluorescence microscopy images of astroglial cells on pentacene 12, 24, 48h incubation times.

NEW MATERIALS

United Colors of Lanthanons

In our technology driven lives, light-emitting and photo-switchable molecular systems are ubiquitous. Indeed, they find applications as active components in many kind of advanced materials such as diagnostic tools, sensors and biosensors, optical fibers, lasers and amplifiers, displays, just to mention a few. In this framework, the development of luminescent materials with improved colour brightness and stability holds great promise for the production of highly efficient large-area light sources with potential use in displays and lighting applications and it is also expected to have positive effects in terms of energy consumption.
This goal has stimulated a team of chemists of the CNR Institutes of Molecular Science and Technology (ISTM) and Organic Synthesis and Photoreactivity (ISOF) to develop over the years a molecule-to-material approach to prepare luminescent layers by combining light-emitting dyes based on lanthanide (so called because of their chemical similarity to lanthanum) coordination compounds with stable and optically transparent glassy films. Highly efficient lanthanide complexes, emitting bright colour throughout the visible spectrum, have been *ad hoc* designed using a macrocyclic coordinating cage with an appended antenna unit, acting as light collector, and a terminal hydroxyl group as grafting site to the inorganic silica glass *via* a sol-gel procedure. Hence, through a simple fabrication process, europium and terbium antenna complexes have been chemically anchored to silica thin layers in a controlled combination thus gaining relevant ready colour tunability.
On this route, glassy layers emitting bright light from emerald green to ruby red, passing through yellow lemon, have been obtained with extraordinary technological impact in lighting and multiple-colour sensing applications.

L. Armelao, S. Quici, F. Barigelletti, G. Accorsi, G. Bottaro, M. Cavazzini, E. Tondello, "Design of luminescent lanthanide complexes: from molecules to highly efficient photo-emitting materials", *Coordination Chemistry Reviews*, 254 (2010), pp. 487-505.



Silica films emitting bright light with extraordinary technological impact in lighting and sensing are obtained via a soft sol-gel procedure.

PHYSICS

Discovering the natural source of graphene

A study from the NEST laboratory at the Institute of Nanoscience at the CNR and the Scuola Normale Superiore of Pisa, realized in collaboration with Columbia University, has demonstrated that the best existing graphene, for purity and consistency, is contained in graphite, the mineral which is mined for the creation of pencils. Graphene, considered one of the most promising and versatile minerals, is the subject of international research which has led to a Nobel prize in physics, and it is a unique laboratory for studies of fundamental physics. It consists of a single sheet of carbon atoms arranged in a two-dimensional honeycomb lattice in which observable physical phenomena occur only in extreme conditions recreated with particle accelerators. By analyzing a block of graphite with the techniques of laser microscopy, the researchers have discovered the presence of crystals of ultra grapheme in which they measured, for the first time in this material, the megnetophonon resonance, a particular quantum effect due to the coupling of the relativistic electrons of the grapheme with vibration of its crystalline lattice.

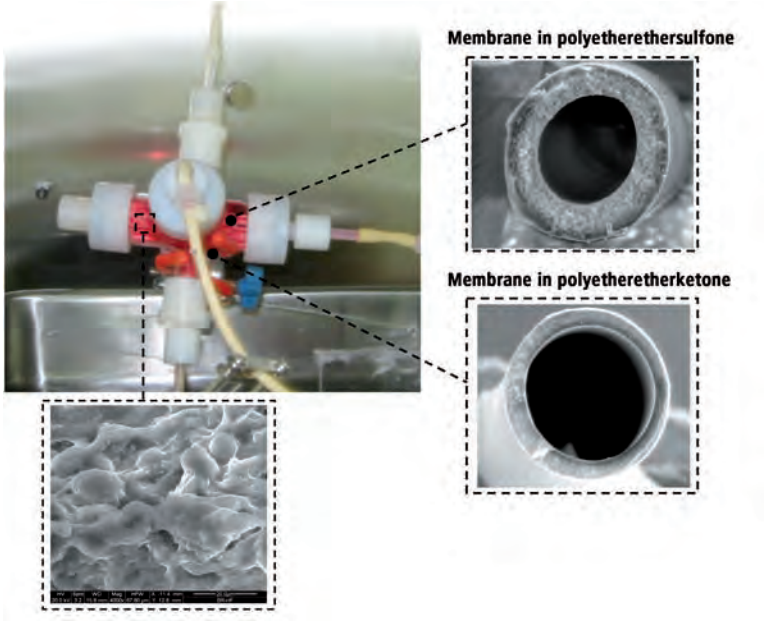
BIOMATERIALS

Alternative pharmacological tests by using a membrane bioreactor with liver cells

The Institute on Membrane Technology of CNR has developed a hepatic membrane bioreactor that performs the same functions of synthesis, detoxification and elimination of the liver in vivo. This bioreactor is able to test the drug toxicology and the metabolism alternatively to animal experimentation, accelerating in this way the development of new molecules and therapies. Furthermore, this device classifies the toxicology of compounds that the European Union regulates in the Reach – Registration, Valuation Authorization and Restriction of chemical compounds. The bioreactor is constituted by artificial polymeric membranes in a hollow fiber configuration and by human liver cells isolated from biopsy or organs not suitable for transplantation. Membranes act as support for the adhesion of liver cells favouring the spatial organization of the cells in vitro and allowing the selective transport of molecules from and to the cells, which is necessary for the equilibrium of cellular microenvironment.

The bioreactor consists of two separate bundles of polymeric fibers with different permeability properties, which are cross-assembled in perpendicular and alternating manner in order to perform different functions: fibers in modified polyetheretherketone and in polyetherethersulfone. The modified polyetheretherketone fibers are devoted to provide the cells with oxygen, nutrients and molecules to be metabolized. The polyethersulfone fibers are devoted to remove wastes and synthetic products from cell compartments. In this way the two bundles of fibers mimic our body arterious and venous blood vessel system. The combination of these two fiber sets produces an extracapillary network that provides a wide surface area for the cell adhesion and ensures an efficient transport of nutrients and metabolites. The liver cells in the bioreactor maintain their viability for long time performing drug biotransformation and synthetic functions of plasmatic proteins such as albumin and of urea at the same levels of the liver in vivo.

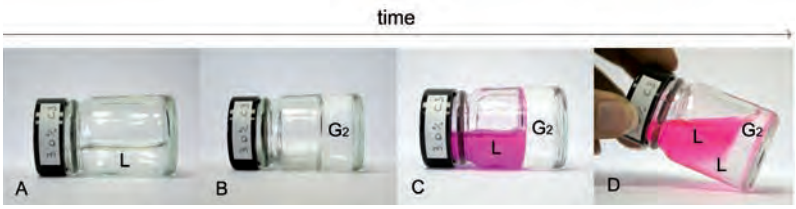
L. De Bartolo, S. Salerno, E. Curcio, A. Piscioneri, M. Rende, S. Morelli, F. Tasselli, A. Bader, E. Drioli, "Human hepatocyte functions in a crossed hollow fiber membrane bioreactor", *Biomaterials*, (2009), 30:2531-2543.



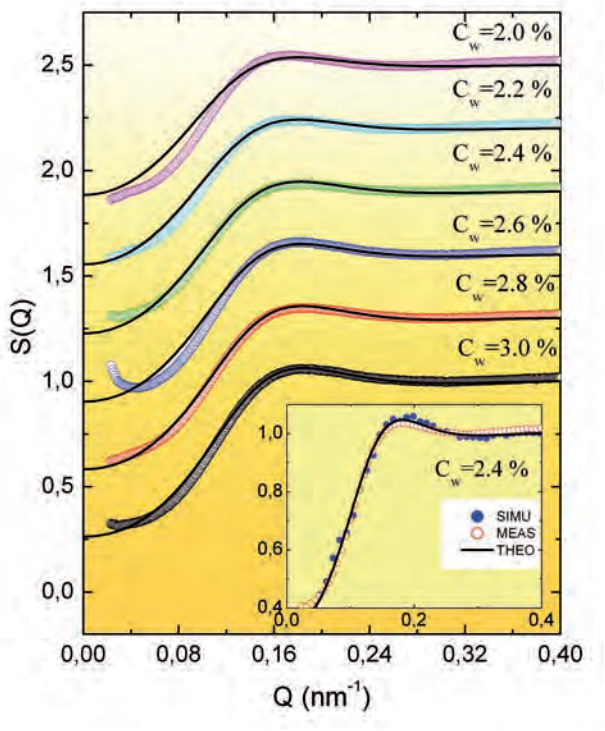
Membrane bioreactor with liver cells.

COLLOIDS

Arrested states in colloidal systems



The complex dynamics that leads colloidal systems to slow down their motion up to arrest has recently become the subject of an intense research activity. Gels and glasses have been identified respectively at low and high colloidal concentrations. To investigate the formation of multiple arrested states, colloidal clays have emerged as suitable candidates and Laponite, a synthetic clay widely used for technological applications, is a prototype system. It shows a very complex phase diagram due to the anisotropy of the particles, combined with the presence of attractive and repulsive terms in the interactions. It is also characterized by an aging dynamics which gives rise to (at least) two final arrested states, gel and glass, obtained by increasing Laponite concentration from low to high values.
Here we report the static structure factor S(Q) (that gives indications on structural arrangements of particles) measured with small angle x-ray scattering together with theoretical and numerical calculations in the high concentration region. The experimental data can be fully described by theoretical S(Q). Numerical S(Q) obtained by Monte Carlo simulations at the same density as that extracted from the fits are also in good agreement with experimental and theoretical ones. Moreover a simple but impressive dilution experiment for a low and a high concentration sample permits to distinguish whether attractive or repulsive interactions are dominant in the formation and stability of the arrested structure.
The combination of experiments, theory and simulation allows us to identify the observed arrested state at high concentrations as a Wigner glass , i.e. a glass stabilized by the residual electrostatic repulsion. Thereby Laponite shows a counterintuitive scenario which involves gel-like structures at lower concentrations and a (truly) disconnected glass at larger (but still very low) ones.



Comparison between measured $S^M(Q)$ (symbols) and theoretical $S^{th}(Q)$ (lines) for high concentration samples. Inset: measured $S^M(Q)$, theoretical $S^{th}(Q)$ and simulated $S^n(Q)$.

B. Ruzicka, L. Zulian, E. Zaccarelli, R. Angelini, M. Sztucki, A. Moussaïd, G. Ruocco, "Competing Interactions in Arrested States of Colloidal Clays", *Phys. Rev. Lett.*, 104 (2010), pp. 085701-085704.

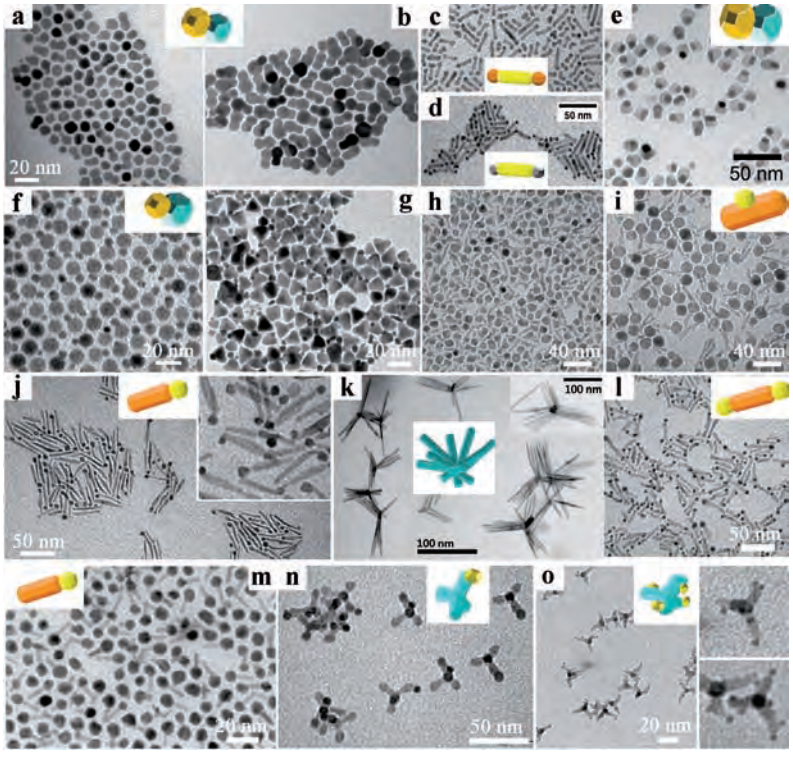
Top: Photographs of dilution experiment. The liquid (L) sample (a) arrests in a glassy state (G2) (b). Colored water is added to the sample (c) which progressively fluidizes (d), (e).

COLLOIDS

Heterostructured nanocrystals

Colloidal nanocrystals, nanometer-scale crystalline particles prepared by wet-chemical approaches, represent key elements on which the current scientific revolution of nanoscience is being founded. They stand out over other nanomaterials due to the high degree of control with which their properties can be tailored through structural engineering in the synthesis stage and to the versatility with which they are exploitable in optoelectronics, sensing, biomedicine and catalysis. Recently, in response to the growing demand for nano-entities capable to exhibit diversified, enhanced or even unconventional functionalities, colloidal routes have enabled access to unprecedented breeds of so-called heterostructured nanocrystals (HNCs) with a spatially defined distribution of their composition. HNCs are free-standing, all-inorganic multicomponent nanoheterostructures, in which size- and shape-controlled domains of distinct materials are epitaxially interconnected in onion-like or oligomer-type architectures. Development of HNCs transcribes a smart paradigm in synthetic nanochemistry, whereby increased structural-architectural complexity allows boosting the potential of standard single-material nanoparticles beyond limitations posed by their composition and geometry. In 2010 researchers of the NNL of the Nanoscience Institute of CNR, Lecce, who are actively involved in this field, elaborated a critical account of progress made in the chemical fabrication of HNCs based on associations of semiconductors, metals and magnetic compounds. Synthetic strategies based on seeding techniques and the mechanisms by which HNCs can be grown in selected topologies were discussed. The unique properties and technological perspectives offered by such novel class of nanomaterials were also highlighted.

L. Carbone, P.D. Cozzoli, "Colloidal heterostructured nanocrystals: synthesis and growth mechanisms", *Nano Today*, 5 (2010), pp. 449-493.



Gallery of TEM images showing various examples of HNCs based on Au, $CoPt_3$, FePt, TiO_2, CdSe, CdTe, Fe_3O_4, Ag and/or Co, all developed at NNL of CNR.

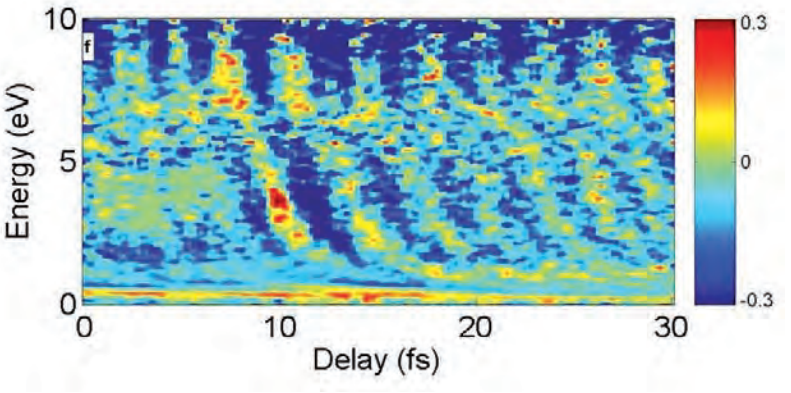
MOLECULAR PHYSICS

Ultrafast electron motion in molecules

While many chemical reactions occur by the rearrangement of atoms, which determines the breaking and remaking of chemical bonds, in a number of important physical processes the relevant time scale is set by the motion of electron, which can evolve on a much shorter temporal scale. This is the case when charge transfer, i.e. the motion of an electron along a molecule, is the crucial step. Biophysics offers various examples where charge transfer plays an essential role, such as photosynthesis and various chemical reactions in large peptides and proteins. Another emerging research field where charge transfer represents a key process is molecular electronics. Theoretical studies have pointed out that very efficient charge transfer can evolve on a temporal scale ranging from few femtoseconds (1 fs = 10^{-15} s) down to tens of attoseconds (1 as = 10^{-3} fs = 10^{-18} s).

In this work, we report on the first attosecond pump-probe measurement on molecules, to investigate the charge migration process. In a pump-probe experiment a first pulse (pump) excites the sample under investigation and initiates a fast relaxation process, which is probed by a second (probe) pulse. Isolated attosecond pulses were used to excite H_2 and D_2 molecules. The kinetic energy and angular distribution of H^+ and D^+ ionic fragments were measured as a function of the delay between the XUV pump and a 6-fs, infrared probe pulse. The attosecond pump pulse removes one electron from the molecule and the remaining electron undergoes a rearrangement. Subsequently the molecule dissociates during the interaction with the infrared probe pulse. This allowed the authors to examine how the electron charge distributed itself between the two fragments: since one electron is missing, one fragment will be neutral and the other positively charged. Upon measuring, as a function of the temporal delay between pump and probe pulses, the angular distribution of the ionic fragment it was possible to follow the migration process of the electron remaining on the neutral fragment. Using numerical simulations it was shown that the electron that is removed from the molecule by the attosecond laser pulse also plays an important role in the subsequent dynamics of the molecular ion that is left behind.

These results represent the first step in the understanding of the physical processes at the basis of electron-driven processes in molecules. The use of the pump-probe scheme with attosecond temporal resolution can allow the development of the experimental techniques required to achieve a coherent control of the electronic motion in complex systems on a purely electronic time scale. The investigation and control of attosecond electron dynamics in biomolecules can open new avenues in the biophysics field, since the electron migration process in large molecules is at the basis of fundamental reactions in biology.



Asymmetry parameter (color scale) for D^+-ion formation after attosecond excitation vs. fragment kinetic energy and time delay between pump and probe pulses.

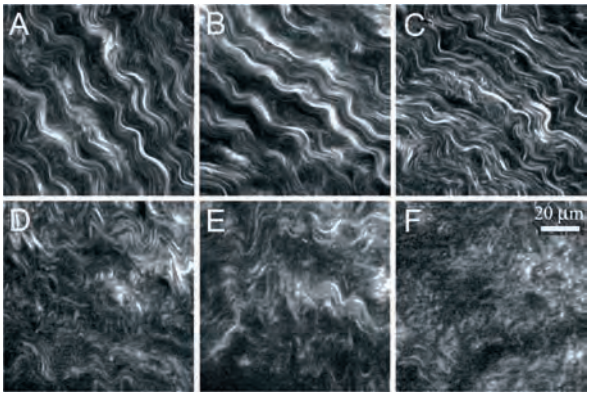
G. Sansone, F. Kelkensberg, J.F. Perez-Torres, F. Morales, M.F. Kling, W. Siu, O. Ghafur, P. Johnsson, M. Swoboda, E. Benedetti, F. Ferrari, F. Lepine, J.L. Sanz-Vicario, S. Zherebtsov, I. Znakovskaya, A. L'Huillier, M. Yu. Ivanov, M. Nisoli, F. Martin, M.J.J. Vrakking, "Electron localization following attosecond molecular photoionization", *Nature*, 465 (2010), pp. 763-766.

MICROSCOPY

The laser welding of corneal tissue: what happens at the microscopic level?

The cornea is among the most transparent tissues of the human body, which is due to its orderly architecture of collagen fibrils with their even separation and regular arrangement in lamellar sheets. Indeed if this order fades out, the transparency of the cornea becomes impaired and so does the vision. The Institute of Applied Physics "Nello Carrara" at CNR has developed a new technology to suture corneal cuts based on the use of laser light and named "laser welding", whereby the sealing effect results from well controlled heating.

This technology already finds application in corneal transplant surgeries. But what happens to the corneal structure at the microscopic level when it is exposed to laser light during the welding process? In order to answer this important question, it was established a close cooperation between CNR and the European Laboratory for Nonlinear Spectroscopy. The latter is pioneer in an innovative microscopy technique based on second harmonic generation, and already tested in a variety of biological tissues. By application of this technique to the corneal tissue, the orderly architecture of collagen proves to respond to the laser excitation as a nonlinear crystal capable to halve the wavelength of the laser light as it travels across the sample. This property allows one to precisely map the distribution, orientation and conformation of collagen fibrils. In the case of the laser welding, it was observed that the individual fibrils do not undergo denaturation, but rather maintain a substantial degree of integrity, which promotes rapid healing of the corneal cut, with minimal scar formation. The remarkable success of this technique for corneal microscopy paves the way towards its application to the diagnosis of corneal disorders which presently challenge available tools.



Corneal tissues and distribution, orientation and conformation of collagen fibrils. From A to F: increase of disorder related to laser light.

Laser welding: a new technology to suture corneal cuts based on the use of laser light during cornea transplant at the "Unità Oculistica" of Prato Hospital.

P. Matteini, F. Ratto, F. Rossi, R. Cicchi, C. Stringari, D. Kapsokalyvas, F.S. Pavone and R. Pini, "Photothermally-induced disordered patterns of corneal collagen revealed by SHG imaging", *Optics Express* n.17, pp. 4868-4878 (2009).

MICROSCOPY

A TAC for anisotropic fluids as DNA

"Optical Nanotomography" has been developed for the first time at Case Western Reserve University in Cleveland (Ohio, USA), being considered the first TAC related to liquid crystals and anisotropic biological fluids. This technique is able to reconstruct in three dimensions molecular orientation and structure.

It is 500 times more precise than the actual analysis instruments, and it will be possible to use it in biochemistry, pharmacology, electronic and chemical sciences, in which liquid crystals, and in general anisotropic fluids, are the main ingredients: in fact liquid crystals are widely used in computer and television displays, but also DNA as well as cellular membranes possess liquid crystals behaviors.

Thanks to a modified Scanning Near Field Optical Microscope (SNOM), an instrument able to make optical surface scans with a resolution of a few nanometers, some researchers from Licryl CNR Laboratory, in collaboration with other italian and foreign people, were able to observe a nematic liquid crystal droplet (identical to that used in LCD displays), acquiring several images at different height positions. As it can be made by a usual TAC, used for medical purposes, the acquired sections of the sample, made at only 10 nanometers one from each other, have been utilized to reconstruct a three dimensional image describing the molecular orientation of the anisotropic fluid inside the droplet. The SNOM tapered tip has been immersed inside the liquid crystal droplet, whereas polarized light was sent on it through a thin material layer. A second polarizer, on the bottom of the sample, permitted to analyze the polarization state of the entire area (30X30 microns), obtaining a high resolution image of the particular molecular film. By moving up the tip, and acquiring another image, until a height of about 500 nm from the substrate, we were able to obtain a 3D image of the molecular orientation of the entire droplet.

With respect to the usual and well known techniques (confocal microscope, NMR), in which the analysis is made by the outside and on the entire sample, the strong possibility to make the analysis "inside" a thin film of an anisotropic fluid represents one of the most important innovation made by using the SNOM technique.

A. De Luca, V. Barna, T.J. Atherton, G. Carbone, M.E. Sousa, C. Rosenblatt, "Optical Nanotomography of Anisotropic Fluids", *Nature Physics*, 4, 869-872 (01 Nov 2008), doi: 10.1038/nphys1077 e *Phys. Rev. Lett.*, 102, 167801 (2009).

PHYSICS

The amplifier which paves the way for quantum computers

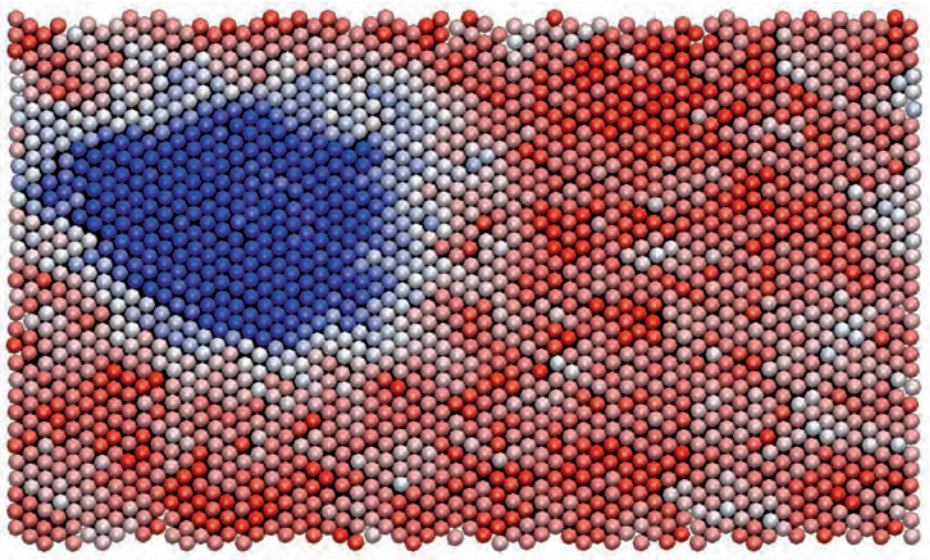
Researchers at the National Institute of Optics in Florence (Ino-CNR) and at the Czech University of Olomouc were able to experiment with a "perfect amplifier" able to quadruple the intensity of very weak light signals without introducing any additional noise. According to the researchers, the prototype seems to violate the rules of quantum mechanics, moving closer to the creation of a quantum computer. The results, published in *Nature Photonics*, were obtained using techniques, which were developed at the Ino-CNR, based on the controlled addition and subtraction of single photons, the essential and inseparable particles which make light.

This "hi-fi" quantum system could be used for making new types of ultra-sensitive measurements by creating quantum repeaters and amplifying the so-called "entanglement" which is the particular correlation between distant particles at the base of more advanced concepts of the quantum computer.

MICROSCOPY

Onset of friction at the atomic scale

M. Reguzzoni, M. Ferrario, S. Zapperi, M.C. Righi, "Onset of frictional slip by domain nucleation in adsorbed monolayers", *PNAS* 107 (2010) pp. 1311-1316



The formation of a new bubble prior to the global slip. Blue particles have slipped to the left while red particles are left behind.

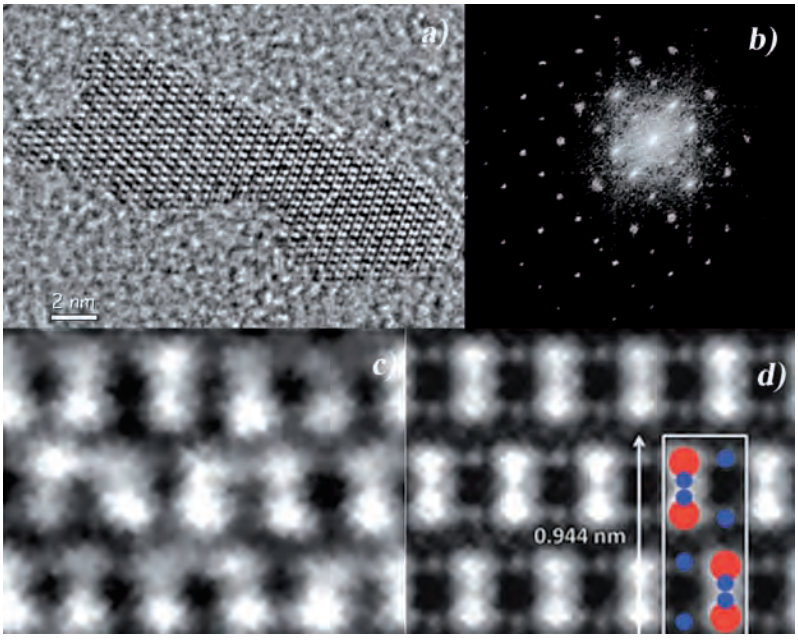
Understanding the microscopic mechanisms that govern friction represents a fundamental scientific problem with important practical applications. For instance in some micro-electro-mechanical systems (MEMS), friction and wear on very small contact areas may cause the failure of the device. While the macroscopic laws of friction are known since centuries, their microscopic origin is still the subject of active research. The Amontons laws, formulated at the end of the XVII century, state that two bodies in contact under a normal force start to slide when subjected to a lateral force exceeding the static friction force. On the other hand, a sliding body is subject to a dynamic friction force that is typically smaller than the static friction force. These concepts are not completely well, because even when the lateral force is below the nominal static friction, a body can slowly creep forward due to a thermal activation. Direct visualization of the contact area at the onset of slip indicate the formation and propagation of detachment fronts fracturing the contact interface. These findings suggest that the onset of slip is due to microscopic processes, ultimately due to the interactions between individual atoms lying on the surfaces in contact, propagating up to the macroscale to yield collective sliding.

To investigate friction at atomic scale, we have studied by numerical simulations the onset of slip of a xenon (Xe) monolayer sliding on a copper (Cu) substrate. In this system each atom of the xenon crystal falls into a minimum of the potential induced by the copper substrate, forming a commensurate interface, a condition that maximizes static friction. Considering thermal-activated creep under small external lateral forces, we observed that the monolayer moves by forming and expanding "bubbles" in the interface between the film and the substrate, a process that is reminiscent of nucleation in phase transitions (e.g. the gas-liquid transition). To understand the results, we use the classical theory of nucleation and compute analytically the activation energy which turns out to be in excellent agreement with numerical results. Our results are relevant to understand experiments on the sliding of adsorbed monolayers, with far reaching implications for atomic scale friction.

MICROSCOPY

Looking at the world with sub-atomic eyes

High-Resolution Transmission Electron Microscopy (HRTEM) has revolutionized our understanding of nanoscale materials by identifying structure-properties correlations at the atomic level. The spatial resolution achievable by TEM is related to the short wavelength of the high-energy electrons (e.g. 2.5 picometers for 200 keV) used for imaging samples. However, despite technical progress achieved in the construction of modern microscopes the diffraction limit has not yet been approached due to the aberrations and finite size of electromagnetic lenses. In 2010 CNR researchers from the IC, IOM-TASC and NNL Institutes have demonstrated how to improve the resolution of a HRTEM experiment by using an approach that bypasses such drawbacks. The key relied on recording a phase-contrast HRTEM image of the target object together with the corresponding electron nano-diffraction (n-ED) pattern with a standard TEM microscope. While the resolution of the HRTEM image was limited to 0.19 nanometers, the n-ED pattern contained reflections corresponding to significantly smaller lattice spacings. The resolution of the n-ED pattern was hence much higher than that of the HRTEM image. A new phase retrieval algorithm was developed to extract the information contained in the n-ED pattern by using the information contained in the HRTEM image as input data. This approach is called electron diffractive imaging (EDI). The Figure shows an individual anatase TiO_2 nanorod that was imaged by EDI at a record resolution of 70 picometers, unambiguously revealing the presence and location of light atomic elements, namely oxygen, in the relevant lattice. Subtle deformation of the anatase crystal cell was also detected, which can be responsible for the peculiar properties of nanostructured TiO_2 materials.
With EDI the study and understanding of matter at ultimate resolution is now possible.



L. De Caro, E. Carlino, G. Caputo, P.D. Cozzoli & C. Giannini, "Electron diffractive imaging of oxygen atoms in nanocrystals at sub-angstrom resolution", *Nature Nanotechnology*, 5 (2010), pp. 360-365.

a) HRTEM image of an anatase TiO_2 nanorod down the [100] zone axis;
b) Combination of the fast Fourier transform (FFT) of a) with the n-ED pattern of the relevant nanorod after subtraction of the contribution of the amorphous carbon substrate;
c) Magnified view of the HRTEM image contrast in a);
d) EDI-retrieved image, where the rectangular box highlights the TiO_2 lattice along the [100] direction (blue: O atoms, red: Ti atoms).

MICROSCOPY

Measuring the electric potential of tiny, fragile nano-objects

In microelectronics and biology, many fundamental processes involve the exchange of charges between small objects, such as nanocrystals in photovoltaic blends or individual proteins in photosynthetic reactions. As these nanoscale electronic processes strongly depend on the structure of the electroactive assemblies, a detailed understanding of these phenomena requires unraveling the relationship between the structure of the nano-object and its electronic function. Because of the fragility of the structures involved and the dynamic variance of the electric potential of each nanostructure during the charge generation and transport processes, understanding this structure-function relationship represents a great challenge. This account discusses how our group and others have exploited scanning probe microscopy based approaches beyond imaging, particularly Kelvin probe force microscopy (KPFM), to map the potential of different nanostructures with a spatial and voltage resolution of a few nanometers and millivolts, respectively. We describe in detail how these techniques can provide researchers with several types of chemical information. First, KPFM allows researchers to visualize the photogeneration and splitting of several unitary charges between well-defined nanoobjects having complementary electron-acceptor and -donor properties. In addition, this method maps charge injection and transport in thin layers of polycrystalline materials. Finally, KPFM can monitor the activity of immobilized chemical components of natural photosynthetic systems. In particular, researchers can use KPFM to measure the electric potential without physical contact between the tip and the nanostructure studied.

Liscio A., Palermo V., Samori P., "Nanoscale Quantitative Measurement of the Potential of Charged Nanostructures by Electrostatic and Kelvin Probe Force Microscopy: Unraveling Electronic Processes", in *Complex Materials*, Vol. 43, No. 4 April 2010 541-550.

SPECTROSCOPY

With spectroscopy, the fingerprint of the chiral molecules

The chiral molecules, from the ancient greek "cheir" (hand), are a class of molecules that can not be superimposed on their mirror image: amino acids, proteins, sugars and about 50% of the active principles of medicines are chiral molecules. The study of the properties of the electronic structure of chiral molecules is carried out by means of circularly polarized light (right and left), a probe that is not symmetric for specular reflections. The chiral molecules, in fact, respond differently to the two circular polarizations, and the difference (dichroism) provides information on the structural and electronic properties of molecules. With the development of synchrotron light sources, which offer a range of wavelengths from visible to X-rays, it was possible to extend the dichroism to the emission of electrons by photoionization, which is the process describing the emission of an electron after the absorption of an ultraviolet photon, thus combining the study of the molecular orbitals with the chiral character.

What emerges is that the probability of emitting an electron from the chiral molecule is dependent on the polarization of light, and the difference between these probabilities produces a characteristic modulation of the oscillating photo-emitted number of electrons as a function of the kinetic energy of the electron. This signal represents a true 'fingerprint' of the orbital and molecular structure of a chiral molecule. Using this spectroscopy and quantum-mechanical calculations, researchers at the CNR - Institute of Structure of Matter of Rome were able to highlight the influence of the conformations of a chiral molecule on the molecular orbitals, providing a contribution to the study of electronic properties of conformations, which are important for the control of their reactivity in different biological environment, in the production of pharmaceuticals and in nanotechnology.

S. Turchini, D. Catone, G. Contini, N. Zema, S. Irrera, M. Stener, D. Di Tommaso, P. Decleva, and T. Prosperi, "Conformational Effects in Photoelectron Circular Dichroism of Alaninol", *ChemPhysChem* (2009), 10, 1839-1846.

SPECTROSCOPY

Fingerprinting of genetically modified foods

Genetically modified foods are foods in which DNA has been modified to confer new properties and abilities. It is possible to shorten the ripening time of plants, it is possible to make a plant more resistant in low temperature conditions, or it is possible to make a plant more resistant to a specific pathogen attack. However genetic modification may also induce modification on the plant metabolism. Therefore it is important to develop methodologies able to detect possible undesired effect due to the genetic modification itself.

Researchers of the Methodological Chemistry Institute (IMC-CNR) developed protocols based on Nuclear Magnetic Resonance spectroscopy (NMR), able of producing the fingerprinting of the investigated food, i.e. the metabolic profiling of the food, and to detect the different metabolites contained in the food. In the case of GM food, according to the developed analytical protocols, a comparison is always performed between the metabolic profiling of GM and that of not GM food which is used as a control. Investigations on both GM and not GM tomatoes, maize and lettuce have been performed. In particular, a very recent study has been performed in which the comparison between the metabolic profiling of GM maize (Cry1A(b) gene) and not GM maize has been reported. The study has clearly shown that GM and not GM maize samples contain the same metabolites, however the amount of few metabolites is very different in the two set of samples. In fact in GM maize a greater amount of citric acid, glycine-betaine, trehalose and ethanol has been found. The different amount of these metabolites along with the use of statistical analysis methods allow a clear differentiation between GM and not GM maize.

F. Piccioni, D. Capitani, L. Zolla, L. Mannina, "NMR Metabolic Profiling of Transgenic Maize with the Cry1A(b) Gene", *Journal of Agricultural and Food Chemistry*, 57, 6041-6049 (2009).

CATALYSTS

Metal-oxo clusters: new catalysts for eco-compatible chemical processes

The chemical industry strongly requires the development of efficient and clean procedures to synthesise high added-value fine chemicals in few steps and high selectivity. Catalysis provides powerful tools to reach this goal. The keypoint to perform sustainable transformations is the selection of a catalytic system that shows selectivity, activity and stability (high turnover frequency (TOF) and turnover number (TON) respectively). Additionally, the catalyst must be easily recovered and recycled. An ideal clean catalytic system does not produce large amounts of by-products, avoids the use of toxic reagents and shows an high atom economy, defined as the weight percentage of the atoms that are found in the final product with respect to those introduced in the process at any stage.

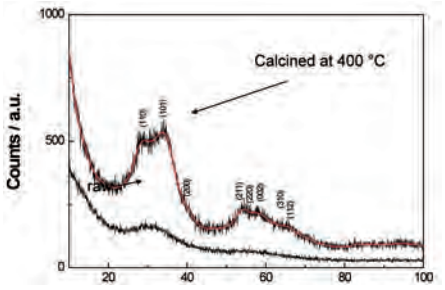
With these concepts in mind we have studied the synthesis of cyclopropanes that represents a research area of high impact due to the utility of such molecules as precursors for biological or pharmaceutical compounds. The employment of non conventional catalysts such as oxo clusters of transition metals, namely polyoxometalates (POMs), provides several advantages. Their molecular structure and properties can be widely modulated and they exhibit high robustness.

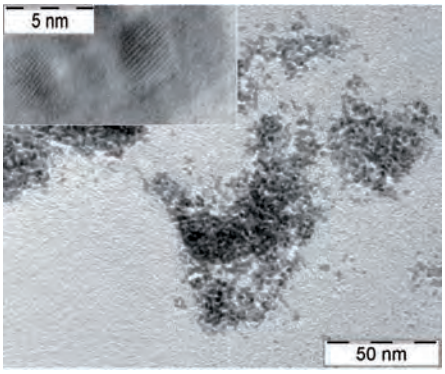
A wide class of cyclopropanes were obtained in yield up to 98% by employing copper substituted polyoxometalates as catalysts, ethyldiazoacetate (EDA) as carbene sources and a molar ratio catalyst/EDA/olefin = 1: 100000: 100000. The use of an equimolar ratio EDA/olefin and the formation of N_2 as a by-product confers to this methodology a very high atom-efficiency. Besides, the very low amount of employed catalyst (TON = 100000) circumvents problems connected to the catalyst recovery and it is promising for industrial applications of POMs as cyclopropanation catalysts.

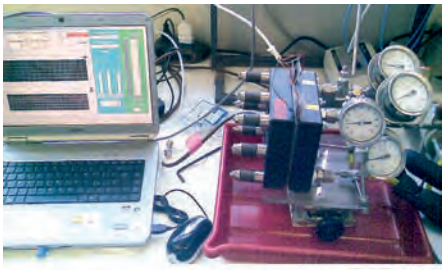
I. Boldini, G. Guillemot, A. Caselli, A. Proust, E. Gallo, "Polyoxometalates: Powerful Catalysts for Atom-Efficient Cyclopropanations", *Advanced Synthesis and Catalysis*, 352 (2010), pp. 2365–2370.

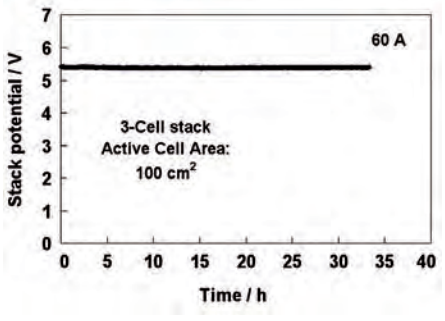
ELECTROCATALYSTS

A new approach for electrochemical hydrogen generation









In the future, hydrogen may play an important role as energy carrier. To this aim, research efforts are now oriented towards the development of innovative catalysts for electrochemical water decomposition. Hydrogen generation through water electrolysis in a proton exchange membrane (PEM) electrolyser is characterized by high performance and efficiency. In comparison to traditional alkaline devices, advantages of PEM electrolysers are ecological cleanliness, a smaller mass and volume characteristics, high degree of gas purity and the possibility to obtain compressed gases directly from the electrolyser at an increased level of safety. The high overpotential for oxygen evolution during water splitting is the limiting factor for the whole process. It is therefore important to find an optimal oxygen evolution electrocatalyst to minimize the energy loss. In this work, a nanosized Iridium oxide (IrO_2) oxygen evolution catalyst was prepared by a new sulfite-complex route. The peculiarity of this catalyst was the presence of 2-3 nm crystalline IrO_2 particles embedded in an amorphous matrix. This characteristic reduced the sintering phenomena and showed a good compromise between specific activity and suitable surface area due to the small particle size. To assess the IrO2-based membrane-electrode assembly in an electrochemical device of an appropriate size, suitable for scaling up, a short stack PEM electrolyser was assembled and characterized. An optimal normalized performance in terms of high current density (1.26 A cm^{-2}) at relatively low cell voltage (1.8 V/cell) was obtained. Good stability was also achieved during steady-state operation and proper performance under duty-cycles simulating the behaviour of renewable sources. The electrical power consumption of a short stack producing 80 litres per hour of hydrogen was smaller than 330 W with an electrical efficiency of 81%. These results appear promising for hydrogen generation from renewable energy sources through PEM electrolysers.

Top left: X-Ray diffraction patterns of colloidal IrO_2 (bottom) and calcined IrO_2 oxygen evolution catalysts.

Top right: TEM micrographs of IrO_2 catalyst calcined at 400°C.

Bottom: SPE stack electrolyzer under operation.

S. Siracusano, V. Baglio, A. Di Blasi, N. Briguglio, A. Stassi, R. Ornelas, E. Trifoni, V. Antonucci, A. S. Aricò, "Electrochemical characterization of short stack PEM electrolyzers based on a nanosized IrO_2 anode electrocatalyst", *International Journal of Hydrogen Energy*, 35 (2010) 5558-5568.

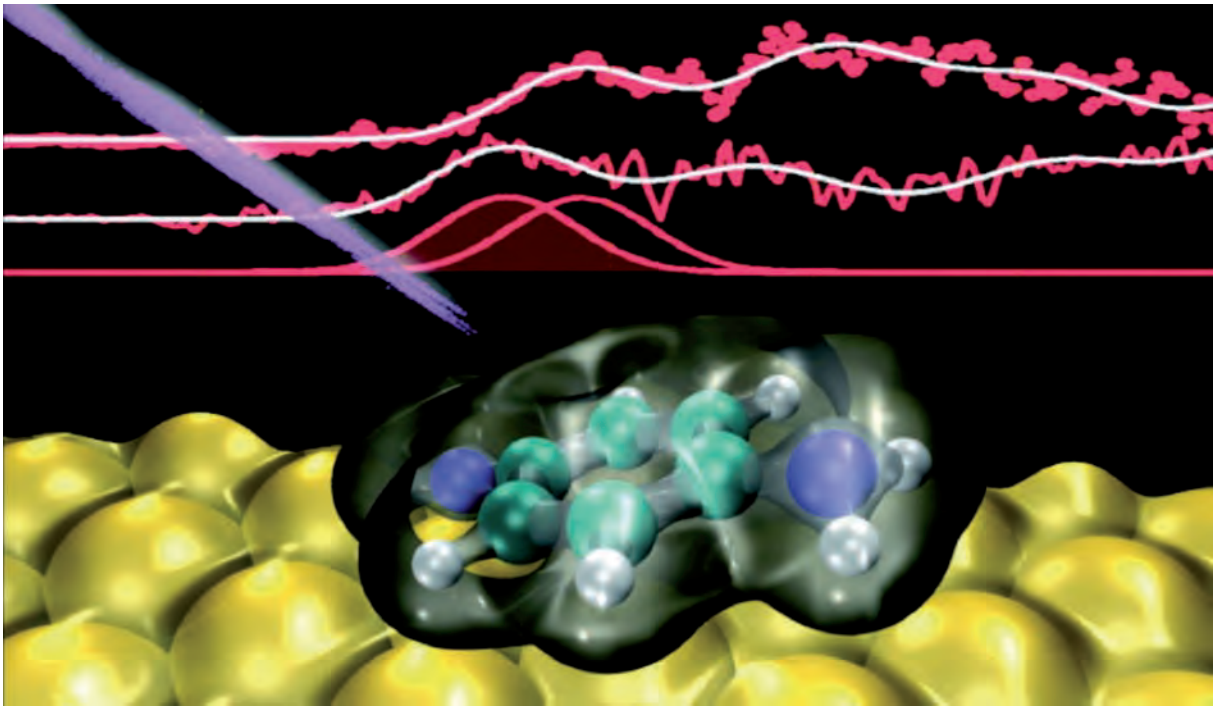
ELECTRONICS

Conductance of a single molecule: a novel approach

The understanding of the electronic transport processes at the molecular level is the key for the development of organic based electronic devices. In particular, the transport mechanisms at the interfaces between the molecules and the metallic electrodes strongly affects the performances of the systems in terms of their reliability and efficiency. In this view, we adopt a multitechnique approach for the study and control of such interfaces. We combine x-ray spectroscopy (Resonant Photoemission), single molecule conductance measurements and theoretical calculations to investigate the correlation between the energy level alignment at the interface and the conductance for three BenzeneDiAmmine (BDA) derivatives on gold surfaces. The choice of the systems is suggested by the reliability of the single molecule conductance measurements for amino-terminated molecules.
The charge transport processes at an organo-metallic junction involve the molecular levels which are energetically close to the Fermi level of the metallic electrodes. In this view, we measure the position of the highest occupied molecular orbital (HOMO) relative to the Au metal Fermi level for three 1,4-benzenediamine derivatives on different gold surfaces with ultraviolet and resonant X-ray photoemission spectroscopy. We compare these results to scanning tunnelling microscope-based break-junction measurements of single molecule conductance and to first-principles calculations. We find that the energy difference between the HOMO and Fermi level for the three molecules adsorbed on gold correlates well with changes in conductance and agree well with quasiparticle energies computed from first-principles calculations incorporating self-energy corrections. This work thus provides the first direct comparison between energy level alignment and single molecule transport measurements and indicates a novel approach to the study of the organo-metallic interfaces.

M. Dell'Angela, G. Kladnik, A. Cossaro, A. Verdini, M. Kamenetska, I. Tamblyn, S.Y. Quek, J.B. Neaton, D. Cvetko, A. Morgante, L. Venkataraman, "Relating Energy Level Alignment and Amine-Linked Single Molecule Junction Conductance" *NanoLetters*, 10 (2010), pp. 2470-2474.

Graphical representation of the BDA molecule on the Au(111) surface.

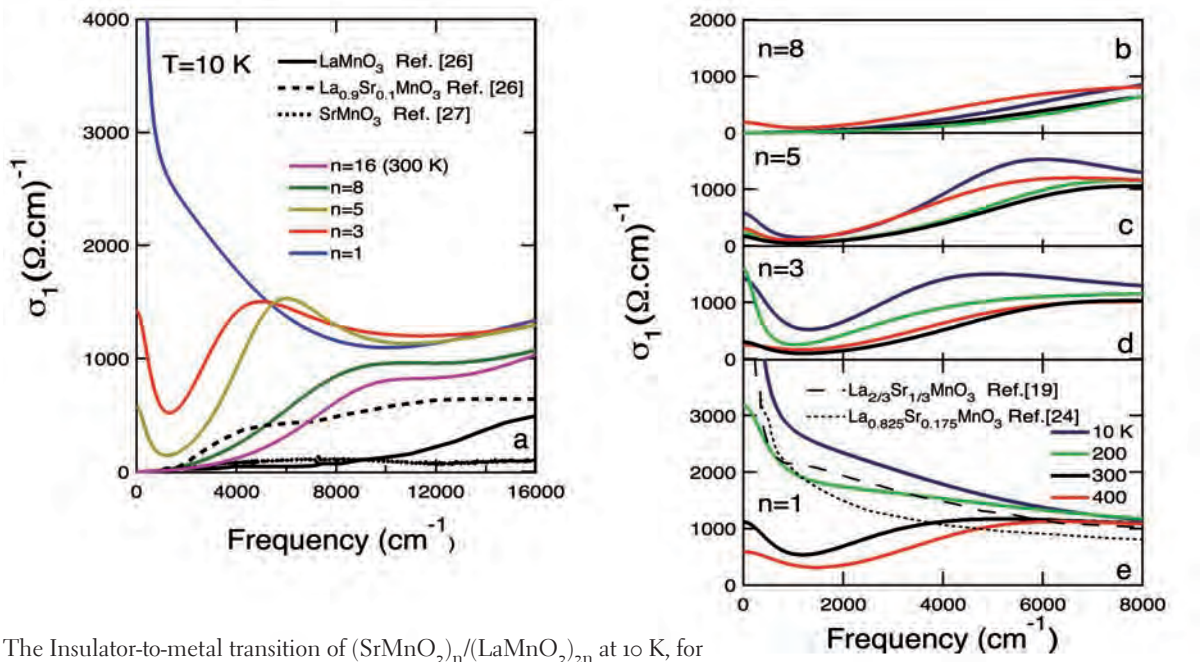


ELECTRONICS

Optical properties of functional oxides

Recent progress in the engineering of atomically sharp oxide interfaces paves the way to the application of oxides in useful devices. Thanks to electron reconstruction and changes in the ionic positions, new unexplored electronic and magnetic phases can be observed at the interfaces between strongly correlated materials. One of these novel systems is the Strontium-Lanthanum manganite oxide $[(SrMnO_3)_n/(LaMnO_3)_{2n}]$, made up of 2n atomic layers of the Mott insulator $LaMnO_3$, interleaved by n layers of the band insulator $SrMnO_3$. Bulk $La_{1-x}Sr_xMnO_3$ exhibits the Colossal Magnetoresistance (CMR) effect, i.e. a dramatic change of its resistence in the presence of a magnetic field. This effect is amplified near the doping-level ≈ 1/3 where a metallic phase appears from an insulating state through the so-called Insulator-to-Metal Transition (IMT). Here the IMT is concomitant with a ferromagnetic transition. Thus, a metallic and a ferromagnetic phase are established simultaneously at the Curie temperature.
However, the properties of the bulk CMR systems are partially masked by lattice disorder. Instead, by using infrared spectroscopy, we were able to observe the IMT in the $(SrMnO_n)n/(LaMnO_3)_{2n}$ (disorder-free) superlattices. We showed that such heterostructure is characterized by novel electronic states, profoundly different from those of doped bulk manganites. In this "sandwich" of insulators indeed, the metal phase is obtained by decreasing *n*. The carriers freely propagate for short (*n* = 1,2,3) interface distance, while they become localized for larger spatial separations. Such an observation, which opens interesting application of this artificial material, would be impossible in bulk manganites, where the doping impurities are randomly distributed throughout the lattice.

A. Perucchi, L. Baldassarre, A. Nucara, P. Calvani, C. Adamo, D.G. Schlom, P. Orgiani, L. Maritato, and S. Lupi, "Optical properties of $(SrMnO_3)_n/(LaMnO_3)_{2n}$ superlattices: an insulator-to-metal transition observed in the absence of disorder", *Nano Lett.*, (2010), 10 (12), pp. 4819-4823.



The Insulator-to-metal transition of $(SrMnO_3)_n/(LaMnO_3)_{2n}$ at 10 K, for decreasing interlayer spacing *n*, is monitored through the filling-up of the insulating gap and the building-up of the Drude term of the free carriers (top). The optical conductivity vs. temperature and n (bottom).

BIOSENSORS

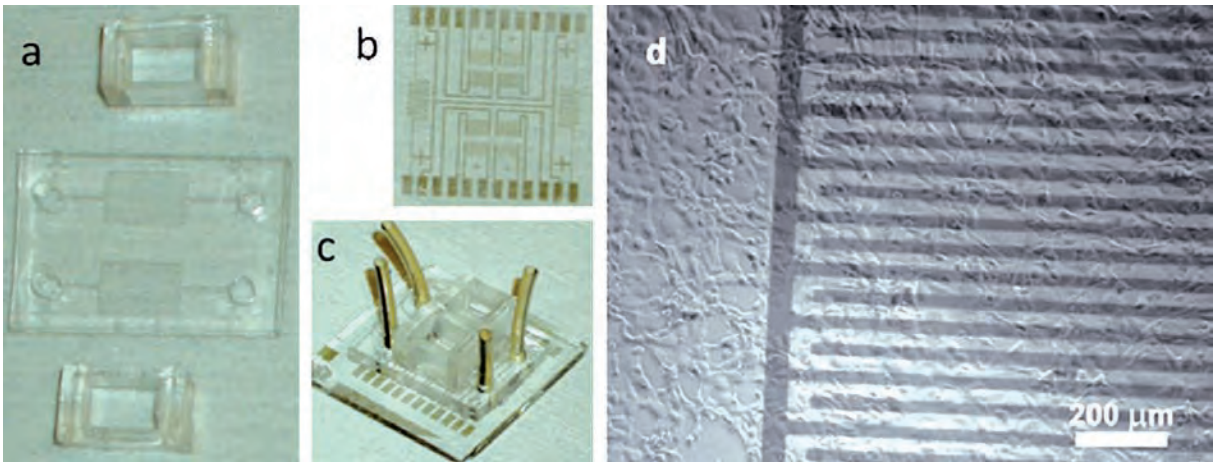
Electrochemical cell chips: new tools for toxicological studies and drug discovery chips

E. Primiceri, M. S. Chiriacò, E. D'Amone, E. Urso, R.E. Ionescu, A. Rizzello, M. Maffia, R. Cingolani, R. Rinaldi and G. Maruccio, "Real-time monitoring of copper ions-induced cytotoxicity by EIS cell chips", *Biosensors and Bioelectronics*, 25 (2010), pp. 2711-2716.

An important goal of biomedical research is the development of tools for high throughput evaluation of potentially new drugs and their possible side effects. However, widely-used biochemical methods are laborious and time consuming requiring complex steps with multiple reagents. In addition, these techniques are invasive and destructive against target cells, making impossible to monitor a dynamic process. Therefore, new tools for real-time and high-throughput screening are needed. On-chip cell-based assays are emerging as a valid alternative to conventional methods and electrochemical impedance spectroscopy (EIS) represents a suitable transduction technique enabling non-invasive, real-time studies of cell behavior. Here, we fabricated EIS cell chips able to monitor cell adhesion and morphological changes and, for the first time, we used them in combination with off-chip methodologies such as atomic force microscopy (AFM), viability tests like MTT (3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) and western blot) to perform a complete characterization of the changes induced by copper ions on two cell lines (B104 and HeLa).

Our results revealed a strong correlation between EIS data and both MTT test and AFM characterization but EIS enables to real-time monitor cellular processes that is not possible with standard techniques. Then this combined approach has provided also further insight on the effects of copper which is an essential trace metal in human nervous system and has a key role in its development as well as the pathogenesis of several diseases including Alzheimer's disease.

Thanks to multiplexing and integration of complex fluidic networks, these biochips can be particularly useful in the field of drug discovery in order to test with high-throughput a large library of drugs or the effect of the same drug on different cell lines.



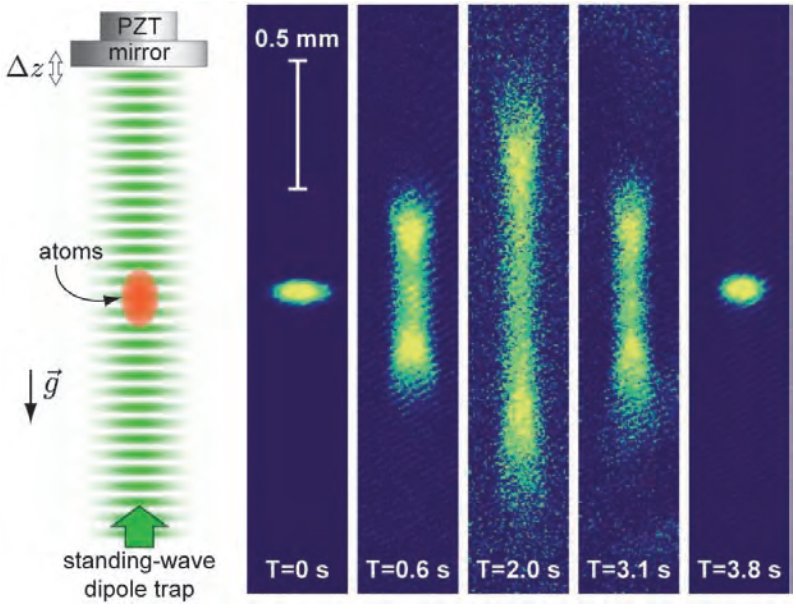
Scheme of chip components: pictures of (a) PDMS chambers, (b) interdigitated electrodes and (c) of the assembled device. (d) Optical image of interdigitated electrodes and cells on the top: Cells are optically accessible through an inverted microscope during the measurements.

SENSORS

Extending and manipulating matterwaves: experimental laser techniques to tailor the wavefunction of laser cooled atoms

A. Alberti, V.V. Ivanov, G.M. Tino e G. Ferrari, "Engineering the Quantum Transport of Atomic Wavefunctions over Macroscopic Distances", *Nature Physics, Letters* Published online: 28 june 2009. doi: 10.1038/nphys1310.

The atomic spatial wavefunction counts among the most important parameters in the realization of novel devices, or sensors, based on the quantum nature of matter. Indeed, the capability of tailoring in specific states the spatial wavefunction of atoms is at the basis of new quantum devices that, potentially, could outperform state-of-the-art giroscopes, accelerometers, clocks, and even computers. This quantity is generally very fragile against external perturbations: in the atomic case its extension ranges between fractions of nanometer at room temperature, up to few tens of microns for ultracold gases at the quantum degeneracy. While changing its properties, the probability to "break" the wavefunction, or rather to loose its properties of quantum coherence, increases critically with the increase of its spatial extention. Through researches brought forward at the National Institute of Optics of the CNR, in collaboration with the laboratory LENS in Florence, it was identified a new experimental method to extend and manipulate the wavefunction of laser cooled atoms which were trapped in periodic optical potentials realized with interfering laser beams. By applying a periodically modulated acceleration along the axis, the transport, that corresponds to the tunneling among the lattice's sites, is dynamically activated such that the wavefunction which initially is less than 500 nanometer wide (about the distance between adjacent lattices cells), is stretched to more than one millimeter, then delocalizing the wavefunction over more than 4000 lattice sites. The novelty here is in preservation of the wavefunction's coherence properties during the stretching and, by acting on easily accessible modulation parameters, in the capability to fully reverse the process hence recovering the initial state. In addition, this method of tailoring the quantum transport was demonstrated employing strontium as atomic species, which is one of the most promising candidates towards the realization of novel quantum sensors.



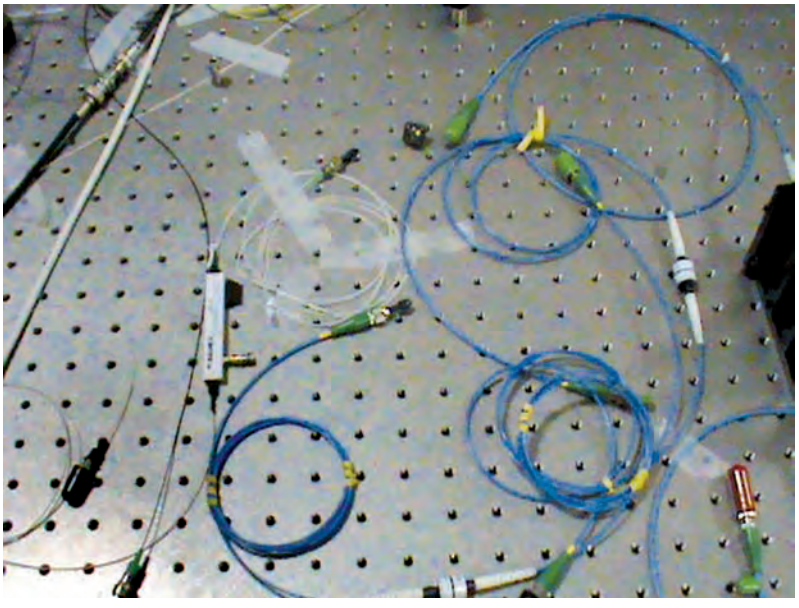
Spatial distribution of Sr atoms.

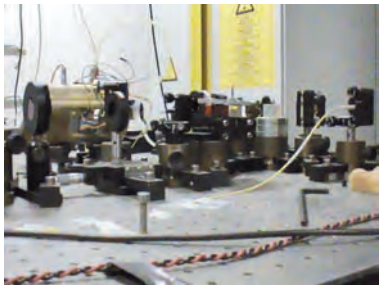
SENSORS

Probing the ultimate limit of fiber-optic strain sensing

The measurement of relative displacements and deformations is important in many fields such as structural engineering, aerospace, geophysics and nanotechnology. Optical fiber sensors have become key tools for strain measurements. The ultimate performance of fiber-optic sensor is often hampered by the light source phase noise, which traditionally restricts the achievable strain (fractional length change) resolution to the range of 10^{-6}–10^{-9} $Hz^{-1/2}$. This level is not sufficient for a number of high-precision applications (i.e. geophones, accelerometers, seismometers, gravimeters). By exploiting the high stability of a pulsed-laser frequency comb — an optical frequency reference with a spectrum made of equidistant longitudinal laser modes, — researchers at CNR - National Institute of Optics (INO) of Naples, Italy have now pushed this sensitivity down to 10^{-13} $Hz^{-1/2}$, even in the infrasonic frequency range. The system sensitivity appears to be limited only by spontaneous fiber refractive-index fluctuations of thermodynamic origin. Their setup consists of a sensing element and a diode laser emitting at 1560 nanometers which is directly referred to an optical frequency comb with a quartz reference oscillator. The sensing element is a Fabry–Pérot resonator comprising two fiber Bragg-grating reflectors. The laser noise is drastically reduced by phase-locking to the comb. This results in a phase coherent link between the laser and the quartz oscillator, allowing an almost frequency-noise-free interrogation system to be achieved. Changes in the cavity resonance frequency resulting from mechanical perturbations are translated into frequency changes in the comb spectrum, which can be measured by a precision counter. Such a high strain sensitivity may help scientists to design new sensors for measuring fundamental physical quantities in different application fields.

G. Gagliardi, M. Salza, S. Avino, P. Ferraro, P. De Natale, "Probing the Ultimate Limit of Fiber-optic Strain Sensing", *Science*, 330 (2010), pp. 1081-1084.





Typical optical fiber devices used for strain sensing.

Detail of the optical set-up used for interrogation of the fiber sensor.

NANOSCIENCES

Microdisk lasers for a future generation of sensors

Semiconductor lasers are probably among the technologies that in the last years have had more impact in everyday life; one can just recall CD and DVD players and fibre-optics telecommunications. Research in this field is proceeding at a rapid pace, and one of the most relevant challenges is the more and more extreme miniaturization, both to reduce consumption and to allow the use of an ever-increasing number of lasers in parallel.

In this direction one can also place the invention developed in the present work by the scientists of the NEST centre of the Institute of Nanoscience. Through electron lithography techniques, a microdisk laser has been realized in which the radiation, through total internal reflection, is forced to travel along the circular perimeter of the device (analogously to the well-known phenomenon of acoustic waves propagating along curved surfaces, for instance in the apses of churches). This kind of semiconductor lasers was already known, but the researchers have succeeded in solving the fundamental problem of how to extract in a useful way the emitted light. Normally, in fact, in this class of devices, the radiation is strongly confined within the laser resonator and the weak emission is uniformly distributed over the whole disk plane. Implementing a special metallic grating, composed by a prime number of slits, over the surface of the laser, the emitted radiation is extracted and collimated in the vertical direction, thanks to a peculiar interference effect. This innovation has been here applied with success to so-called "quantum cascade lasers", emitting radiation at frequencies in the range 1 and 10 THz (1 THz corresponds to one trillion oscillations per second), a spectral region between infrared and microwaves that is nowadays still underdeveloped commercially, precisely for the lack of compact, low consumption, solid-state components.

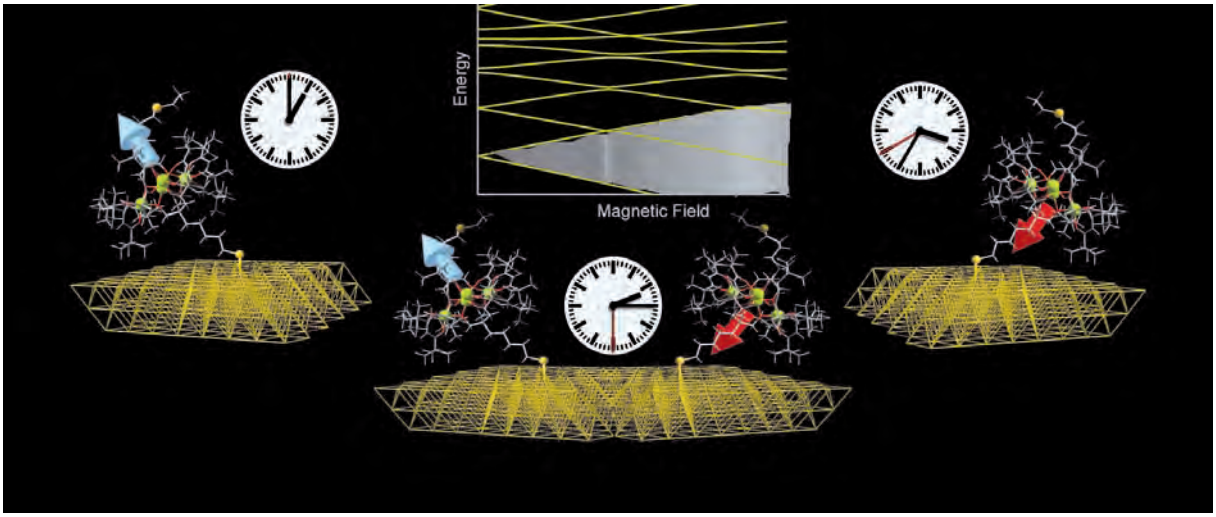
In the figure an electron microscope picture of a device is reported together with the calculated emission profile. Already in this first implementation record high efficiencies have been obtained and high-power devices are now possible with ring geometries and larger diameters. The invention allows the realization of microchips containing an array of lasers in parallel, paving the way to the application of THz technologies in various industrial fields, for instance as biomolecular sensors, or in security-control imaging, or in quality control of several production processes.

Microdisk laser.

L. Mahler, A. Tredicucci, F. Beltram, C. Walther, J. Faist, B. Witzigmann, H.E. Beere, e D.A. Ritchie, "Vertically Emitting Microdisk Lasers", *Nature Photonics*, Vol. 3 (2009), January 46.

NANOSCIENCES

Molecular magnetism at the nanoscale



Representation of the observed resonant quantum tunneling of the magnetization.

The exciting aspect of nanomaterials is being borderline between classical and quantum world. Single-molecule magnets blend together classical and quantum physics showing a spectacular memory effect and quantum effects, whose application in the field of information storage and spintronics is a long-sought goal. The Laboratory for Molecular Magnetism of the University of Florence, URT of the Institute of Molecular Science and Technologies (ISTM) of the CNR, this year achieved a fundamental result in the field of Molecular Magnetism, the observation of the resonant quantum tunneling of the magnetization on a monolayer of magnetic molecules assembled on a metallic surface. This result has been reached by exploiting an international collaboration within several groups in the aegis of an European Network of Excellence coordinated by INSTM, the Italian consortium for Science and Technology of Materials.

The strength of the work published on *Nature* comes from combining synthetic chemistry, measurements with synchrotron light in extreme conditions and three different types of theoretical approaches to substantiate the experimental findings. By a rational design of the magnetic molecules, the molecular orientation of the assembled units has been controlled permitting to observe by using the X-ray Magnetic Circular Dichroism (XMCD) technique, at low temperature, the non-classical effects in the dynamics of the magnetization, which could be exploited to realize quantum operations in future molecular spintronic technology. XMCD is one of the most powerful techniques available to study the magnetism of ultra diluted systems, having an incredible sensitivity and a perfect element selectivity permitting to focus the analysis only on the monolayer of iron-based molecules grafted on top of a gold surface. A solid theoretical analysis permitted to fully understand the observed phenomena and scanning tunneling microscopy has been employed to directly image the monolayer film down to the molecular resolution. Although applications in current technology are not foreseen in short times because of the low working temperatures of single molecule magnets, this kind of fundamental investigations pave the way for future spin-based technologies. Of course the job is not ended, the next goal would be the fascinating possibility to probe and control the dynamics of the magnetization at the single-molecule level.

M. Mannini, F. Pineider, C. Danieli, F. Totti, L. Sorace, P. Sainctavit, M.-A. Arrio, E. Otero, L. Joly, J.C. Cezar, A. Cornia, R. Sessoli, "Quantum tunnelling of the magnetization in a monolayer of oriented single-molecule magnets", *Nature*, 468 (2010) pp. 417-421.

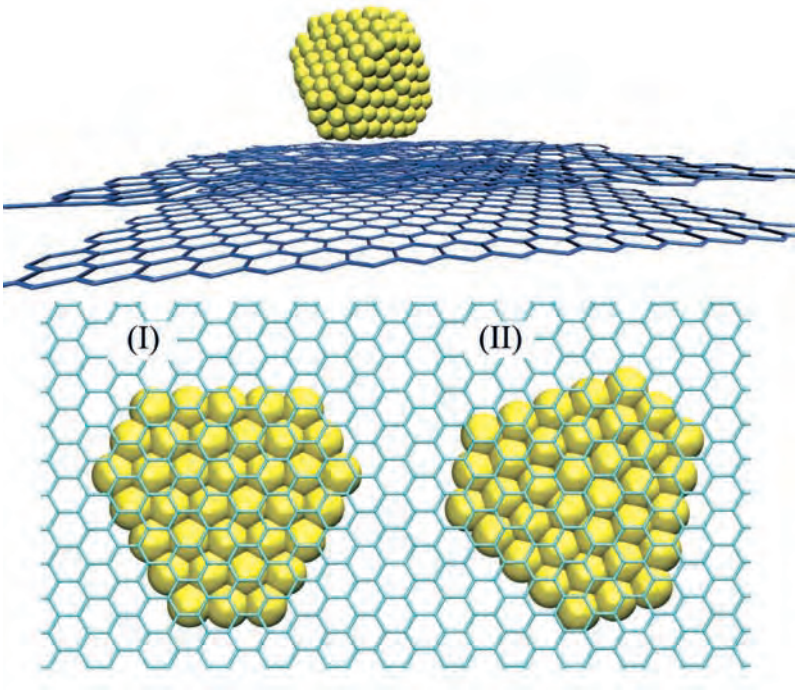
NANOSCIENCES

Ballistic nanofriction

R. Guerra, U. Tartaglino, A. Vanossi, E. Tosatti, "Ballistic nanofriction", *Nature Materials*, 9, 634 (2010). [Highlighted by A. Schirmeisen in 'News & Views' of Nature Materials, *Nature Materials*, 9, 615 (2010)].

Friction is a hot topic for scientific and technological reasons; yet, five centuries after Leonardo da Vinci, much effort is still devoted to understand the underlying physics, particularly in new directions including nanosystems. In that area, one direction which is currently neglected is high speed friction – most fundamental physical tribology and nanofrictional studies focus on exceedingly low speeds. Yet, there are situations where it may be important to know what exactly happens when for example an adsorbed molecule or cluster slides over a solid surface at hundreds of meters per second. Employing a "molecular dynamics" simulation study, CNR researchers have begun to unravel the elemental mechanisms at play in the frictional dynamics of fast nano-objects sliding on crystalline surfaces. The system chosen for the prototype study is a gold nanoparticle on graphite – small gold clusters are in fact known to be thermally mobile when deposited on the very "slippery" graphite surface.

Simulating the motion of diffusing and slowly drifting, and of fast moving "kicked" gold clusters on graphite, the study demonstrates analogies and differences between low speed sliding, which is diffusive and long understood, and high speed sliding, so far unexplored. At high speed, a novel frictional regime, freshly designated as "ballistic", emerges. The slowing down of the cluster's speed appears as the result of successive collisions with thermal excitations of the surface; as a result, ballistic friction increases with temperature, unlike standard diffusive friction, which is well known to decrease. Also, the interplay of rotations and translations is completely opposite in low speed friction, where the two work in phase, and in ballistc friction, where they are out of phase, and kinetic energy bounces back and forth between translation and rotation. A broad crossover regime of intermediate speeds between ballistic and diffusive friction is identified and described. Finally, and perhaps surprisingly in view of their different mechanisms, the ballistic frictional force grows roughly linearly with speed, similar to low speed "viscous" friction. While these results highlight exquisitely physical aspects of high speed friction, the ballistic friction concept may be expected to become of future relevance to potential applications in nanosystems such as, e.g., nanoelectromechanical systems and nanomotors, as well as to other problems involving high speed gas collisions with solid surfaces.



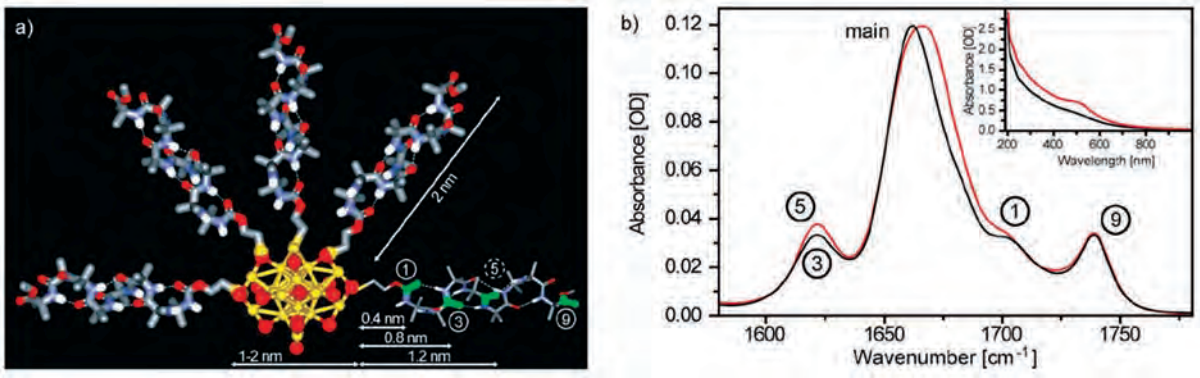
Simulated gold cluster sliding over a graphite surface. In-registry (I) and out-of-registry (II) geometries for the cluster's (111) contact facet and the graphite.

NANOSCIENCES

Molecular thermometer using peptide helices over gold nanoparticles

Although gold is the subject of one of the most ancient themes of investigation in science, its renaissance now leads to an exponentially increasing number of publications, especially in the context of emerging nanoscience and nanotechnology with nanoparticles (AuNPs). AuNPs, the most stable metal nanoparticles, present fascinating aspects, such as their multiple types of assembly, involving materials science, behavior of the individual particles, size-related electronic, magnetic and optical properties, and their applications to catalysis and biology. We are currently interested in plasmonically heated AuNPs that have found numerous therapeutic applications in the field of life sciences. For example, in hyperthermal therapy of cancer, plasmonically heated AuNPs are used for the localized deposition of heat into human cancer tissues resulting in irreversible thermal cellular destruction. In the AuNPs synthesis, a mixture of molecular precursors is converted by the addition of appropriate reagents into a collection of monodisperse and well-organized objects wherein an inorganic core is coated with a tightly packed three-dimensional monolayer of organic species. A target that has been extensively addressed over the years is the preparation of nanoparticles coated with peptides that have a defined helix structure. Viewed from the outside, such nanoparticles closely resemble artificial globular proteins, where the biocompatibility of the coating, chiral space organization, and functional group crowding could pave the way for the realization of complex functional systems. In our specific application, we used time-resolved, visible pump/visible probe spectroscopy to determine the cooling times of plasmonically excited nanoparticles and derive the thermal conductance of the metal/capping layer/solvent interface to better understanding the mechanism by which heat is transported over a specifically designed, biocompatible capping layer.

M. Schade, A. Moretto, P. Donaldson, C. Toniolo, P. Hamm, "Vibrational energy transport through a capping layer of appropriately designed peptide helices over gold nanoparticles", *Nanoletters*, 10 (2010), pp. 3057-3061.



(a) Cartoon structure of the peptide-capped nanoparticles. The labels indicate the positions of the different CdO thermometers in the capping layer relative to the gold core at the N-terminus. (b) FTIR and UV-vis (inset) spectra in acetonitrile-d_3 recorded for nanoparticles 1 (black) and 2 (red) at equal effective peptide concentration.

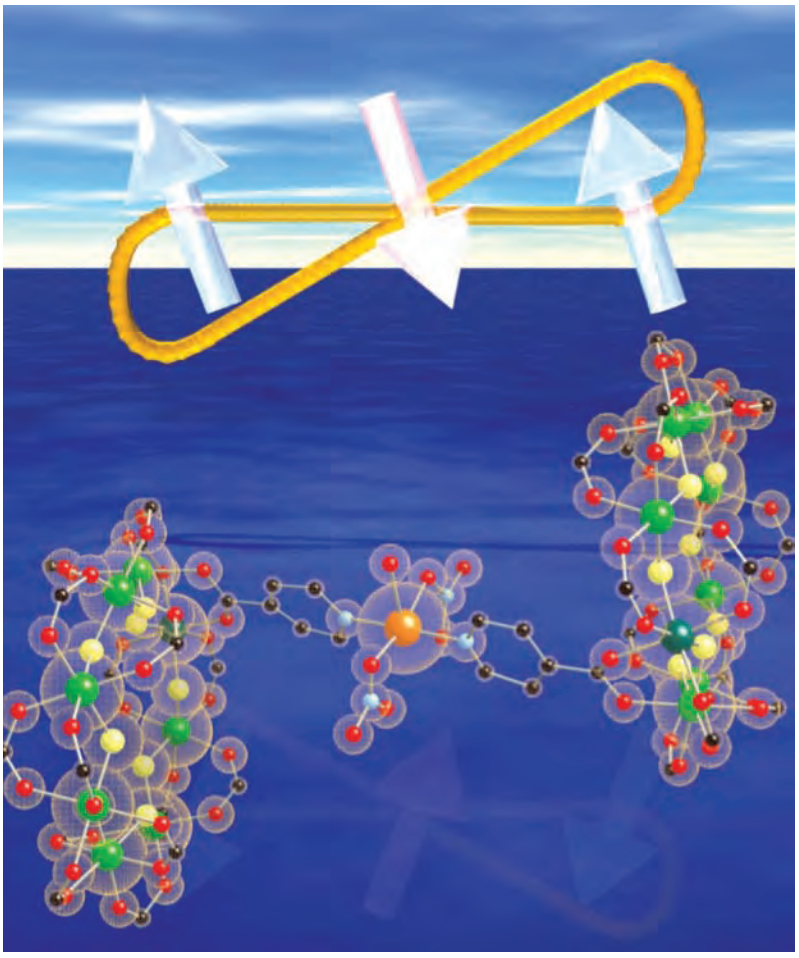
NANOSCIENCES

Control of spin correlation between molecular nanomagnets

Nanoscale engineering enables to control interactions between well-defined molecular building blocks; this is a fundamental step for the implementation of logic gates in molecular devices envisaged for the future. The ability to assemble weakly-interacting subsystems is, indeed, a prerequisite for generating controlled entanglement between molecular building blocks and eventually for implementing quantum-information processing. Entanglement is a genuine characteristic of quantum systems which makes each part of it to posses information about the other constituents of the system (quantum correlation). As such, entanglement is fragile and difficult to control, especially in solid state systems. In recent years, molecular nanomagnets have attracted much interest as suitable candidates for the qubit encoding and manipulation. The work carried on at CNR Nanoscience Institute S3 refers more specifically to antiferromagnetic Cr_7Ni rings that at low temperature behave as effective spin-1/2 systems and exhibit long decoherence times.

The S3 team, with British and French colleagues, succeeded in controlling the quantum correlation (entanglement) between molecular spins, more specifically between two weakly-coupled antiferromagnetic rings (purple-Cr_7Ni). The observed entanglement is, therefore, beyond the molecular scale, that is, it occurs at "supramolecular level". The molecular structures have been characterized by low-temperature specific heat, magnetization measurements and EPR spectra. Intra and inter-ring interactions are modelled through a microscopic spin Hamiltonian approach that reproduces the experimental data quantitatively and legitimates the use of an effective two-qubit picture. Spin entanglement between the rings was then quantified by computing the concurrence as a function of temperature and magnetic field.

This work shows the deep level of control that was achieved at synthetic level as well as by experiments at very low temperature and by theoretical models that encompass full description of the system with microscopic and molecular degrees of freedom.

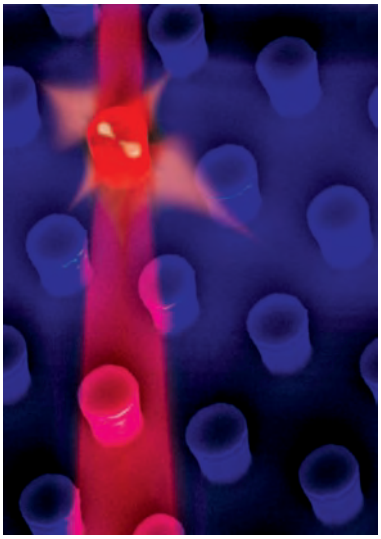


This picture simultaneously shows the molecular assembly we have studied and the pictorial representation of spin entanglement between the different molecular spin degree of freedom.

A. Candini, G. Lorusso, F. Troiani, A. Ghirri, S. Carretta, P. Santini, G. Amoretti, C. Muryn, F. Tuna, G. Timco, E.J.L. McInnes, R.E.P. Winpenny, W. Wernsdorfer, M. Affronte, "Entanglement in Supramolecular Spin Systems of Two Weakly Coupled Antiferromagnetic Rings (Purple-Cr7Ni)", *Phys. Rev. Lett.* 104, 037203 (2010).

NANOSCIENCES

Building an electron dimer molecule with light



Pictorial representation of the experiment: measuring with light the vibrational frequency of an electron dimer molecule.

Two electrons have been trapped within an area of a few nanometers inside a semiconducting crystal nanostructure -a quantum dot. Their peculiar quantum state, which is known as an 'electron molecule' being very similar to that of a diatomic molecule, has been measured for the first time by a team involving scientists from CNR-NANO (NEST and S3 centers in Pisa and Modena, respectively), Columbia University, and Bell labs.

This result has been obtained by employing a new technique to control the number of electrons in the quantum dot: one may add or remove electrons one by one from this 'nano-trap' by shining light on it by means of a laser beam. Such precise method has made possible to single out just two electrons as well as to measure the energy of their excitations. Theoretical calculations have clarified that the motion of the two electrons inside the dot has a vibrational character, being analogous to the one observed for the atoms of a diatomic molecule.

Electrons confined in quantum dots are important candidates for quantum computation: one challenge is their precise manipulation. Usually this is achieved by electrical control. Hower, in order to attach electric contacts to the quantum dot one has to cover the crystal nanostructure with metallic layers. The new technique has the same ability to inject single electrons but it is not invasive. In fact, manipulation by means of light does not affect the crystalline structure, allowing for the study of the inherent properties of the electrons inside the dot.

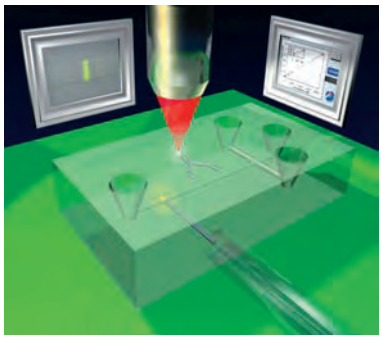
The electron molecule state was theoretically predicted but never directly measured so far. The motion of the electrons is ruled by the competition between two opposite effects: the repulsion between like electric charges tends to keep electrons far apart whereas the quantum confinement of the nanostructure tends to make them stay close. The overall result is that the two electrons oscillate in a classical vibrational motion, as if they were connected by a spring. This study is the first measure of the fundamental frequency of the vibrational mode of the electron molecule.

A. Singha, V. Pellegrini, A. Pinczuk, L.N. Pfeiffer, K.W. West, M. Rontani, "Correlated electrons in optically tunable quantum dots: Building an electron dimer molecule", *Physical Review Letters* 104, 246802 (2010).

NANOTECHNOLOGIES

Advanced optical analysis techniques integrated in a lab-on-a-chip for rapid and point-of-care diagnostics

A lab-on-a-chip is a device that aims to replicate a biological laboratory into a chip: an extraordinary result being possible thanks to microfluidic techniques, where minimum quantities of liquid flow along microscopic channels. Significant results have been achieved by this approach, such as the possibility of separating biochemical



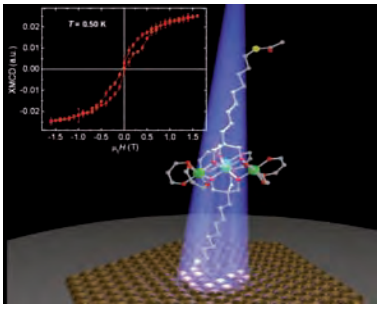
samples, at molecular level, in a microchip. However, to identify the molecules flowing inside the microchannels in the chip, a massive benchtop instrument, as an optical microscope, is required; thus undermining many of the advantages of Lab-on-a-chip devices. Nowadays, thanks to IFN (CNR) capabilities in femtosecond laser micromachining it is possible to design a lab-on-a-chip with integrated optical detection systems: the laser beam can indeed be used as a microscopic "pen" able to "write" waveguides in glass lab-on-a-chip to confine and guide the light that is necessary for the optical analysis of the molecules in the microchannel.
Recent application of this approach demonstrated an integrated detection of DNA fragments for a fast diagnosis of genetic illnesses, that in the future could be performed directly at the local doctor office. These results have been achieved in the framework of a European project (HIBISCUS - IST-2005-034562) in collaboration with academic and industrial partners.

R. Martinez Vazquez, R. Osellame, D. Nolli, C. Dongre, H. van den Vlekkert, R. Ramponi, M. Pollnau, and G. Cerullo, "Integration of femtosecond laser written optical waveguides in a lab-on-chip", *Lab Chip*, 9 (2009), pp. 91-96.

NANOTECHNOLOGIES

Magnetic molecules for future storage

One of the greatest challenges of our time is the miniaturisation of the bit, the basic unit in computer memories. As research advances, it will be possible to use molecule-based memories, which shall be developed through the design and synthesis of magnetically active molecules, their organisation into nanometric structures, and the optimisation of techniques for reading and writing the information contained in them.



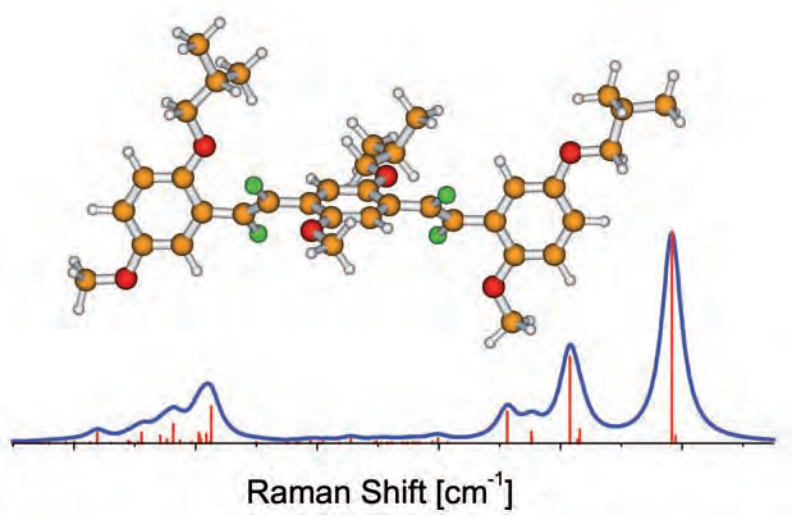
Final structure of the nanostructured material and (upper left) the resulting measurement obtained from X-ray magnetic circular dichroism experiments.

One of the most well known classes of functional molecules are the so called Single Molecule Magnets, that at sufficiently low temperatures behave like nanoscale magnets: one molecule, one bit. This class of molecules is currently being studied all over the world thanks to the impetus given to the field during the nineties by the group of Dante Gatteschi and Roberta Sessoli in Florence, who discovered the first system of this kind. Thanks to the research performed by this group, in collaboration with colleagues from the University of Modena and the University Pierre et Marie Curie in Paris, recently it was possible to prepare nanostructures of these magnetic molecules on a surface: they succeeded, in fact, in grafting in a controlled manner a single layer of molecules to a gold surface, using the molecular self-assembly method. The team then used an inspection technique based on circularly polarised X-rays to probe the magnetic properties of the very small number of molecules on such surface: working at temperatures close to the absolute zero it was possible to demonstrate for the first time that the amazing features of Single Molecule Magnets are retained also when molecules are isolated on a surface and bound to a conducting material. This result marked an important standpoint toward the production of molecule-based devices, suggesting a valid working strategy to control and study of single molecule with such complex properties.

M. Mannini, F. Pineider, Ph. Sainctavit, C. Danieli, E. Otero, C. Sciancalepore, A.-M. Talarico, M.-A. Arrio, A. Cornia, D. Gatteschi, R. Sessoli, "Magnetic Memory of a Single-Molecule Quantum Magnet Wired to a Gold Surface", *Nature Materials*, 8, pp. 94-197 (2009).

NANOTECHNOLOGIES

Conductive polymers for the realization of OLEDs



The realization of electroluminescent polymers like Organic Light Emitting Diodes (OLED) makes large use of the properties of conjugated polymers, which belong to the class of semi-conducting organic materials. These systems possess optical and electronic properties that can be easily modified using different functional groups.

In this context CNR researchers at the National Nanotechnology Laboratory of CNR-INFM (now CNR-NANO) in Lecce studied the effect of fluorination. Fluorine atoms are introduced in the polymer in order to shift the emitted light in the blue region, a colour needed to create white light emitting OLEDs.

In particular vibrational states of one of the mostly applied polymers, polyphenylenevinylene (PPV) have been investigated, by comparing the properties of PPV fluorinated at the double bond with the non-fluorinated species. The characterization employed Raman spectroscopy and quantum mechanical simulation techniques. The results have shown that the most important difference in the Raman spectra of fluorinated and non-fluorinated polymers can be traced back to an elongation of the carbon-carbon double bond of the vinylene groups. A comparison of the theoretical results with experimental Raman spectra of related oligomers revealed that this difference can be related to the significant distortion of the fluorinated molecules. This effect is due to the repulsive interaction of the fluorine atoms at the vinylene bond with the neighbouring oxygen atoms at the phenyl rings and results in a strong blue shift of the emitted light.

This work was performed in the framework of the FIRB SYNERGY project, funded by MIUR and involved different national institutions (Bari, Genova, Lecce and Pavia) with expertise in various disciplines (chemical synthesis, spectroscopy and theoretical simulations).

M. Piacenza, D. Comoretto, M. Burger, V. Morandi, F. Marabelli, C. Martinelli, G. M. Farinola, A. Cardone, G. Gigli, e F. Della Sala, "Raman Spectra of Poly(pphenylenevinylene) s with Fluorinated Vinylene Units: Evidence of Inter-ring Distortion", *ChemPhysChem*, 10 (2009), pp. 1284-1290.

NANOTECHNOLOGIES

Highly conductive nanoribbons of coordination polymers

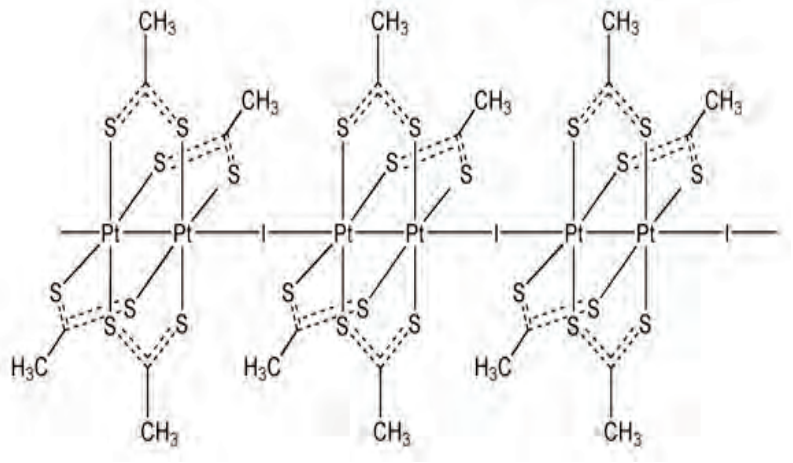
MMX polymers are a key to the implementation of future, powerful and highly-integrated electronic devices and computing architectures.

Molecular electronics is the solution of choice proposed for electronic circuits beyond nowadays silicon-based electronics. Intense research efforts aim at identifying suitable organic components that might be anchored to inorganic supports and integrated in electronic circuits. A molecular wire must fulfill two basic requirements for the construction of complex devices: it should transport charge with a low resistance and should

have structuring capabilities, based on the self-assembly of its building blocks. Very few molecular systems match both requirements: MMX nanoribbons do.

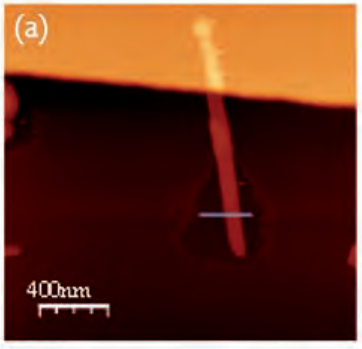
A joint experimental-theoretical investigation of electrically conductive MMX coordination polymers - $[Pt_2I(S_2CCH_3)_4]_n$ - self-assembled on an insulating substrate by direct sublimation of polymer crystals was carried out. The main characteristic of these polymers is the embedding of metal centers into the organic matrix in a controlled, modular manner and the realization of 3-, 2- and 1-dimensional arrangements. The electrical measurements are obtained with the conductive atomic force microscopy (AFM) technique at room temperature. The theoretical characterization of the electronic structure is based on density functional theory (DFT) approaches.

Our results show that one-dimensional MMX chains can be isolated and exhibit striking electrical transport properties. The observed currents exceed those sustained in other organic and metal–organic assemblies on surfaces by orders of magnitude and over longer distances, demonstrating the prime potential of these wires for future ICT. Theory elucidates the structure and electronic coupling at the hybrid interface.



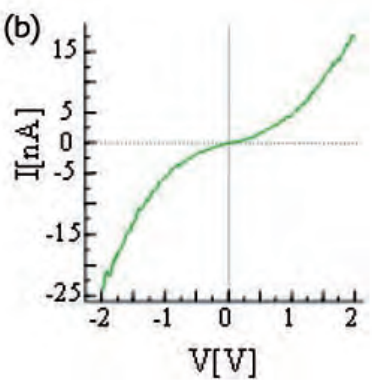
Schematic of a single MMX $[Pt_2I(S_2CCH_3)_4]_n$ wire. Bottom panel.

L. Welte, A. Calzolari, R. Di Felice, F. Zamora, and J. Gómez-Herrero, "Highly conductive nanoribbons of coordination polymers", *Nat. Nanotech.*, 5, 110 (2010). doi:10.1038/nnano.2009.354

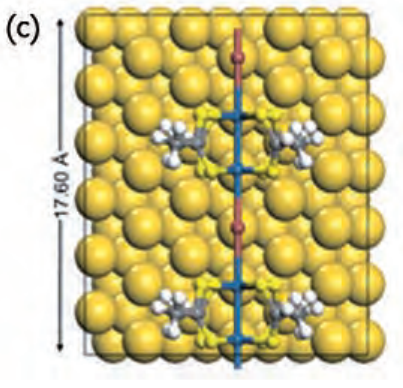


a)

AFM topography showing a MMX wire adsorbed on mica.



b)
Current versus voltage characteristic taken by contacting the nanoribbon 100 nm from the gold electrode. Image adapted from original paper.



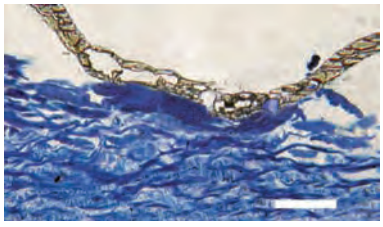
c)

Top view of an infinite MMX chain on Au(111).

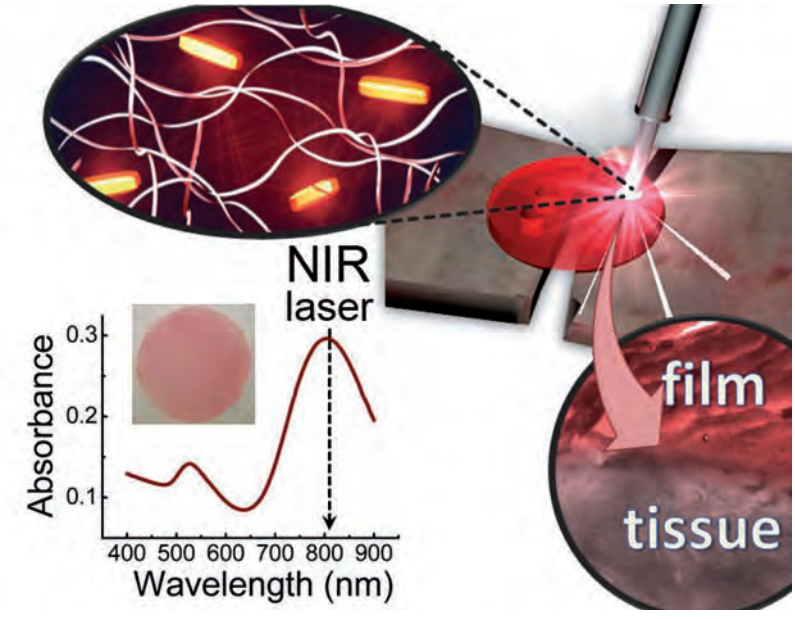
NANOMEDICINE

Laser-activatable adhesive films for the repair of biological tissues

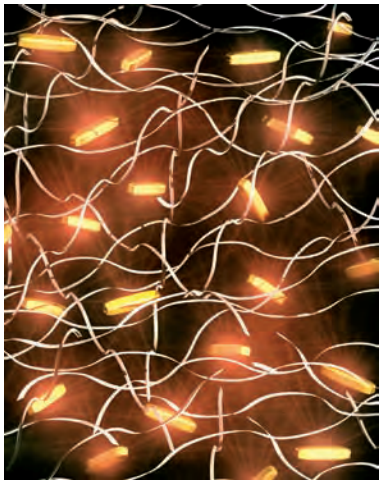
Smart materials that respond to external stimuli, such as light or temperature, are attracting growing interest in several biomedical areas ranging from controlled drug release to tissue repair, as well as in microdevices. In this regard, the Institute of Applied Physics of the CNR, in collaboration with the University of Florence, has recently developed a smart hybrid material consisting of biocompatible chitosan films doped with cylindrical gold nanoparticles (called "gold nanorods"), which can be activated by diode laser radiation at 810 nm and precisely bind biological matter, like a light-activated plaster for tissue repair and wound dressing. These gold nanoparticles absorb laser light in the so-called "therapeutic window", where biological tissues are almost transparent, enabling selective and localized conversion of light into heat. In turn temperature induces the activation of the polar chitosan strands, which become available to bind adjacent biological matter, ultimately resulting in a functional adhesion effect. The chitosan matrix imparts excellent stabilization and distribution of the particles, which translates into a dependable optical response and photothermal conversion, usable for e.g. tissue repair, as well as temperature-controlled drug release. These films are resistant, pliable and stable under physiological conditions and dissolve in the body within several weeks. In addition, chitosan is a natural biopolymer that stimulates tissue regeneration, exerts antimicrobial activity and may be used to host and release drugs. These smart hybrid materials have been successfully tested for the closure of wounds in arteries and the skin.



Functioning of chitosan/gold nanorods films as laser-activatable adhesives.



Cross-sectional slice of a laser-induced weld between a chitosan/gold nanorods film and a porcine carotid artery (bar = 100 μm).



Inside view of a laser-activated chitosan/gold nanorods film.

P. Matteini, F. Ratto, F. Rossi, S. Centi, L. Dei, R. Pini, "Chitosan films doped with gold nanorods as laser-activatable hybrid bioadhesives", *Advanced Materials*, 22 (2010), pp. 4313-4316.

NANOELECTRONICS

New insights on graphene, the material of the future

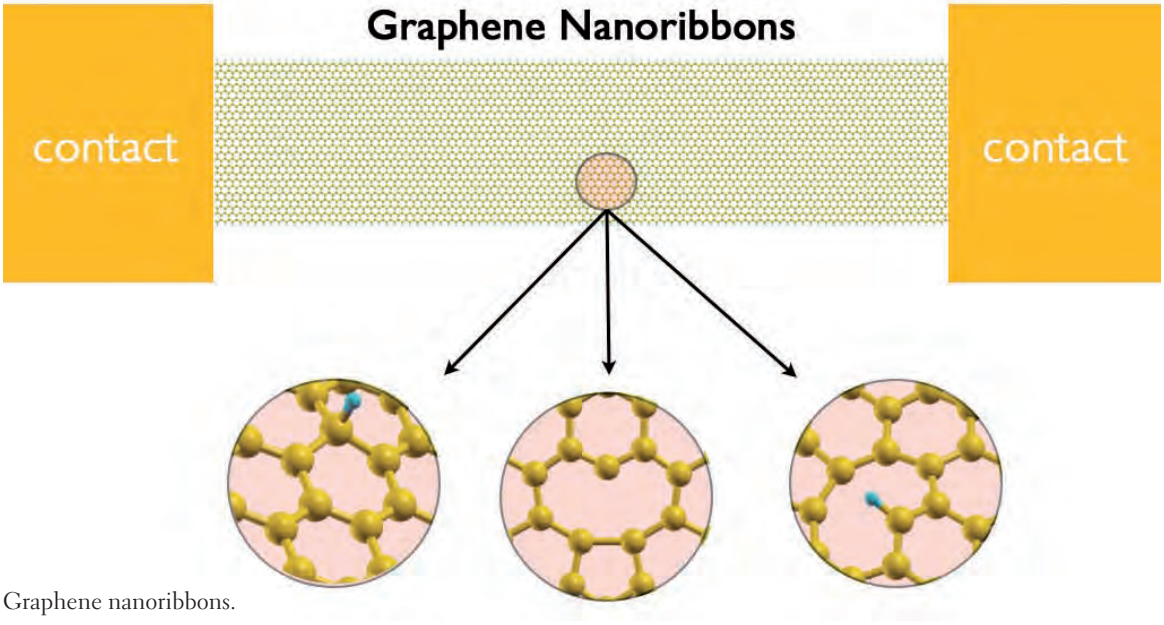
Since it was synthesized in the laboratory for the first time in 2004 by two Manchester University physicists, Andre Geim and Kurt Novoselov, graphene - a single plane of carbon atoms - has become one of the most promising candidates for pioneering applications of nanoelectronics and beyond.

The unprecedented properties of graphene, such as the huge carrier mobility, have pushed towards the development and improvement of synthesis techniques that have allowed, for example, the fabrication of graphene nanoribbons (stripes of nanometric width, see figure) for new generation interconnections and nano-transistors. These systems show very interesting transport behaviour, because the typical graphene electronic properties combine with the carrier lateral confinement, giving origin to an almost one-dimensional system.

An atomistic theoretical study of the electronic and transport properties of large scale graphene nanoribbons has been performed by researchers of the CNR-SPIN Institute (Napoli): one of the most relevant results concerns the possibility of realizing a spin valve, namely, a device which allows spin filtered transport in graphene nanoribbons with well defined crystallographic orientation.

Defects following hydrogenation or treatment with ion or electron beams, can be effectively used to induce asymmetry in the transport of electrons with opposite spins. Therefore, this structural disorder (meant as random distribution of defects within the structure) or the interaction with suitable chemical species (functionalization) are shown to be important tools to modify in a controlled way the properties of this extraordinary material.

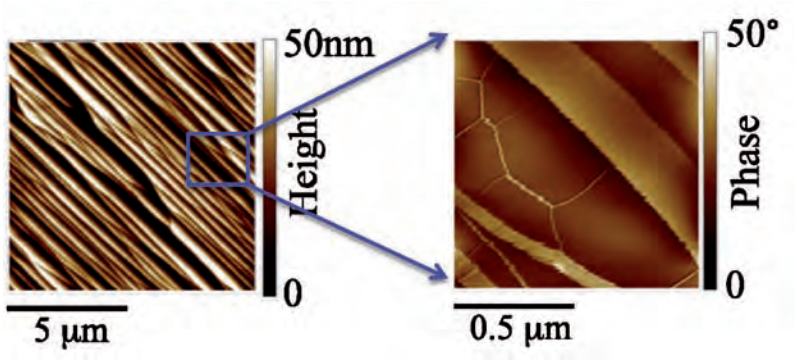
G. Cantele, Y.S. Lee, N. Domenico e N. Marzari, "Spin Channels in Functionalized Graphene Nanoribbons", *Nano Letters*, Vol. 9, No. 10, (2009), 3429.



Graphene nanoribbons.

NANOELECTRONICS

Nanoelectronics in graphene



Epitaxialgraphene grown on 4H-SiC (100 mm diameter).

Graphene nanoelectronics should operate much faster than in Si due to its intrinsic properties. Graphene is a honeycomb sheet of atoms, with carbon atoms at the nodes, in a single atomic plane. Graphite, the pencil mineral, is just formed by many graphene layers overlapped. Charges in graphene lose a very limited amount of energy in scattering or collisions with the network atoms, so that giant mobility (several order of magnitude higher than Si), and an extremely reduced thermal dissipation, allowing huge current densities. Graphene has been experimentally demonstrated only in 2004 (Nobel prize to A. Geim and K. Novoselov in 2010) and just very recently produced in large sheet by several methods.

The CNR researchers at the Institute for Microelectronics and Microsystems in Catania are involved in the development of nanoelectronics in graphene (material growth in large area and innovative devices) since 2005 and have been among the first to measure transport properties locally with a nanometre lateral resolution. In particular, using a scanning capacitance microscopy they measured local variations of the quantum capacitance and consequently determined the local density of states and the carrier diffusion length. The macroscopic capacitance measures the capability of an electrode to accumulate charges per unit of applied voltage. However, in nanomaterials the states available (density of states) are limited so that also capacitance assumes quantum behaviours and became sensible to nanoproperties of the material.

The studies have been preliminary for more recent developments such as the local measure of carrier mobility and its correlation with local defects, opening to new strategies to improve the material quality and propose new high performant devices.

F. Giannazzo, S. Sonde, V. Raineri and E. Rimini, "Screening lenght and quantum capacitance in graphene by scanning probe microscopi", *Nano Letters*, (2009), vol. 9, n.1, 23-29.

SUPERCONDUCTIVITY

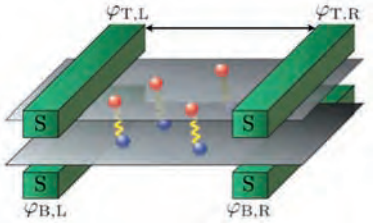
Blocking and dragging supercurrents with exciton condensates

Boson and Fermion-pair condensation is among the most remarkable phenomena in Physics: quantum behavior is promoted from the microscopic to the macroscopic scale. The superconducting state of a metal, for instance, consists of a spontaneous condensation of conduction electron pairs (Cooper pairs), which allows dissipationless charge flow. Recently, a considerable interest has been devoted to Exciton condensates (ECs), macroscopically ordered states of a solid in which phase coherence establishes between electrons and holes in different bands. Spontaneous coherence between separate two-dimensional electron layers has been reported in quantum Hall bilayers as well as in optically-excited cold gases. When the two layers are contacted separately, bilayer ECs can exhibit counterflowing supercurrents.

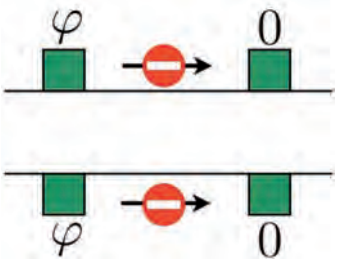
In this article we propose a new mechanism for dissipationless transport associated to the conversion of the EC neutral supercurrent into Cooper-pair charged supercurrent. We demonstrate that, when two superconducting circuits are coupled by planar weak links forming a bilayer EC, the behavior of supercurrents is dramatically affected. If the same phase bias is applied to both junctions, an exciton blockade of the Josephson currents occurs. In contrast, when a phase bias is applied to only one layer it induces a superdrag in the

other i.e. a counterflow supercurrent of the same magnitude appears in the unbiased layer.
The unique properties of the conversion of EC currents into charged supercurrents can be exploited for a number of possible applications, such as for the design of coherent electronic devices. In addition, graphene-based bilayer systems seem to be optimal candidates to observe this effect, due to their weak dielectric screening and linearly dispersive bands.

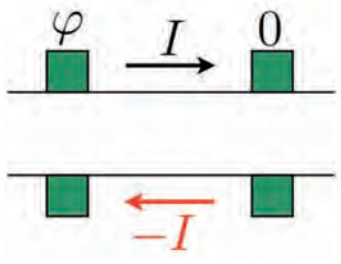
F. Dolcini, D. Rainis, F. Taddei, M. Polini, R. Fazio, A.H. MacDonald, "Blockade and Counterflow Supercurrent in Exciton-Condensate Josephson Junctions", *Phys. Rev. Lett.* 104 (2010), pp. 027004-1 - 027004-4.



Sketch of a superconductor-exciton-condensate-superconductor system. A double-layer exciton condensate is contacted with four superconductors.



When the applied phase biases in the top and bottom layers are identical no current can flow ("exciton blockade" regime).

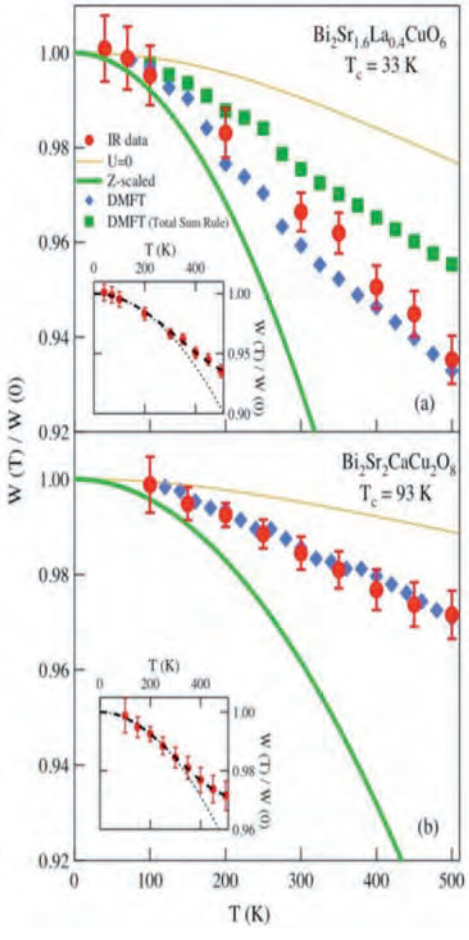


When a phase bias is applied to the top layer only, a supercurrent I flows and a supercurrent -I is dragged in the bottom layer ("superdrag" regime).

SUPERCONDUCTORS

Optical study of Bi-based cuprates at high temperatures

Since their discovery in 1986, the research on superconducting cuprates, (perovskites containing one or more copper-oxygen plane in each unit cell) has been obviously focused on their "low-temperature" properties, like the superconductivity and the so-called pseudogap. This is a zone of empty states which opens in the Fermi surface of the carriers below optimum doping. However, the same effects behind these phenomena, like the electron-electron Hubbard repulsion (also named correlation), are likely to affect the cuprate properties at higher T. For example, the Ioffe-Regel limit for the resistivity saturation (where the scattering by phonons is strong that it localizes the carriers) is not observed at the predicted temperatures. Moreover, the high-T behavior can provide direct information about the real nature of the fermionic excitations, which, at low T, may be masked by competing ordering phenomena. Nonetheless, the high-T properties of the cuprates have been scarcely investigated up to now. The present work is, to our knowledge, the first optical study of two Bi-based cuprates at optimum doping, from their critical temperature T_c (where superconductivity disappears) to 500 K. We have measured their optical conductivity $\sigma(\omega)$ and their spectral weight W (Ω,T) (the integral of $\sigma(\omega)$ up to a cut-off frequency Ω).
The T-dependence of the carrier kinetic energy (which is proportional to W (T)) is described in terms of the Sommerfeld expansion, which is usually arrested to the first term in T^2. We have found that, above 300 K, W (T) deviates



from the T^2 behavior in both compounds, even though the extrapolation to a dc conductivity $\sigma(\omega \to 0)$ remains well far from the Ioffe-Regel limit. As shown in the Figure, the deviation is well described by the second term of the Sommerfeld expansion, namely that in T^4. This is surprising because, despite all the anomalies encountered in the behavior of high-T_c superconductors, they can be described by a Fermi-liquid picture up to such a high T. However, the coefficients of both the T^2 and the T^4 term are much enhanced by strong correlations, as it has been shown by the dynamical mean field theory (DMFT) calculations which complete our paper.

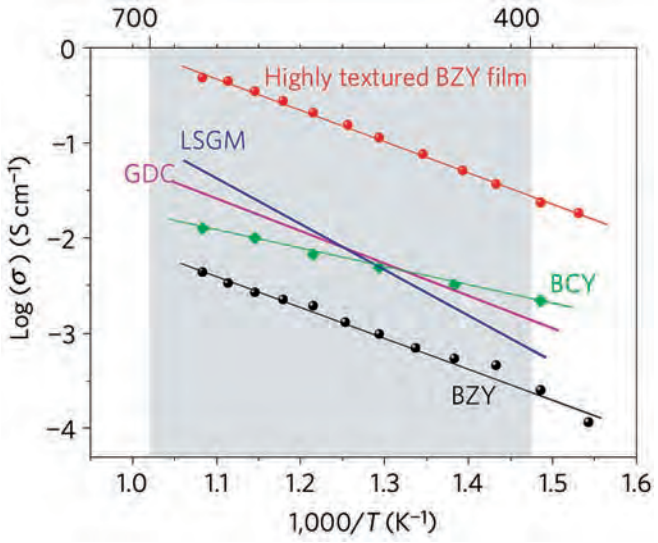
D. Nicoletti, O. Limaj, P. Calvani, G. Rohringer, A. Toschi, G. Sangiovanni, M. Capone, K. Held, S. Ono, Yoichi Ando, and S. Lupi, High-Temperature Optical SpectralWeight and Fermi-liquid Renormalization in Bi-Based Cuprate Superconductors, *Physical Review Letters*, 105 (2010), 077002, pp.1-4.

SUPERCONDUCTORS

The most performing electrolyte for oxide fuel cells

High quality, grain-boundary free, thin films of yttrium-doped barium zirconate ($BaZr_{0.8}Y_{0.2}O_{3-ä}$, BZY) were produced using pulsed laser deposition. These films exhibited the largest proton conductivity values ever reported for BZY samples, namely 0.11 Siemens/cm at 500°C and 0.01 Siemens/cm temperatures as low as 350°C.
These conductivity values are substantially larger than those attained by the $La_{0.8}Sr_{0.2}Ga_{0.2}O_3$ (LSGM) and $Ce_{0.8}Gd_{0.2}O_{1.9-\delta}$ (GDC) that were presently considered to be the oxygen ion conductors with the highest conductivity in the same temperature range.
The high conductivity values of the BZY films, in the intermediate temperature range, mean that the this proton conductor maybe thought of as a possible substitute for the oxygen-ion conductor electrolytes conventionally used in solid oxide fuel cells (SOFCs).
Common to other proton conductors the BZY also offers the important advantage that the water exhaust is produced at the cathode side, avoiding fuel dilution with water and improving efficiency.
In order to be used in a wide range of applications it is mandatory for the SOFCs to exhibit a decrease in operating temperature to below 700°C and more specifically to below 450°C for their use in portable electronic devices (laptop, mobile phone, etc.) to substitute Li-ions batteries. The absence of charge-discharge cycles and a larger energy density are the main benefits offered by the SOFCs with respect to Li-ions batteries.
Our results demonstrated that the highly ordered BZY films without grain boundaries, obtained by pulsed laser deposition, are one of the most performing electrolytes ever developed for SOFC use and open new perspectives in the development of miniaturized SOFCs for a wide range of electronic device applications.

S. Pergolesi, E. Fabbri, A. D'Epifanio, E. Di Bartolomeo, A. Tebano, S. Sanna, S. Licoccia, G. Balestrino and E. Traversa, "High proton conduction in grain-boundary-free yttrium-doped barium zirconate films grown by pulsed laser deposition", *Nature Materials*, Vol. 9, October 2010, p. 846-852.
doi: 10.1038/NMAT2837



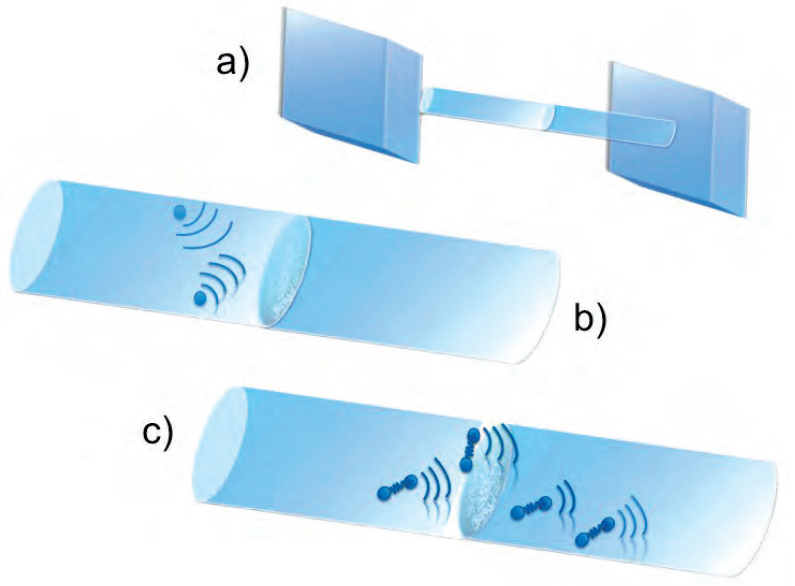
Comparison of the conductivity of the BZY film and of BZY and BCY pellets. Conductivity values of the most performing oxygen ion conducting materials LSGM and GDC are reported

SUPERCONDUCTORS

High Tc superconducting devices down to the mesoscopic scale

Future information technology and new generation of fast computing rely on tailoring and designing of quantum devices. Nanolitography provides scale reduction of devices at an unprecedented pace, but it will soon come to its physical limit. Superconductivity of dissipationless electron pairs realizes macroscopic quantum states (MQS). Superconductor-Insulator-Superconductor junctions (Josephson junctions) represent a unique system to measure and manipolate MQS. High Tc cuprates are recent materials with novel properties common to strongly correlated systems, waiting to be exploited. In the last years hybrid systems are being syntetized at an intermediate, mesoscopic scale, in which sample dependent quantum behavior at low temperatures turns into robust emerging universal responses (independent of the disorder) under electronic control which allows for applications in metrology and quantum computing. One of the goals of the CNR-SPIN group is to investigate the interplay between superconducting coherence and mesoscopic disorder. The nature of HTS promotes an intriguing length scale hierarchy where the mesoscopic normal state coherence prevails over the superconducting order induced in the barrier of grain boundary nanocontacts. It is found that conduction channels are secured, in which high energy anti-nodal quasi-particles coherently interfere with surprisingly long decay times. This provides further understanding for the appearance of Macroscopic Quantum Tunneling in $YBa_2Cu_3O_{7-x}$ Josephson Junctions, as measured in our devices at low temperatures. In our paper in Ref.[*], the experimental observation of another mesoscopic property is reported, i.e. a minigap in the excitation spectrum of a Grain Boundary HTS Josephson Junction, which has been quite elusive to observation in transport measurements, up to now. More is to expect from the confluence of HTS and nanophysics.

P. Lucignano, D. Stornaiuolo, F. Tafuri, B.L. Altshuler, A. Tagliacozzo: "Evidence for a minigap in YBCO grain boundary Josephson Junctions", *Phys. Rev. Lett.* 105, 147001 (2010).



a) Scheme of the YBaCuO nanochannel; b) and c) enlargement of grain boundary (GB) region belonging to the naochannel. Interfering quasiparticles and Cooper pairs transport processes across the GB are sketched in b) and c) respectively.

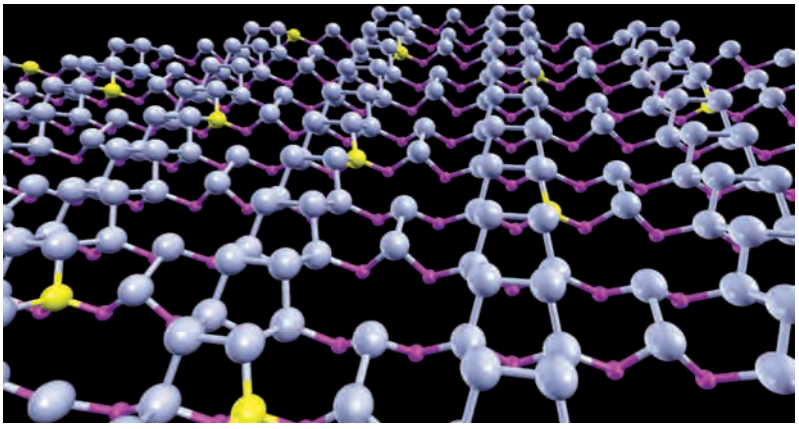
SEMICONDUCTORS

C. Hogan, R. Magri, R. Del Sole, "Spontaneous formation of surface antisite defects in the stabilization of the Sb-rich GaSb(001) surface", *Physical Review Letters* 104, (2010) pp. 157402.

Discovery of a new mechanism for stabilizing semiconductor surfaces

As the trend in device miniaturization continues, most of the system appears in the form of surfaces and interfaces. Hence it is crucial to understand and control the processes that drive surface formation and determine its structure. Surfaces arrange themselves so as to reach the lowest energy possible. On a wide range of (001)-oriented crystals, this happens through surface electrons forming "dimer" bonds not present in the crystal below. A general rule exists that determines which structural configurations of dimers make the surface low energy and semiconducting. The antimony-rich (001) surface of gallium arsenide, GaSb(001), was considered an archetypal case where this picture appears to break down. Experiments showed that it does not satisfy the rule – being metallic rather than semiconducting – and calculations found the surface energy to be indeed very high. While similar surfaces form short dimer chains, GaSb(001) uniquely forms long chains in what is a long-standing mystery within surface science.

Researchers at the Institute for Complex Systems in Rome and the S3 Centre-Institute for Nanoscience in Modena have solved this enigma by carrying out precise atomistic simulations of the structure and optical properties of GaSb(001). They found clear evidence that substitutional defects are formed underneath the dimer chains that trap any extra electrons and render the long dimer chain stable. They also showed that it is the very existence of the electron-rich long chains that drives the defect formation, as part of a delicate balance between surface strain and bonding energy. Understanding this unusual mechanism opens up new possibilities for controlled surface and interface engineering by means of external probes during growth.



Subsurface defects of Ga (in yellow) help stabilize long-chain GaSb(001) surface reconstructions.

SEMICONDUCTORS

Enhancing high temperature superconductors for technological devices

The high temperature superconductors (HTS) promise a high impact in wide-ranging technological applications, such as faster quantum computers, high speed trains and new electrical distribution networks without energy loss. HTS are hetero-structures at the atomic limit; they consist of parallel planes of active layers, copper oxide in the case of cuprates, sandwiched between rock-salt layers. The copper atoms lie on a plan lattice where charge is carried by "holes" provided by dopants whose distribution is believed to play a fundamental role in the complex interplay of superconducting and magnetic properties. The work carried on at Cnr-Ic Institute in Monterotondo (Rome) referred to superconductor cuprates La_2CuO_{4+y}, where the chemical dopants are mobile oxygen interstitial ions (i-O) inserted in the rocksalt $[La_2O_{2+y}]^{2-\delta}$ intercalated by $[CuO_2]^{2-\delta}$ layers. This compound exhibits a well known complex phase diagram, passing from insulating to superconducting while changing i-O concentration, y.

In this framework, our idea has been that the mobility of the intercalated oxygen ions, i-O is expected to affect these intriguing features; in other words we wondered whether, beyond the concentration, y, also the i-O arrangement could affect the material functionality, in particular its superconducting properties.

On the basis of this insight, the study of i-O atomic positions was carried out on the XRD1 beamline at the ELETTRA; here we identified weak diffraction superstructure spots, named Q2, in La_2CuO_{4+y} single-crystals showing that i-O dopants assume three-dimensional ordered architecture. Using X-ray micro-diffraction measurements on the ID13 beamline at ESRF, we found that the spatial distribution (Fig. 1a, 1b) of these ordered domains follows a scale-free, power law behavior (Fig. 2a): this is to say that the ordered patterns draw fractal networks. It was really surprising, then, to discover that the fractal distribution, as well as the larger spatial correlation lengths of i-O ordered domains (Fig. 2b) enhance superconductivity at high temperature. These results open new avenues in the double handed issue pertaining both to technology, relative to controlled fabrication of superconducting devices, and to basic physics dealing with the formation and evolution of quantum coherence in the matter.

M. Fratini, N. Poccia, A. Ricci, G. Campi, M. Burghammer, G. Aeppli & A. Bianconi, "Scale-free structural organization of oxygen interstitials in La2CuO41+y", *Nature*, 466 (2010) pp. 841-844.

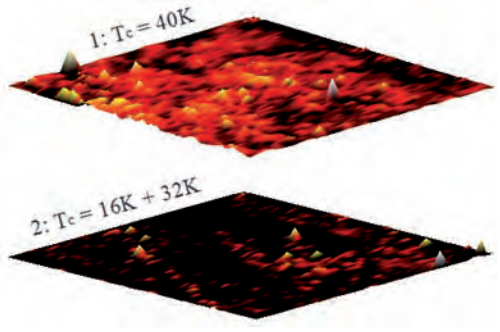


Figure 1 (a) Intensity map of i-O superstructure for two [600 x 400]μm samples: (1) the first with T_c=40K and (b) the second with two phases with lower T_c (16K and 32K).

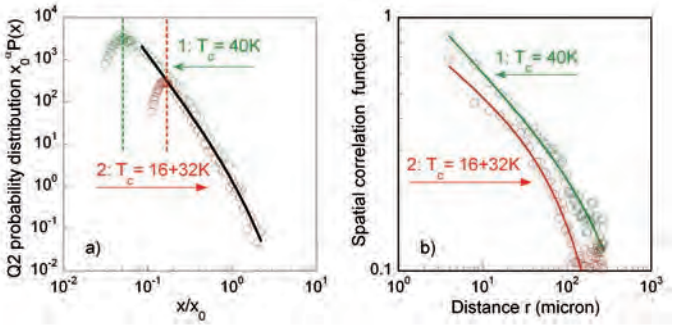


Figure 2 (a) Scaled probability distributions and (b) spatial correlation function of Q2 intensity for the two samples (1 and 2) of Figure 1. The scale free power law regime, (black line in a), associated to the extent of fractal geometry and the spatial correlation lengths are larger for samples with larger T_c.

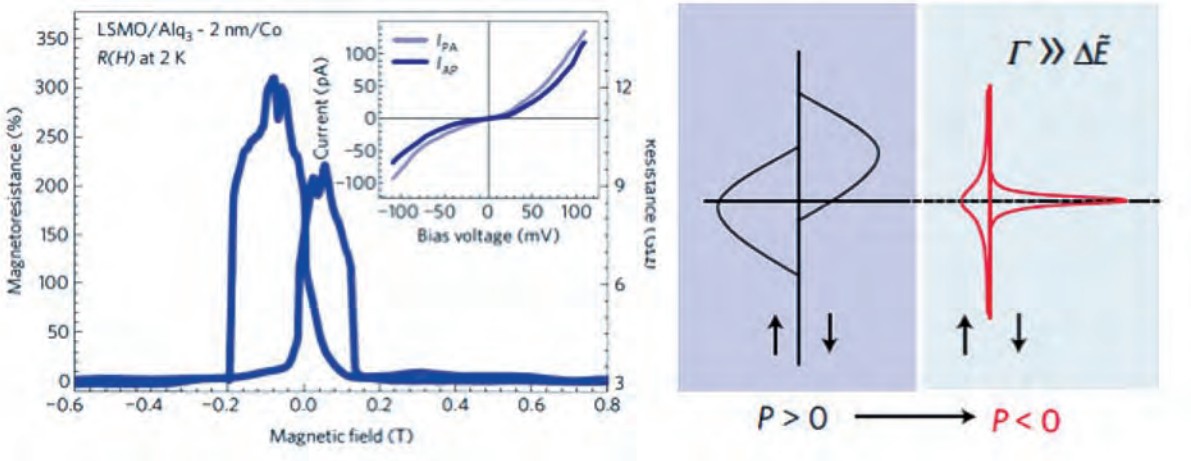
SEMICONDUCTORS

Unravelling the role of the interface for spin injection into organic semiconductors

Organic semiconductors are among the most promising materials for future ICT devices. On the other hand, Spintronic operation promotes attractive paradigms for ultra-low consumption information processing. The joint paper by CNR - Institute of Nanostructured Materials (ISMN) and Unité Mixte CNRS-Thales published recently in Nature Physics presents intriguing spintronic effects in organic magnetic tunnel junctions (MTJ) involving both record strongest magnetoresistance and unusual physics. The results have been achieved under the first EU project on organic spintronics, OFSPIN, coordinated by ISMN-CNR. Within this multi-partner framework, the collaboration with the group from Unité Mixte CNRS-Thales, guided by Nobel Laureate Albert Fert, was focused on the fabrication by nanoindentation technique of tunneling magnetoresistive nanodevices LSMO/Alq3/Co featuring few nm in width. The devices showed magnetoresistance reaching 300% at low temperatures — a new record for organic devices close to best inorganic MTJ.
Moreover, intriguing physics was revealed by the positive sign of the tunneling magnetoresistance, opposite to one measured in injection devices (independent ISMN-CNR research). This unexpected result allowed to establish perhaps the most attractive functionality of the organic based spintronics – a strong spin selection at the hybrid organic-inorganic interface. This selection is based on the interface proximity effect, leading to a different broadening of spin-up and spin-down organic levels. Although the effect is totally confined at the interface it supports a severe modification of the device current. A detailed quantitative model was developed putting basis for a smart tailoring of the magnetic properties of hybrid interfaces.
Moreover, this discovery has got a significant consideration of the spintronic community, tracing the research agenda for next years: a large EU project (HINTS, coordinator – ISMN-CNR) starting in 2011 and featuring a 14 Partners Consortium will develop further these ideas, trying to build a solid bridge between the scientific research and promising future applications.

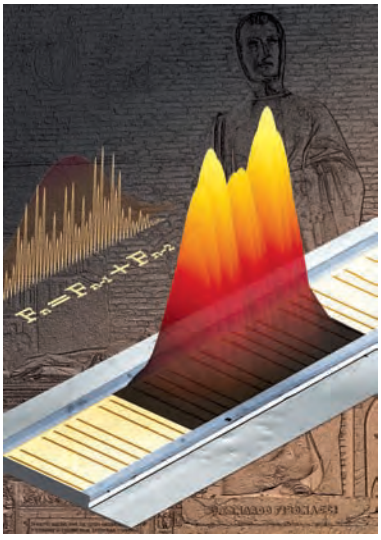
(left) 300 % Magnetoresistance curve of the organic MTJ; Inset: I-V curves. (right) Sketch of the spin-dependent interfacial molecular hybridization obtained for strong coupling to a ferromagnetic electrode. The spin polarization at the Fermi level (dashed line) is reversed.

C. Barraud, P. Seneor, R. Mattana, S. Fusil, K. Bouzehouane, C. Deranlot, P. Graziosi, L. E. Hueso, I. Bergenti, V. Dediu, F. Petroff, A. Fert, "Unravelling the role of the interface for spin injection into organic semiconductors", *Nature Phys*, 6 (2010), pp. 615-620.



SEMICONDUCTORS

A quasi-crystal semiconductor laser

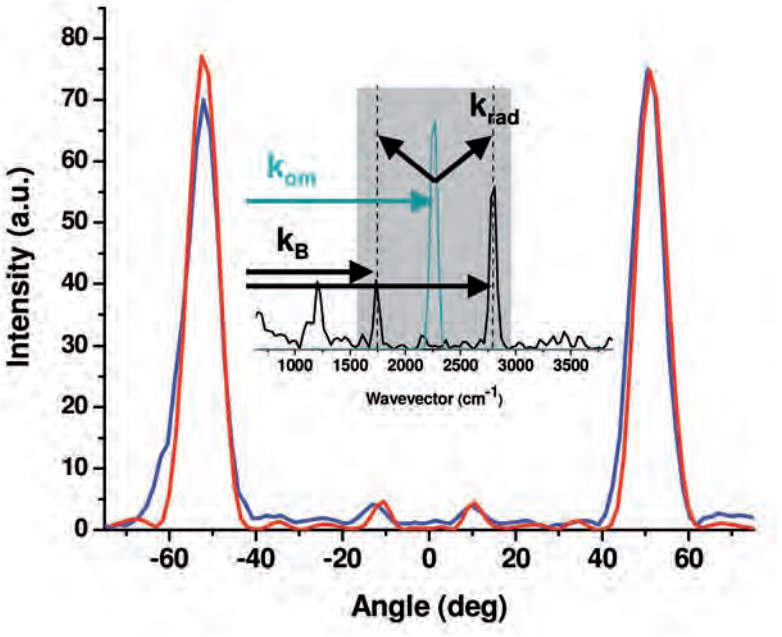


Leonardo Pisano, better known as Fibonacci, was one of the most brilliant mathematicians of the medieval age. He would unlikely have guessed, though, that the famous numerical sequence, he originally developed to describe the population growth of a rabbit family, would have been at the foundation of a new type of semiconductor laser.

Semiconductor lasers have had a huge impact on everyday life: as is well known, they are the defining element of optical storage systems (CD, blu-rays), fibre optics communications, optical sensors, pointers, etc. When high spectral purity is desired, like in spectroscopy and telecom systems, this is typically achieved inserting in the laser cavity a grating that produces a periodic variation of the refractive index (i.e. of the light propagation velocity). This grating selects the lasing mode whose wavelength matches the grating periodicity.

Here, CNR researchers have instead employed a special grating following the Fibonacci sequence, realizing what is called an optical quasi-crystal. These structures, though based on a precise mathematical rule, are not periodic and already display many properties of disordered systems. It's the first time a laser diode is produced with this approach, allowing greater flexibility in the design and novel functionalities. In this work the grating was realized in the metallic waveguide of a so-called quantum cascade laser to demonstrate the possibility of independently controlling emission angle and frequency, as well as to develop multi-colour devices operating contemporarily at two or more, specifically chosen, frequencies.

These characteristics are presently of great interest for lasers in the THz spectral range (i.e. between microwave and infrared), intensively investigated for security applications. The result also opens the way toward the development of semiconductor lasers in completely disordered materials, where light propagation is dominated by diffusion.



Left: Lasing in a Fibonacci quasi-crystal. Artwork by Michele Fiaschi.

Right: Measured (blue) and calculated (red) emission profile. The inset displays the Bragg spectrum of the grating and illustrates the operating principle.

L. Mahler, A. Tredicucci, F. Beltram, C. Walther, J. Faist, H.E. Beere, D.A. Ritchie, D.S. Wiersma, "Quasi-periodic distributed feedback laser", *Nature Photon.*, 4 (2010), pp. 165-169.

PIEZOELECTRICITY

Piezoelectricity and flexoelectricity

The Democritos Center of CNR-IOM in Trieste has a tradition of excellence in the theory of electrical properties of insulating and semiconducting materials, including piezoelectricity and ferroelectricity. This work addresses a less familiar property, flexoelectricity, which made its appearance in recent applied research publications. Electromechanical coupling in devices (transducers and actuators) is mostly based on piezoelectricity, i.e. macroscopic polarization induced by homogeneous strain, or conversely macroscopic stress induced by a uniform electric field. Since a few years, there has been much interest in fabricating piezoelectric composites from materials which are not themselves piezoelectric. Therein, the coupling is based on flexoelectricity: macroscopic polarization induced by strain gradient. While piezoelectricity is symmetry forbidden in high-symmetry crystals, flexoelectricity is instead allowed in any material. Despite much work, the basic issue of whether flexoelectricity is a pure bulk effect - or instead it has a contribution which depends on the surface conditions of the sample - was unsettled until our paper. It is worth mentioning that the analogous issue about the much simpler case of piezoelectricity is far from being trivial either, and spurred much discussion among theorists until two decades ago.

Our work is a first step towards a bulk theory of flexoelectricity. Only the simplest case study is addressed: elemental crystals having a cubic primitive lattice. The theory shows that, at least in this case, flexoelectricity is indeed a pure bulk effect. Contrary to a previous incorrect belief, there is no extrinsic (i.e. surface) contribution to the effect, which can be expressed and computed as a linear response function of the bulk solid. The same response function governs the macroscopic polarization associated to a long-wavelength lattice vibration (phonon).

R. Resta, "Towards a bulk theory of flexoelectricity", *Phys. Rev. Lett.*, 105, 127601 (2010).

MAGNETIC FIELDS

Magnetic imaging in photonic crystal microcavities

The ultimate tailoring of the electromagnetic field, developed in the last years, has been made possible by the capability of storing photonic modes in very small volume. These achievements have generated a renewed interest in nano-optics for a detailed knowledge of the spatial distribution of the optical fields. While measurements of the electrical response of materials has been intensively studied, the access to the magnetic component was only recently investigated due to its wreak interaction with matter at optical frequencies.

In our work we demonstrate that it is possible to interact with the magnetic field associate to a photonic crystal micro-cavity and we show that we can exploit this interaction to map its spatial distribution. In particular, we probe the magnetic field intensity of the near-field emission from semiconductor quantum dots embedded in a photonic crystal micro-cavity using a standard commercial metallic coated scanning near field optical microscope's tip. The aluminum coating at the tip aperture acts as a conductive ring in which an electric current is induced via the Faraday-Newmann law. This conductive ring creates a magnetic moment that is opposite to the inducing magnetic field. The resulting perturbation of the magnetic environment of the photonic structure produces a sizeable high frequency shift of the photonic eigen-modes, which can be measured and used to map accurately the spatial distribution of the magnetic field normal to the plane of the micro-cavity.

By constructing near-field maps of this shift one obtains an experimental determination, with high resolution, of the spatial distribution of the magnetic field normal to the plane of the micro-cavity. The experimental data are found to be in very good agreement with theoretical predictions.

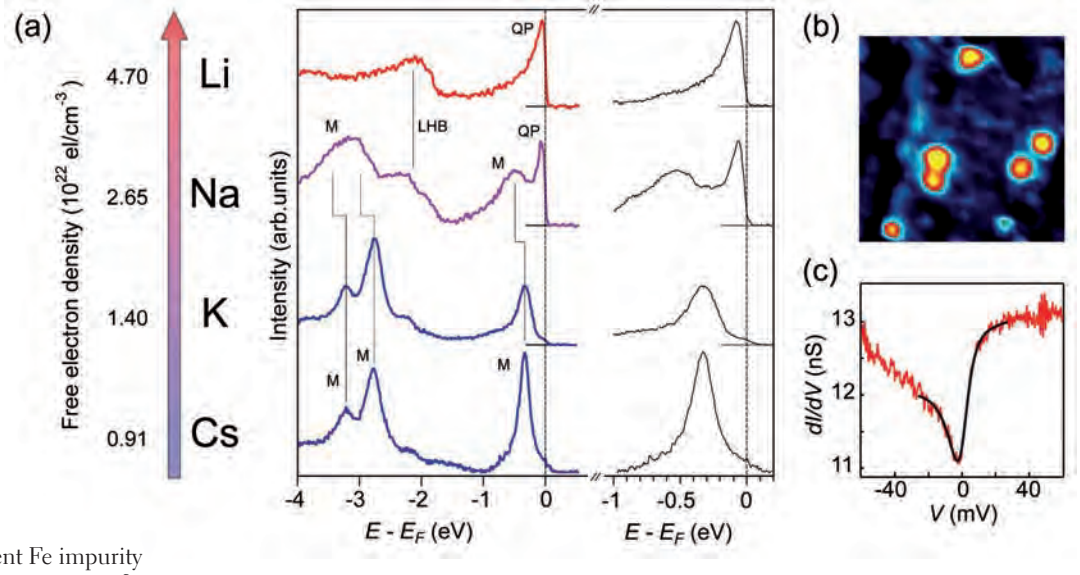
S. Vignolini, F. Intonti, F.Riboli, L. Balet, L.H. Li, M. Francardi, A. Gerardino, A. Fiore, D.S. Wiersma, and M. Gurioli, "Magnetic Imaging in Photonic Crystal Microcavities", *Phys. Rev. Lett.* 105, 123902, (2010).

MAGNETISM

Exploring magnetism at its ultimate limit

Nanomagnetic materials made of a few atoms and organized into regular patterns offer the possibility to extrapolate established principles of magnetic storage to novel applications for spintronics and quantum computation. The miniaturization of finely structured magnetic elements requires a particularly demanding control of growth processes as well as a detailed knowledge about the fundamental physical properties of the single particles. While electron states in free atoms are classified in terms spin and orbital quantum numbers, electrons become free to propagate in solids and the magnetic moment generally vanishes. In materials approaching the atomic limit, however, one may expect the atomic or the solid state theoretical models to fail, and the question is how to describe magnetism in these systems appropriately. Scientists at the CNR - Istitute of Structure of Matter (ISM) have been extensively examining, within a research program of the European Science Foundation, the properties of magnetic materials with dimensions reduced to the sub-nanometer and atomic scale. By means of advanced spectroscopic and theoretical methods they were recently able to solve, in particular, the ultimate case of a single magnetic atom interacting with different supporting substrates, by describing in a consistent way the continuous transition from a fully developed to a largely quenched magnetic moment. Together with other investigations, these results provide novel insights on fundamental and practical issues, such as the survival of the moments in nanoparticles, their magnetization stability and temperature-dependent magnetic behavior, and illustrate how an extreme flexibility in the engineering of functional properties can be achieved through atomic-scale design of the magnetic elements.

C. Carbone, M. Veronese, P. Moras, S. Gardonio, C. Grazioli, P.H. Zhou, O. Rader, A. Varykhalov, C. Krull, T. Balashov, A. Mugarza, P. Gambardella, S. Lebègue, O. Eriksson, M.I. Katsnelson, and A.I. Lichtenstein, "Correlated Electrons Step by Step: Itinerant-to-Localized Transition of Fe Impurities in Free-Electron Metal Hosts", *Physical Review Letters*, 104 (2010), pp. 117601-117604.



Host-dependent Fe impurity photoemission spectra on free-electron like substrates and scanning tunneling images.

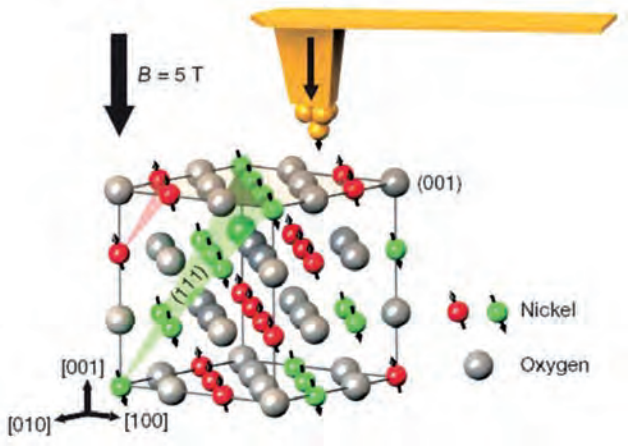
MAGNETISM

Atomic spin sensitive dissipation on magnetic surfaces

Atomic Force Microscopy (AFM) is a powerful imaging tool that allows the investigation of the atomic structure of surfaces by measuring their interaction with a microscopic oscillating tip, revealing the surface topography. In recent experiments with a magnetic tip, AFM revealed not only the surface spin pattern, but also a different energy dissipation over different spins. This kind of "magnetic nanofriction" is unexplained by standard theories, and it is potentially important, associating the tip oscillation quality factor, (a macroscopic mechanical property), with surface spin orientation, a delicate atomic level information. The peculiarities of this magnetic dissipation are its sign (dissipation is larger for spins antiparallel to the tip magnetization), its large magnitude and its surprising persistence at the low tip oscillation frequency.

The sign of the effect is easy to explain: a surface spin aligned to the tip magnetization does not flip and, hence, dissipates less. The flip of a spin must, by necessity, couple to a surface phonon, realizing a spin-boson model. In a strongly coupled spin-boson model, the free dynamics of the spin is hindered by the boson "bath", giving rise to a new, sluggish, timescale for spin flip, comparable with the period of tip oscillation. By simulating in that model the time evolution of the tip-spin-phonon system, we show that the direction of the spin is indeed different during the approach and retraction of the tip. This effectively provides a single-spin hysteresis cycle, explaining the magnetic dissipation. The magnitude and the characteristic features of the proposed effect not only reproduce all the experimental observations, but also provide a first example of magnetic nanofriction, a mechanism which we expect to be of broader relevance.

F. Pellegrini, G.E. Santoro, and E. Tosatti, "Atomic Spin-Sensitive Dissipation on Magnetic Surfaces", *Phys. Rev. Lett.* 105, 146103 (2010).



A magnetic AFM tip oscillating over the surface of NiO, an antiferromagnetic insulator. Figure taken from R. Wiesendanger, *Rev. Mod. Phys.* 81, 1495 (2009), with courtesy of the author.

SPACE SCIENCE

The ESA Rosetta spacecraft encountered the asteroid (2867) Steins

The European Space Agency's (ESA) Rosetta mission was launched in 2004 with the aim to rendezvous with comet 67P/Churyumov-Gerasimenko in 2014. During its long interplanetary journey (Fig. 1), the Rosetta spacecraft experienced many swing-bys to gain the energy needed to reach the comet orbit. Rosetta had three swing-bys with the Earth and one with Mars. It had also the chance to fly-by two main belt asteroids (Steins in 2008 and Lutetia in 2010). Asteroid (2867) Stein was encountered on September 5 2008, the spacecraft passing it with a relative velocity of 8.6 km s^{-1}. The OSIRIS (Optical, Spectroscopic, and Infrared Remote Imaging System) cameras on board Rosetta acquired hundreds of images which

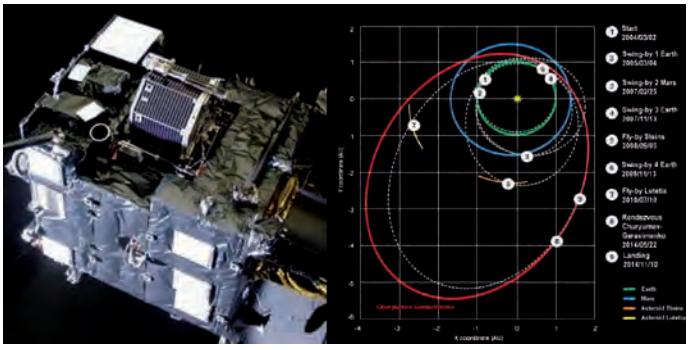
allowed to study the morphology of the asteroid and to determine its volume.

The Closest Approach (CA) took place at a distance of 803 km, chosen such that the spacecraft could keep the instruments continuously pointed toward the asteroid. During the fly-by the Rosetta scientific camera system OSIRIS was able to acquire Steins's images with resolution up to 80 m/px (Fig. 2).

OSIRIS consists of a Narrow-Angle Camera (NAC) and a Wide-Angle Camera (WAC), which have been realized through the joint work of an European consortium led by the MPS Institute (Lindau-Germany). Most of the mechanical and optical components of the WAC has been designed and built in Italy and the researchers of the CNR-IFN LUXOR Laboratory in Padova have been responsible for the optical design, alignment and calibration of the WAC.

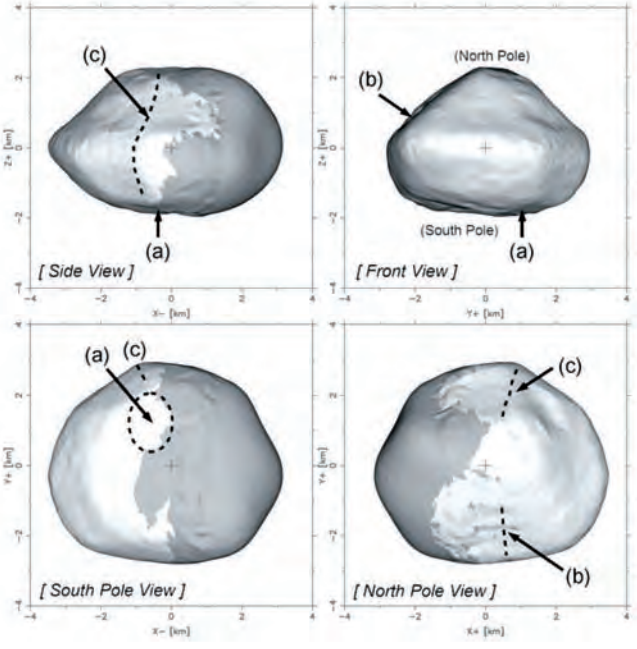
OSIRIS images allowed to resolve approximately 60% of Steins's surface. The NAC (with five times higher resolving power than WAC) unfortunately stopped its automatic operation at a distance of 5200 km, 10 min before CA. Thus the highest-resolution images of Steins's surface were taken by the WAC. The acquired images enabled the astronomy researchers to derive important information on the asteroid. They discovered that Steins's morphology is dominated by a large 2.1-km-diameter crater, whose presence provides information about the physical properties of the interior. Based on limb positions from 1 NAC and 61 WAC images and the simultaneous inversion of a set of 28 light curves taken from Earth and during approach, the asteroid shape has been modeled (Fig. 3). Steins's overall dimensions are $6.67 \times 5.81 \times 4.47$ km^3 and its volume is equivalent to a 2.65-km-radius sphere.

H.U. Keller et al., "E-Type Asteroid (2867) Stein as Imaged by OSIRIS on Board Rosetta", *Science*, 327, pp. 190-193 (2010).



Left: The Rosetta spacecraft and its interplanetary trajectory.

Right: Asteroid Steins WAC images taken before, during and just after CA. A large crater is visible near the asteroid south pole, which is up in the images.



Asteroid Steins reconstructed shape is illustrated by two equatorial views (top panels) and two polar views (bottom panels).

OPTICAL IMAGING

Differential ghost imaging: a novel imaging technique

How can we form the image of an object immersed in an optically harsh or noisy environment, for example in a turbid medium or in the presence of strong aberrations? Here, standard techniques, which form images by using pixelated detectors (such as charge coupled devices or CCD cameras) are likely to fail.

Conversely, statistical methods relying on spatial correlations of two optical beams such as the ones used in the so-called Ghost Imaging (GI) protocol, appear to be very promising. In GI the object is illuminated by an *object beam*, and all the transmitted light is collected by a single "bucket" detector, with no spatial resolution, so that it can work finely even under prohibitive optical conditions. The image is instead formed by correlating the signal out from the bucket detector with the light intensity distribution of a *reference beam*, which never interacted with the object, so that it can be sensed at a remote location. The method works thanks to spatial correlations existing between the light distributions of the reference and object beams.

The price to pay, however, is a very high noise present in the retrieved images, which makes GI impractical for real world applications. In our work we proposed a novel statistical technique, which we named *Differential Ghost Imaging* (DGI), capable of lowering by orders of magnitudes the noise of GI. This feature allowed, for the first time, the imaging of complex quasi-transparent objects (Fig. 1) or the sensing and sizing of small absorbing particles located in a large scattering volume (Fig. 2). Both figures show the spectacular improvement offered by DGI over conventional GI and suggests that DGI could find future applications in many fields of optical science, such as in bio-medical imaging (imaging in tissues) or atmospheric imaging (imaging trough clouds or fog).

F. Ferri, D. Magatti, L.A. Lugiato, and A. Gatti, "Differential ghost imaging", *Phys. Rev. Lett.*, 104, (2010) 253603-1/4.

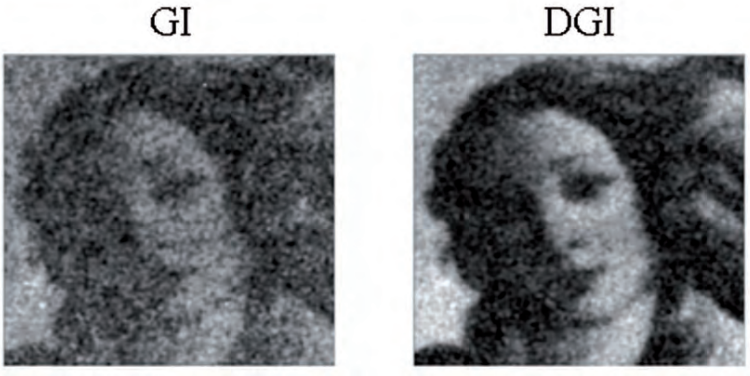


Figure 1 Comparison between GI and DGI for a grayscale slide of a detail of the famous painting "Nascita di Venere" by S. Botticelli (Firenze, Italy, A.D.~1484).

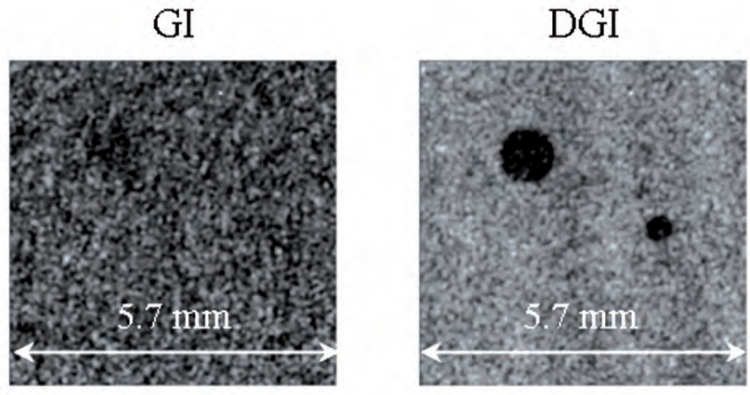


Figure 2 GI and DGI of two absorbing particles, 820 and 400 μm in diameter. Only DGI retrieves accurately positions and diameters of the two particles.

OPTICS

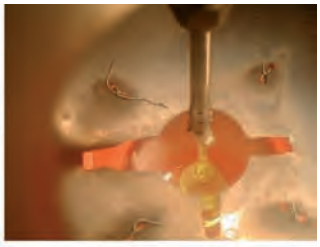
Optical cooling of solids

The optical cooling of solids has been first proposed in the 1929 and observed one year later, but only the development of powerful and tunable laser sources has generated a real interest. In the last decade, several research groups have focused their activity on developing a fully solid-state cryocooler, because the temperature range obtainable with optical cooler is functional for many applications, like high-Tc superconductors, infrared detectors, cooled electronic devices and would be well-suited also for aereo-space applications. The basic idea of optical cooling take advantage of the anti-Stokes luminescence, where a center (like an active atom or ion) – after the absorption of a photon – thermally interacts with the host and eventually spontaneously emits another photon at a different wavelength. The difference in energy between the absorbed and emitted photon produces an overall heating or cooling of the matrix surrounding the atom or ion.

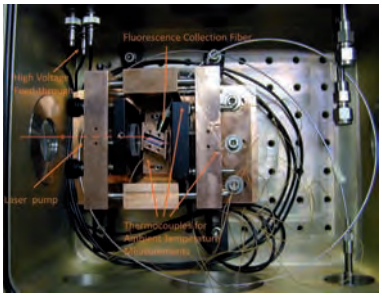
When the pumping frequency is lower than mean fluorescence frequency, the emitted average energy is larger than the absorbed energy and the cooling effect is effective. It is obvious that this mechanism can produce a net cooling only when all other detrimental processes are avoided (nonradiative decay, etc…). For this reason it is very important that the crystal used in the experiment has a very high quality. We developed a Lithium Yttrium Fluoride ($LiYF_4$) crystal doped with 5% Ytterbium trivalent ion (Yb^{3+}) that in a suitable experimental apparatus has been cooled down to the absolute temperature of 155 K, by starting from room temperature. This result is a milestone in this field, because it is the first demonstration that optical cooling can reach temperature below the minimum obtainable with a thermo-electric cooler.

D.V. Seletskiy, S.D. Melgaard, S. Bigotta, A. Di Lieto, M. Tonelli, M. Sheik-Bahae, "Laser cooling of solids to cryogenic temperatures", *Nature Photonics*, 4, pp.161-164 (2010).

$LiYF_4$ crystal doped with 5%Yb_{3+} ion.



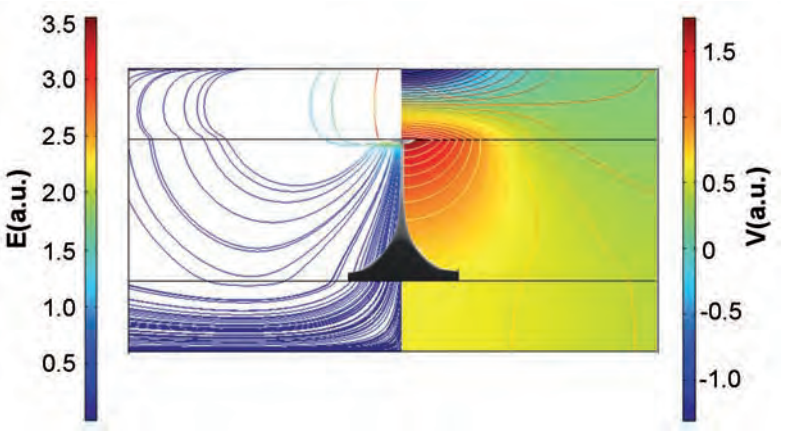
Chochralski furnace for crystal growth.



Experimental apparatus for cooling effect.

OPTOFLUIDICS

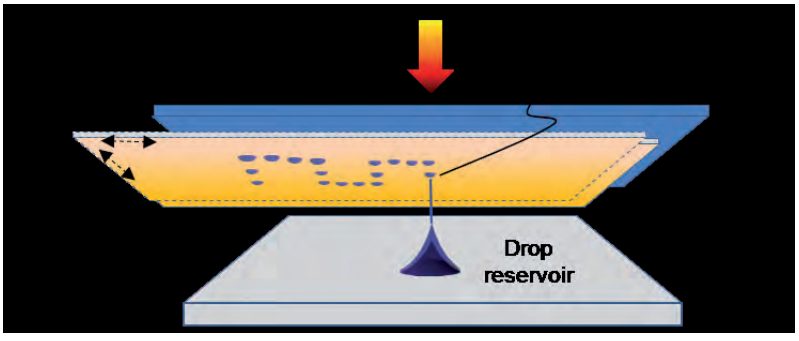
A new technique for dispensing 'nanodrops'



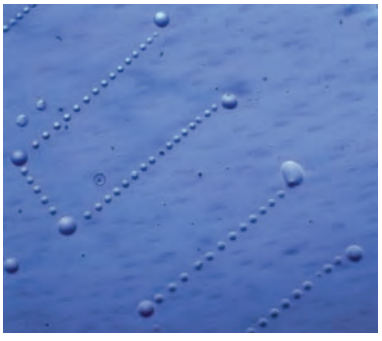
Three-dimensional axially symmetric plot of the electric field lines (left) and electric potential (right) responsible of the streaming effect.

Manipulation of liquids on micro-nano scale is a key issue in many fields of technology: biotechnology, combinatory chemistry, patterning by deposition of inorganic, organic and biological inks. Electric field induced formation of microliter and nanoliter droplets is useful in electrospray mass spectroscopy, ink-jet printing, manipulation of biomolecules providing the so called "on-demand" material dispensing. We present a new concept of electrohydrodynamic-based droplet generation called 'pyroelectrohydrodynamic shooting', for the direct drawing and dispensing of droplets with volumes on the scale of attolitres (a fluid measure equal to 10^{-18} litres) and radii as low as ~300 'nanometers' from liquid drops or film reservoirs. This technique does not require electrodes, high-voltage circuit connections or special capillary nozzles. The electric fields are generated pyroelectrically using functionalized substrates of lithium niobate. The pyroelectric effect has been used recently for wettability patterning, particle trapping and liquid microlenses. For the dispensing application we use this effect to transfer liquids between two substrates and manipulate the droplets threedimensionally. The simplicity of the technique suggests potential uses in a range of liquid manipulation and printing fields, such as generating and dispensing daughter droplets, fragmenting microlitre drops and liquid printing. Such printing method can also provide the flexibility desired in direct patterning of fragile organics or biological materials that are incompatible with conventional patterning methods. This system is easy to use and non-invasive, and is therefore potentially useful as a portable instrument for *in situ* drawing and delivering of liquid biological samples within a chip.

P. Ferraro, S. Coppola, S. Grilli, M. Maturzo & V. Vespini, *Nature Nanotech.* 5, 429-435 (2010).



Set-up of the nanodispenser.



Demonstration of ink-jet printing by liquid nanodrops.

HYDRODYNAMICS

Swimming in a sea of superfluid light

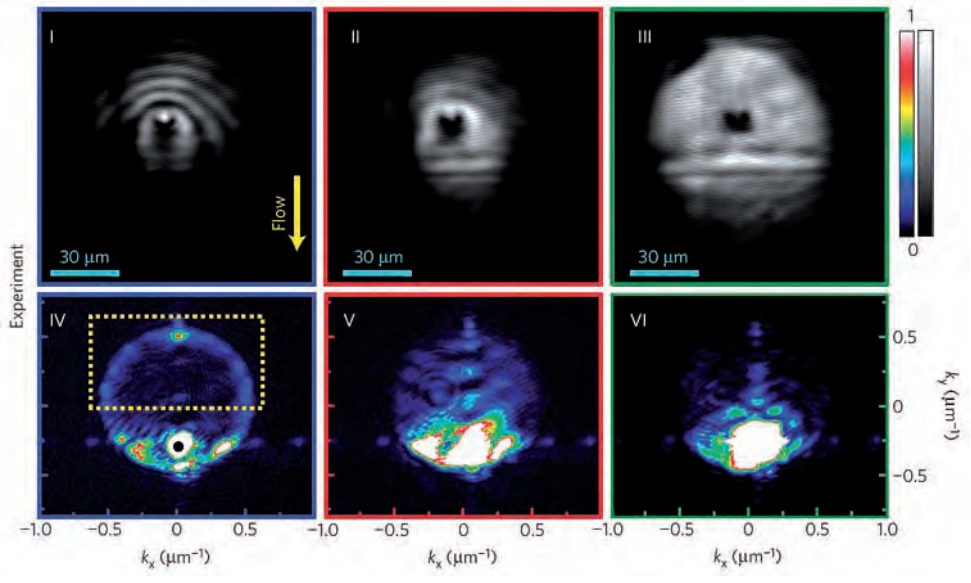
Superfluidity is among the most remarkable manifestations of quantum mechanics in the macroscopic world. So far, it has been observed as a sudden disappearance of mechanical friction in fluids of very different natures -from liquid Helium, to electrons in metals, to gases of ultracold atoms- when they are cooled below a critical temperature.

Recently, researchers have started investigating systems in which an assembly of light quanta (the so-called photons) behaves as a fluid of interacting particles. At high enough densities, the quantum nature of the constituent photons becomes crucial and a macroscopic fraction of the photons are accumulated in a single quantum state, the so-called Bose-Einstein condensate. Superfluidity is a consequence of the macroscopic order present in the Bose-Einstein condensate. Evidence of superfluid behaviour in a photons gas in a semiconductor microcavity is illustrated in the figure: this experimental image was taken in the group of A. Bramati and E. Giacobino at LKB, Paris.

While a complete theoretical understanding of superfluidity in standard material systems has been available for a few decades, the goal of this research activity is to understand the novel features that stem from the non-conservation of the total number of particles. New photons have in fact to be continuously injected into the system to replace the ones that are lost because of absorption: this seemingly minor difference induces major conceptual changes in the theoretical picture.

On the long run, understanding and controlling the behaviour of systems of many interacting photons will hopefully lead to the development of a novel generation of opto-electronic devices which take full advantage of the quantum nature of light for sensors, telecommunications, and information processing.

M. Wouters and I. Carusotto, "Superfluidity and Critical Velocities in Nonequilibrium Bose-Einstein Condensates", *Phys. Rev. Lett.*, 105, 020602 (2010).



Light fluid flowing against a defect in the normal (left) and superfluid (right) regimes from Amo *et al.*, Nature Phys. 5, 805 (2009).

FLUID DYNAMICS

New phases in supercritical fluids

The properties of fluids in the supercritical regime are mostly unknown despite intense research efforts throughout the past Century. This region is above the *critical point*, the thermodynamic point in pressure (P_c) and temperature (T_c) above which distinction between liquid and gas phases was thought not to exist. Research on fluids under extreme conditions was typically hampered by technical difficulties encountered with complex sample environments such as high pressure diamond anvil cells or laser shock techniques. Important new insights were recently gained through an inelastic X ray scattering experiment on supercritical argon (at $T=4\times T_c$ and $P>10_2\times P_c$) in conjunction with molecular dynamics simulations, which revealed distinct changes in the dispersion of nanometric acoustic waves depending on the thermodynamic conditions. At high pressures it was observed an increase of the sound velocity as a function of wavelength from the continuum limit (at very large wavelengths) in which acoustic waves propagate adiabatically, to the short-wavelength limit, that is, when approaching interparticle distances. Its origin can be traced back to the presence of at least one relaxation mechanism interacting with the dynamics of the density fluctuations induced by the propagation of acoustic waves. This dynamical feature represents the so-called positive sound dispersion, observed for most liquids and it can be considered a fingerprint of the liquid state. Figure 1 reports the amount of positive sound dispersion as a function of pressure, derived from the inelastic X ray scattering experiment and molecular dynamics simulations. A sharp decrease from about 13% to 4% is observed on pressure decrease with a cross-over located at 0.4 GPa. This distinct decrease is due to the disappearance of the structural relaxation process, and thus marks the transition from a collective liquid-like to a single particle gas-like behaviour. This clearly provides a connection between dynamics and thermodynamics, contradicting the widespread belief of a homogeneous supercritical fluid phase. Most remarkably, the crossover value of 0.4 GPa corresponds to the extrapolation of the so-called Widom

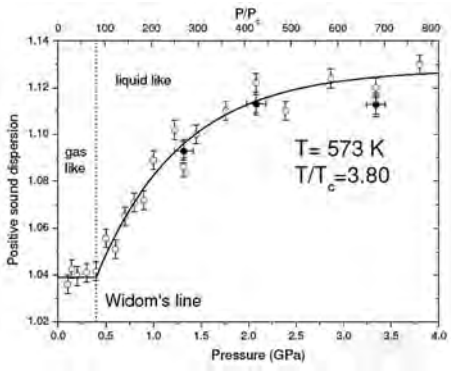


Figure 1. Positive sound dispersion of argon as a function of pressure at 573 K. Full and open circles indicate the positive sound dispersion as obtained from the IXS experimental data from the molecular dynamics simulations, respectively. The two solid lines represent fits to the data set below and above the cross-over points at 0.4 GPa, and the dotted line marks the point on the extrapolated Widom line at 573 K.

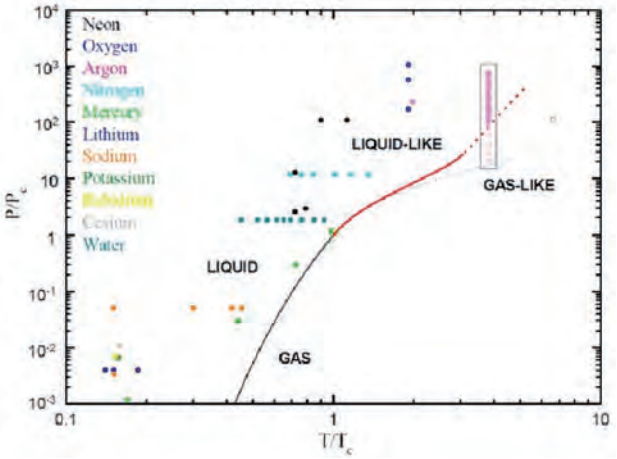


Figure 2. Sketch of the (P/Pc, T/Tc) plane. Red line: Widom line of argon obtained from the NIST database (continuous) up to the highest temperature where a maximum in Cp vs. P can still be identified (T=470 K; T/Tc=3.12), and extrapolated (dotted) above this temperature. Black line: best fit of the average of the liquid-vapour coexistence lines for argon, neon, nitrogen and oxygen using the Planck-Riedel equation. Dots with different colours mark data from a variety of systems (this study, and also ref. [2] and references therein). Isothermal, experimental and molecular dynamics simulation data on argon are reported in pink inside a black rectangle. Open circles represent cases where the positive dispersion of the sound velocity exhibits low values, full circles cases where there is a clear signature of large positive dispersion.

line, constituting the locus of the maxima of the isobaric specific heat C_P (see Figure 2) in the supercritical fluid phase. We then identify the Widom line with the partition line between liquid-like and gas-like regions in the supercritical fluid region of the phase diagram, similarly and in continuation to the liquid vapour line which separates the liquid and gas regions in the subcritical region of the phase diagram. This discovery shines new light and redefines the definition of a supercritical fluid in fundamental thermodynamics. This newly discovered relationship between thermodynamics and the viscoelastic behaviour of hot dense fluids is expected to allow major breakthroughs in areas such as the physics of planetary systems, solvation techniques for nanotechnologies, and in geophysics for the validation of seismological models based on the thermophysical properties of materials.

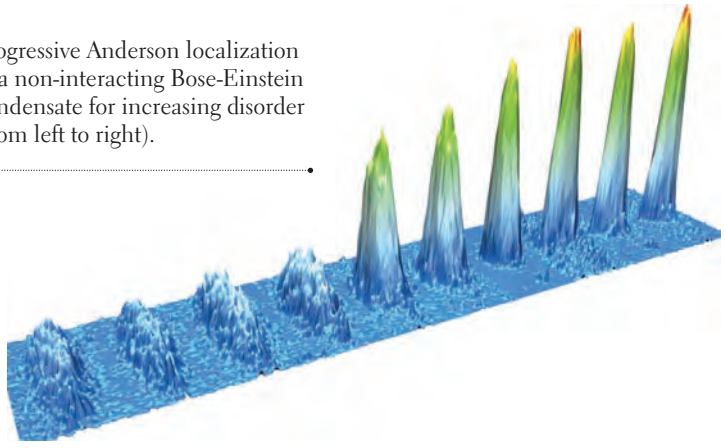
G.G. Simeoni, T. Bryk, F.A. Gorelli, M. Krisch, G. Ruocco, M. Santoro and T. Scopigno, "The Widom line as the crossover between liquid-like and gas-like behaviour in supercritical fluids", *Nature Physics*, 6, 503 (2010).

QUANTUM GASES

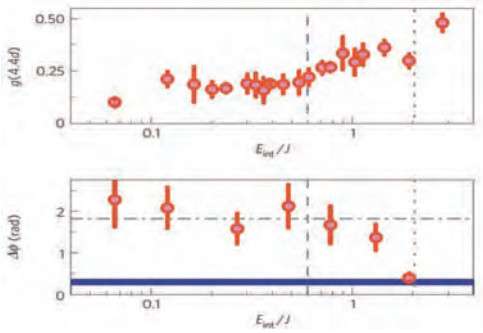
Delocalization of a disordered bosonic system by repulsive interactions

Clarifying the interplay of interactions and disorder is fundamental to the understanding of many quantum systems, including superfluid helium in porous media, superconductors and light propagating in disordered media. One central aspect that has not been clarified yet is the competition between disorder, which tends to localize particles, and weak repulsive interactions, which instead have a delocalizing effect. A systematic experimental investigation of this competition has not so far been possible, because the required degree of independent control of disorder and of interactions is not easily achievable in most available physical systems. In this work we use a Bose-Einstein condensate of ultracold atoms with tunable repulsive interactions and a disordered lattice potential to study this interplay in detail.
We indeed observe and characterize a crossover between a regime in which the system is localized and a delocalized regime, through the study of fundamental properties of the system such as the density correlations and the phase coherence. We identify three different regimes in a experiment-theory comparison: 1) an exponentially localized Anderson glass for vanishing interaction; 2) the formation of locally coherent fragments for increasing interaction; 3) an extended state that is undistinguishable from a single Bose-Einstein condensate for large interaction. These results pave the way to the understanding of many more unexplored regimes of the very complex physics of disordered interacting systems. Future studies might give long sought answer to the open problem of metallic and insulating phases of disordered, strongly correlated bosonic and fermionic systems.

B. Deissler, M. Zaccanti, G. Roati, C. D'Errico, M. Fattori, M. Modugno, G. Modugno, M. Inguscio, "Delocalization of a disordered bosonic system by repulsive interactions", *Nature Physics*, 6, 354-358 (2010).



Progressive Anderson localization of a non-interacting Bose-Einstein condensate for increasing disorder (from left to right).



Evolution of the correlation function (top) and of the phase fluctuations (bottom) of a disordered Bose-Einstein condensate for increasing interaction energy.

QUANTUM GASES

First and second sound in ultracold atomic gases

Superfluidity is a state of matter characterized by very low viscosity and high termal conductivity. Superfluids are known to exhibit, in addition to usual sound, which consists in the propagatation of a density wave, an additional mode, called second sound, where the superfluid and normal components move with opposite phase. In a weakly compressible fluid, like superfluid helium, second sound reduces to a temperature wave, leaving the total density practically unaffected. In helium its velocity was systematically measured as a function of temperature, providing a high precision determination of the superfluid density. Also atomic gases, under proper conditions of density and temperature, are known to exhibit superfluid effects. In this work we have shown that the propagation of sound in non-uniform trapped atomic gases exhibits new interesting features both in the superfluid and in the normal phase. We have focused on cylindrical configurations where the radial trapping of the atoms introduces a strong non-uniformity in the gas. These configurations are well suited for the experimental excitation and detection of sound waves. We have explored the regime where the collisional term in the normal component of the gas is so effective as to ensure that the hydrodynamic equations hold. Furthermore, for the low frequency modes, viscosity and thermal conductivity impose the absence of the radial dependence in the velocity field and in the temperature. Under these conditions the equations of hydrodynamics reduce to a one-dimensional form and allow for an easy study of both the first and second sound velocities as a function of temperature. This paper open new perspectives for the investigation of superfluid as well as transport phenomena in strongly interacting Fermi gases.

G. Bertaina, L. Pitaevskii, and S. Stringari, "First and Second Sound in Cylindrically Trapped Gases", *Physical Review Letters*, 105(15) (2010), pp. 0402-0405.

QUANTUM INFORMATION

Photonic microchip for quantum information processing

Quantum Information claims great potentials in enhancing communication security and in exponentially increasing the computational speed of many algorithms. This revolution consists in encoding the bits of information in delicate quantum systems, such as single photons. Information processing is then performed by a network of optical components, typically mounted and carefully aligned on massive tables to achieve the required system stability. However, a controlled laboratory environment is needed to avoid thermal fluctuations or mechanical vibrations that can perturb the photon propagation and manipulation.

A recent and quite promising approach to Quantum Information processing relies on the use of compact integrated optical circuits to perform the same tasks as the bulky optical components network (composed by, e.g., mirrors, splitters, etc.). The photonic microchip is intrinsically stable and insensitive to external perturbations and represents an important step towards the application of quantum technologies outside a laboratory environment.

The basic element in most quantum optics experiments is the beam splitter, an optical device whose function is to separate a beam into two parts. Its integrated optics analogue is the directional coupler which was fabricated in a centimeter-scale chip using ultrashort laser pulses, which, focused in the glass, can directly draw pathways for the light. Experiments with couples of polarization quantum correlated photons, so called entangled photons, show that the fragile quantum features of the photons are correctly preserved in the chip and can be used for information processing tasks.

This result opens the way towards miniaturization and integration of several other Quantum Information functions, and envisages future applications in many protocols of Quantum Communication and Computation.

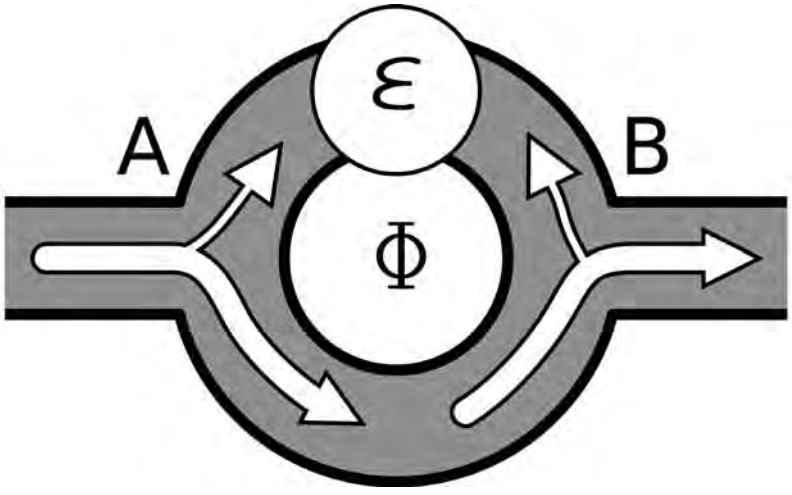
L. Sansoni, F. Sciarrino, G. Vallone, P. Mataloni, A. Crespi, R. Ramponi, and R. Osellame, "Polarization Entangled State Measurement on a Chip", *Phys. Rev. Lett.*, 105, 200503 (2010).

QUANTUM INFORMATION

Coherent detection of electron dephasing

Nanoscale electronic devices, at the basis of future developments in nano-electronics, spintronics and more generally in Quantum Computation schemes, fully exploit the coherence of electrons, the property of a wave to maintain a definite phase. These systems are usually embedded in larger electrical circuit and are subject to random electromagnetic fluctuations that may result in dephasing, a loss of phase coherence, and degrade the performances of the units. Information about the presence of a dephasing source is of high importance, but it is usually gained at the expense of the coherence of system itself. As long as localized classical random fluctuations are concerned, quantum interference may come to our aid and an electronic implementation of the optical interaction-free measurement may reveal very useful. We provide a proof of principle of such a mechanism, showing that a coherent detection of electron dephasing is possible. The system studied is a ring in which the trajectory of an incoming electron is guided through the arms of the ring and it is very sensitive to the phase of the electron. One of the ring's arm is potentially affected by localized noise. By diverting only a small portion of the electronic wave function towards the noisy region, it is possible to determine whether a dephasing source is present or not by monitoring the current, transmitted in the first case or reflected in the second case. Besides, it is shown that the emerging signal is still coherent. This is a manifestation of the interaction-free measurement character of the detection that goes beyond the "which-path" level. This phenomenon could find useful applications as a quantum fuse element, for gradient temperature measurements and in quantum networks.

E. Strambini, L. Chirolli, V. Giovannetti, F. Taddei, R. Fazio, V. Piazza, and F. Beltram, "Coherent detection of electron dephasing", *Phys. Rev. Lett.*, 104, 170403 (2010).



Schematics of an Aharonov-Bohm ring employed to detect the presence of a dephasing source.

QUANTUM SYSTEMS

Quantum teleportation and correlated quantum information channels

Quantum Teleportation is a procedure which allows to recreate the unknown quantum state of a system at a distant location without actually transferring the physical system itself. The key ingredient for such transmission of quantum information are the non local quantum correlations, known as entanglement, of the teleporting media. The experimental teleportation of the quantum state of polarization of a single photon about a decade ago has brought Quantum Information theory from the realm of science fiction to present day technology. Apart from its intriguing aspects the quantum teleportation protocol is a powerful tool to analyze complex situations in which one is interested in the reliable transmission of information encoded in the quantum state of a suitable physical system acting as information carrier. Such information can be corrupted by the action of external noise due to the presence of an external environment, often a quantum system itself. Such scenario is commonly called a Quantum Channel, with the information carriers known as use of the channel and the amount of reliable information transmitted as channel capacity. In recent years, there has been a growing interest to situations in which the quantum noise acting on consecutive channel uses is correlated. We have modeled the correlated Quantum Channel as a teleportation of n information carrier with an entangled state of a suitable multipartite system. This has allowed us to characterize such channels in terms of the correlation functions of the teleporting media. It provides a relatively simple method for determining whether a correlated quantum channel is able to reliably convey quantum messages by studying the entanglement properties of the teleportation mediating system.

F. Caruso, V. Giovannetti, and G.M. Palma, "Teleportation-Induced Correlated Quantum Channels", *Phys. Rev. Lett.*, 104, 020503 (2010).

QUANTUM SYSTEMS

Correlated electrons off equilibrium

The present work deals with the physics of strongly interacting quantum systems driven out of thermal equilibrium. This is one of the most challenging issue in modern physics with fallouts in many fields of great interest from nano-science to condensed matter, up tohigh energy physics.
Our work is motivated by the recent and impressive experimental developments in the field of ultra cold atomic gases, which provide the unique opportunity to explore in a laboratory the non equilibrium dynamical properties of many-body interacting quantum systems. From a theoretical perspective, these experiments raise a number of intriguing questions that require novel ideas and techniques to be developed.
In this manuscript, we introduce a new and very general variational approach to describe the real-time quantum dynamics in strongly correlated fermion systems, which will trigger, we believe, further investigations in this field.
Variational approaches play indeed a central role in our current understanding of correlated materials in equilibrium, hence their extension to that out-of-equilibrium time evolution represents a major achievement.
We apply this method to study the non-equilibrium dynamics in the fermionic Hubbard model after a sudden change of the interaction strength which is the simplest yet highly non-trivial out-of-equilibrium many body problem. We find an extremely rich dynamical behavior which confirms and largely extend previous investigations, providing in addition a very simpleand intuitive mean field picture for them.

M. Schirò and M.Fabrizio, "Time-Dependent Mean Field Theory for Quench Dynamics in Correlated Electron Systems", *Physical Review Letter*, 105, 076401 (2010).

COMPUTATIONAL CHEMISTRY

Synergy between experiment and theory helps fine chemistry industry

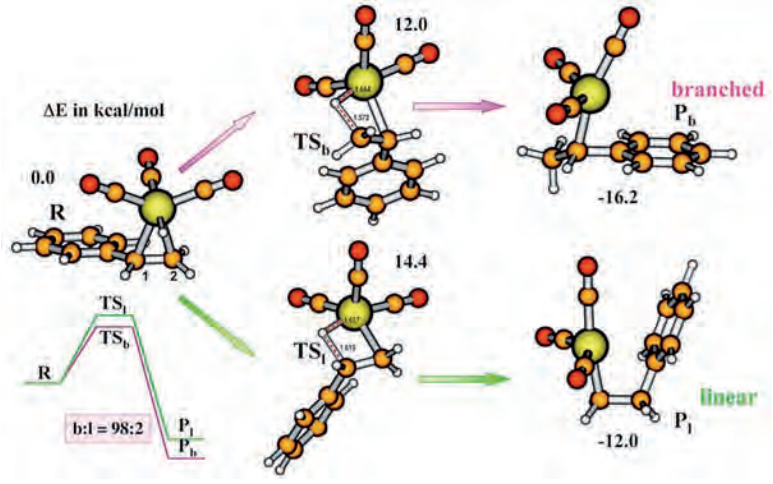
Though discovered in 1938 the "oxo process" or alkene hydroformylation is still one of the most important industrial catalytic reactions to produce aldehydes for detergents or perfumes and fine chemistry in general. Only a catalytic amount of a metal complex (rhodium ones are best suited for organic synthesis) is used, while the product incorporates all atoms of the starting material with high efficiency in terms of atom economy. But the general application of alkene hydroformylation still faces a challenge of controlling reaction selectivities to reduce hazardous waste and minimize environmental impact.

Both possible approaches (experimental control of reaction parameters: substrate nature, temperature and pressure; computational elucidation of reaction pathways: relative stability of transition states) were exploited in a joint CNR ICCOM-IPCF research with the University of Pisa.

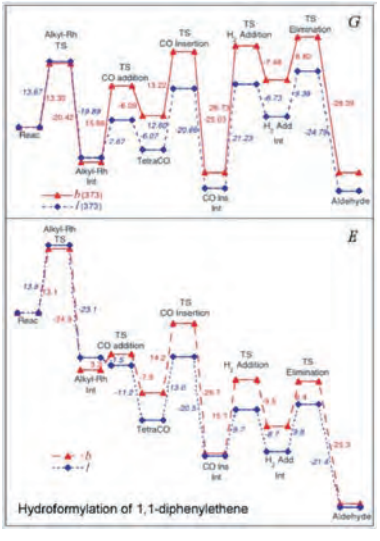
The formation of alkyl-Rh intermediates (aldehyde precursors) is a mechanism key-step: if nonreversible, its selectivity reflects the selectivity for aldehydes; if reversible, the selectivity-determining step occurs later. Nuclear Magnetic Resonance (NMR) analysis of unreacted alkenes, recovered at partial conversion in analogous deuterioformylation runs, indicates the role and involvement of alkyls on the basis of incorporated deuterium, but fails to understand why. Theoretical investigations, allowing energy barrier height comparisons, elucidate what experiment cannot: in the reversible reaction considered, the selectivity originates later along the branched pathway, where the free energy barrier for the CO migratory insertion step is higher than the alkyl-Rh formation one.

Better knowledge of selectivity factors can help the industry to orient the oxo process to high-yield production of fine chemicals without byproducts.

R. Lazzaroni, R. Settambolo, G. Alagona, C. Ghio, "Investigation of Alkyl Metal Intermediates Formation in the Rhodium-Catalyzed Hydroformylation: Experimental and Theoretical Approaches", *Coordination Chemistry Reviews*, 254 (2010), pp. 696-706.



Structures, energy profiles and regioselectivity for the alkyl formation step along branched and linear paths of styrene Rh-catalyzed hydroformylation.

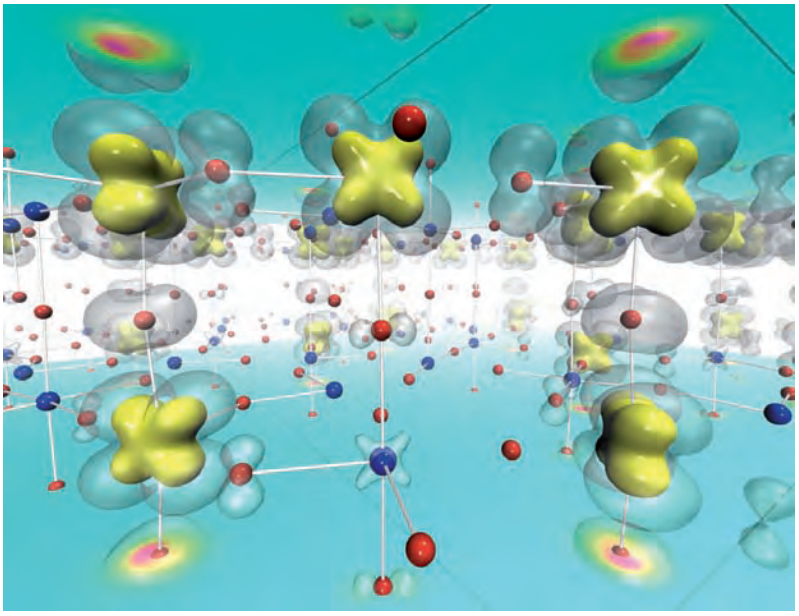


Potential energy (*E*, bottom)/free energy (*G* at 373 K, top) profiles in kcal/mol for the branched (*b*, triangles) and linear (l, rhombs) reaction paths.

COMPUTATIONAL PHYSICS

Coupled degrees of freedom in multiferroics

Spintronics is a novel branch of electronics where the active degree of freedom is the electron spin (and not the electron *charge*, as in "conventional" electronics). Within this framework, multiferroics – multifunctional materials where ferroelectricity and magnetism coexist - are presently drawing enormous interests, due to their technological potential in electrically-controlled spintronic devices; moreover, they constitute an astoundingly rich playground for fundamental condensed-matter physics. The research activity lead by CNR-SPIN in L'Aquila is based on theoretical studies of multiferroics. In particular, several concepts on how to achieve sizable ferroelectricity in magnets have been put forward by the CNR researchers; the approach is corroborated via first-principles calculations as tools to quantitatively estimate relevant ferroelectric and magnetic properties as well as to reveal *ab-initio* the main microscopic mechanisms behind the dipolar and spin orders. The research focuses in particular on the interplay between ferroelectricity and *electronic* degrees of freedom in magnets, i.e. on those cases where *spin-* or *orbital-* or *charge-* ordering can be the driving force for a spontaneous polarization to develop. In their recent study, focused on a novel iron-based compound, $K_{0.6}FeF_3$, the CNR researchers discovered an intimate and unprecedented coupling among charge-order on Fe ions, ferroelasticity and ferroelectricity, that result in a truly peculiar multiferroicity. These effects might pave the way to future applications in spintronics, in view of the $K_{0.6}FeF_3$ experimentally-observed multiferroic behavior persisting at or above room-temperature.



Perspective view of charge-orbital order of t2g minority-spin states in iron-fluoride $K_{0.6}FeF_3$

K. Yamauchi and S. Picozzi, "Interplay between charge order, ferroelectricity and ferroelasticity: tungsten bronze structures as a playground for multiferroicity", *Phys. Rev. Lett.* 105 (2010), 107202.

STATISTICAL PHYSICS

Dynamics and ordering process in artificial spin ice

A central concept in physics is equilibrium. Normally, systems can get to equilibrium, although possibly only over very long time scales. Two features contribute to these long times and therefore merit special attention. The first is large energy barriers that block and freeze the system. And it may be useful for example to stabilize magnetic recording. The second is competition between different couplings so that they cannot both be satisfied, like when we try to be friends with two people who hate each other.

Nanomagnets, which allow manipulation of magnetic units and visualization of their state, are an ideal playground for these fundamental concepts. An artificial spin ice (see Fig. 1) is an ordered two-dimensional array of units, each one magnetized along its longitudinal axis. Since the energy barrier to switch the magnetization is so large that the system is thermally stable, even if not in equilibrium, dynamics can only be induced by an external magnetic field. A key question is to understand the response of the system to the driving field, in much the same way as a granular material in a cylinder responds to its rotation, or a flock responds to a predator. In all these cases, the response depends both on the driving force and on the interaction among constituents (magnetic units, grains, birds). In spin-ice, the interaction is the magnetostatic coupling among units, which is frustrated.

We described the system in terms of 'vertex dynamics': the magnetic states of units converging to a vertex define the vertex type (see Fig. 2, top) and spin switching correponds to vertex processes. We find that a rotating field of suitable amplitude can be very effective to drive the system towards low energy states (Fig. 2, bottom). In a perfect system, effective dynamics are determined by edges and are well-ordered processes. In a real system, disorder is important for the ordering process!

Z. Budrikis, P. Politi, R.L. Stamps, "Vertex Dynamics in Finite Two-Dimensional Square Spin Ices", *Phys. Rev. Lett.*, 105 (2010), 017201.

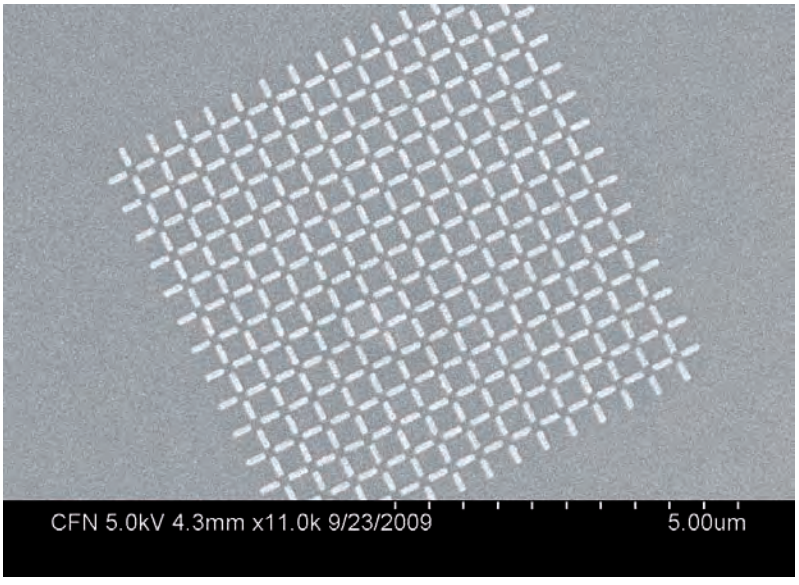


Figure 1 A scanning electron microscopy image of an artificial spin ice pattern (Courtesy of Jason Morgan and Chris Marrows, University of Leeds).

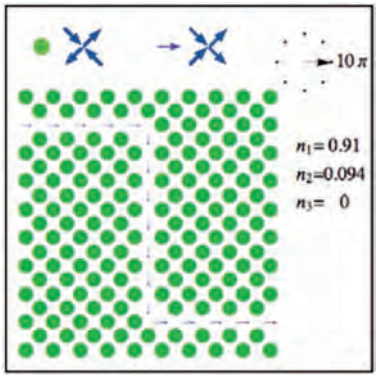


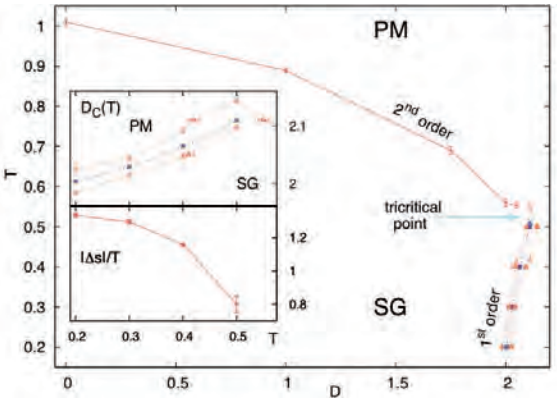
Figure 2 A representation of a low-energy state obtained in our simulations of a rotating field. Green circles represent low energy type 1 vertices and arrows represent higher energy type 2 vertices.

STATISTICAL PHYSICS

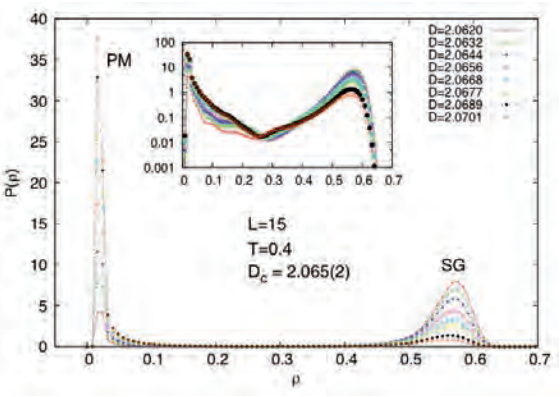
Thermodynamic first order transition and inverse freezing in a 3D spin glass

In the last years the phenomenon of melting upon cooling, else called Inverse Transition (IT), between fluid and solid, has been observed in an increasing number of materials, e.g., polymeric and colloidal compounds, high-Tc superconductors, proteins, nanosystems, bidimensional organic layers, semiconductors and metallic alloys. Technological applications of this counter intuitive reversible phenomenon have been put forward to control impurities in metals and semiconductors, for engineering high–performance semiconductor-based devices, for controlling rheological properties of paints, oils or foods, for thermo-thickening ability in pharmaceuticals or to solubilize and transport materials. Whether the solid phase is crystalline or amorphous, it occurs that a phase usually at higher entropic content happens to exist in very peculiar patterns such that its entropy actually decreases below the entropy of the phase normally considered the most ordered one. Yet, mechanisms allowing for such patterns have still to be clearly established. Using a minimal model for inverse freezing, the Blume-Capel spin-glass model, an Ising-like spin-glass model where the spin variables can assume the values +/-1 and 0, by means of Monte Carlo simulations in 3D we have been able to identify at least one source of IT: the existence of a local 'neutral' state for the system components. That is, the possibility for a component to ignore the rest of the system at given values of temperature and pressure. When the number of variables (spin-1 in our case) in the neutral state grows, e.g., because of increasing pressure or chemical potential, the system can be in a fluid paramagnetic phase even at low temperature and an IT between a "frozen" amorphous spin-glass at higher temperature and a fluid phase at lower T take place.

M. Paoluzzi, L. Leuzzi and A. Crisanti, "Thermodynamic first order transition and inverse freezing in a 3D spin-glass", *Phys. Rev. Lett.*, 104, 120602 (2010).



Phase diagram of the BC-random in three dimensional cubic lattice: a second order phase transition line ends in a tricritical point. IT occurs as first order phase transition.



Density distribution across the inverse first order transition: the two peaks are due to the coexistence of spinglass and paramagnetic phase. The paramagnetic phase has a very low density since we are in the IT regime.

COMPUTATION

Old puzzle solved!

The exhaust gases produced by combustion engines of modern vehicles contain carbon monoxide (CO), a very toxic gas. The catalytic converters exploit the interaction of the CO molecule with metal surfaces, e.g. Platinum, in order to convert CO in CO_2, a less harmful gas. The first step of the chemical reaction is the adsorption (i.e. the binding) of CO to the surface. Despite its conceptual simplicity, the quantum mechanical modeling of CO adsorption based on density functional theory (DFT), a theory which replaces the complicated quantum mechanical many-body system with a simpler one and represents the workhorse computational method in materials and surface science, poses serious problems. In the literature, this fundamental weakness is described as "CO adsorption puzzle". In 2008, A. Stroppa and G. Kresse (University of Vienna) have shown that using traditional approximations to the quantum mechanical many-body problem either the stability of the surface or the interaction with adsorbed molecules is overestimated. This was the 'smoking-gun' evidence that some piece of important physics was missing in traditional approaches preventing reliable computational catalysis modeling. In 2010, a joint collaboration between the University of Vienna and the CNR-SPIN Institute in L'Aquila, solved the "CO puzzle" by introducing a new way to calculate accurately the interactions in a many-electron system, namely the so called random-phase approximation.
It enables us to calculate reliably all the properties of the reaction between molecule and metal surface including weak bonding effects due to Van der Waals interactions, i.e. weak attractive forces between atoms or non polar molecules caused by a temporary quantum fluctuations of the electron clouds. It is now possible to simulate complex catalytic process much more accurately making possible to design new materials for heterogeneous catalysis, pharmaceutical operations, hydrogen storage, materials development and alternative energy.

L. Shimka, J. Harl, A. Stroppa, A. Grüneis, M. Marsman, F. Mittendorfer and G. Kresse, "Accurate surface and adsorption energies from many-body perturbation theory", *Nature Materials,* 9, 741-744 (2010).

MEASUREMENT

On the ultimate limit of measurement precision

Atomic and optical interferometers are among the most sensitive measurement devices available within the current technology. They allow for the measurement of time, inertial forces and magnetic fields, among others. Current state-of-the-art experiments are restricted by the so-called shot-noise limit. This corresponds to a measurement sensitivity increasing as the square root of the number of particles in the interferometer input state. The possibility to overcome this limit by employing quantum correlations (also referred to as entanglement) among the particles is a groundbreaking prediction of quantum mechanics. Impressive proof-of-principle experiments demonstrating a sensitivity beyond the shot-noise limit have been performed recently with photons, ions, cold atoms, and Bose-Einstein condensates. However, while most of the theory has been developed for a fixed number of particles in the probe system, in most experiments the number of particles fluctuates in different measurements. Our job extends the theory of quantum metrology in this respect. Firstly, we derive a condition, based on the quantum Fisher information, which recognizes the whole class of entangled states useful for sub shot noise measurements. Secondly, we rigorously justify the less comprehensive condition (known as spin squeezing inequality) that has been used in current experiments to identify useful entanglement. Finally, we set the precise definition of the Heisenberg limit, the ultimate sensitivity allowed by quantum mechanics. Generically, the measurement sensitivity can never exceed the average total number of particles. This settles a vivid debate initiated in the '80s.

P. Hyllus, L. Pezzé, A. Smerzi, "Entanglement and Sensitivity in Precision Measurements with States of a Fluctuating Number of Particles", *Phys. Rev. Lett.*, 105 (2010), pp. 120501-1 – 120501-4.

CULTURAL HERITAGE

A novel tool for authenticating metal artefacts

Is it possible to authenticate a bronze figurine, a coin, or other metal artefacts of ancient style on the basis of objective material analyses? The answer is yes. This is confirmed by the Institute of Applied Physics-CNR, which recently developed a dedicated device based on Laser Induced Plasma Spectroscopy (LIPS). Such a novel tool allows analyzing in a non-invasive way the compositional profiles of the outermost material layers of a given object, and then to discriminate between natural alteration phenomena and fraudulent patinations. The suitable interpretation of the LIPS data, along with examination of historical, technological, and microstructural aspects, makes the present analytical methodology very reliable. Formerly, historical and stylistic examinations allow formulating the authentication problem through a preliminary attribution hypothesis, then material characterization verify whether it is compatible with the compositional features provided by LIPS and other analyses. This innovative approach, which is entirely based on non invasive analytical techniques, has been applied in order to assess the authenticity of the antiquary bronze collections of Florence's National Museum of Archaeology. The authentication and attribution of artefacts of cultural interest represents a fundamental task for safeguarding the cultural identity of the different civilization and artistic productions, as well as to support the activity of law enforcements for contrasting the illicit traffic.

S. Siano, L. Bartoli, A.A. Mencaglia, M. Miccio, J. Agresti, "Use of Neutron Diffraction and Laser Induced Plasma Spectroscopy in Integrated Authentication Methodologies of Copper Alloy Artefacts", *Il Nuovo Cimento B*, 124 (2009), pp. 671-686.

J. Agresti, A.A. Mencaglia, e S. Siano, "Development and Application of a Portable LIPS System for Characterising Copper Alloy Artefacts". *Analytical and Bioanalytical Chemistry*, 395 (2009), pp. 2255-2262.

LIPS analysis on bronze figurines.

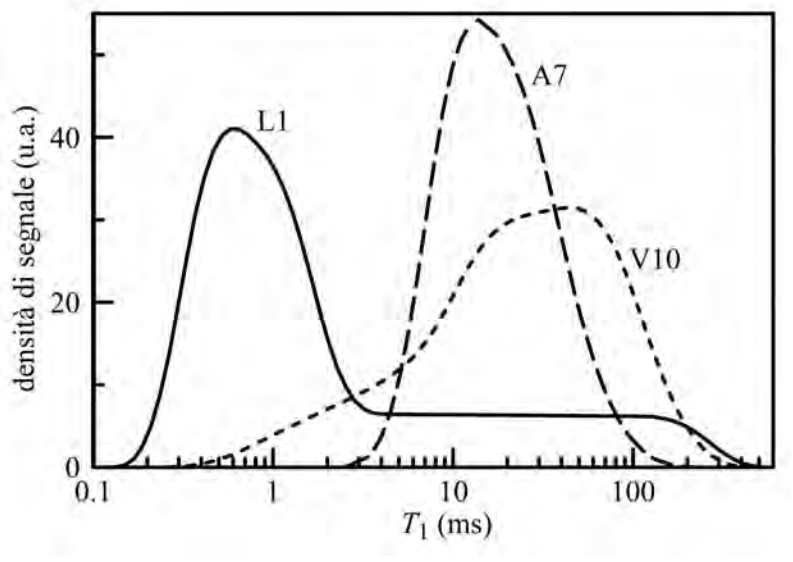
ART CONSERVATION

Magnetic resonance for stone artefacts

Litotipo	Intensità segnale NMR (u.a.)	Tempo di esposizione ad UR= 75%
L1	410	20 min.
V10	400	2 ore
A7	380	48 ore

Water greatly affects the conservation of natural and artificial stone artefacts, entering into contact with them through the rain, the capillary rise from the ground or by condensation of atmospheric moisture. The condensation is influenced by relative humidity, environmental temperature, stone characteristics (architecture of the pore space) and deliquescent salts such as calcium nitrate. The study of the kinetics of vapour condensation in porous structures containing deliquescent salts allows us to understand some phenomena which cause the deterioration of artworks located in sheltered spaces. This study, moreover, allows us to identify the conditions of vulnerability of materials such as stones and plasters. Analysis of the distribution of relaxation times of the hydrogen nuclei (^1H) of water by Nuclear Magnetic Resonance is an investigation technique very useful for determining the water content, following the kinetics of vapour condensation in porous structures containing calcium nitrate, evaluating the size distribution of pores filled with liquid water. With this technique, the Institute for Conservation and Enhancement of Cultural Heritage of CNR studied three lithotypes, similar for composition but different for porous structure. The study showed two behaviours: the condensed water in a porous medium containing deliquescent salts is greater than the water absorbed by the same amount of salt placed on a flat surface, as well as than that absorbed by the not polluted stone; the different architecture of the porous space influences the vapour condensation, the migration of water in well defined dimensional classes of pores, and the kinetics of condensation.

M. Gombia, V. Bortolotti, R.J.S. Brown, M. Camaiti, L. Cavallero and P. Fantazzini, "Water Vapor Absorption in Porous Medium Polluted by Calcium Nitrate Studied by Time Domain Nuclear Magnetic Resonance", *Journal of Physical Chemistry* B, Vol. 113, No. 31;10580-6, 2009.



Top: Exposition time to controlled relative humidity on L1, V10, A7 samples. The time was necessary to have the same amount of condensed water.

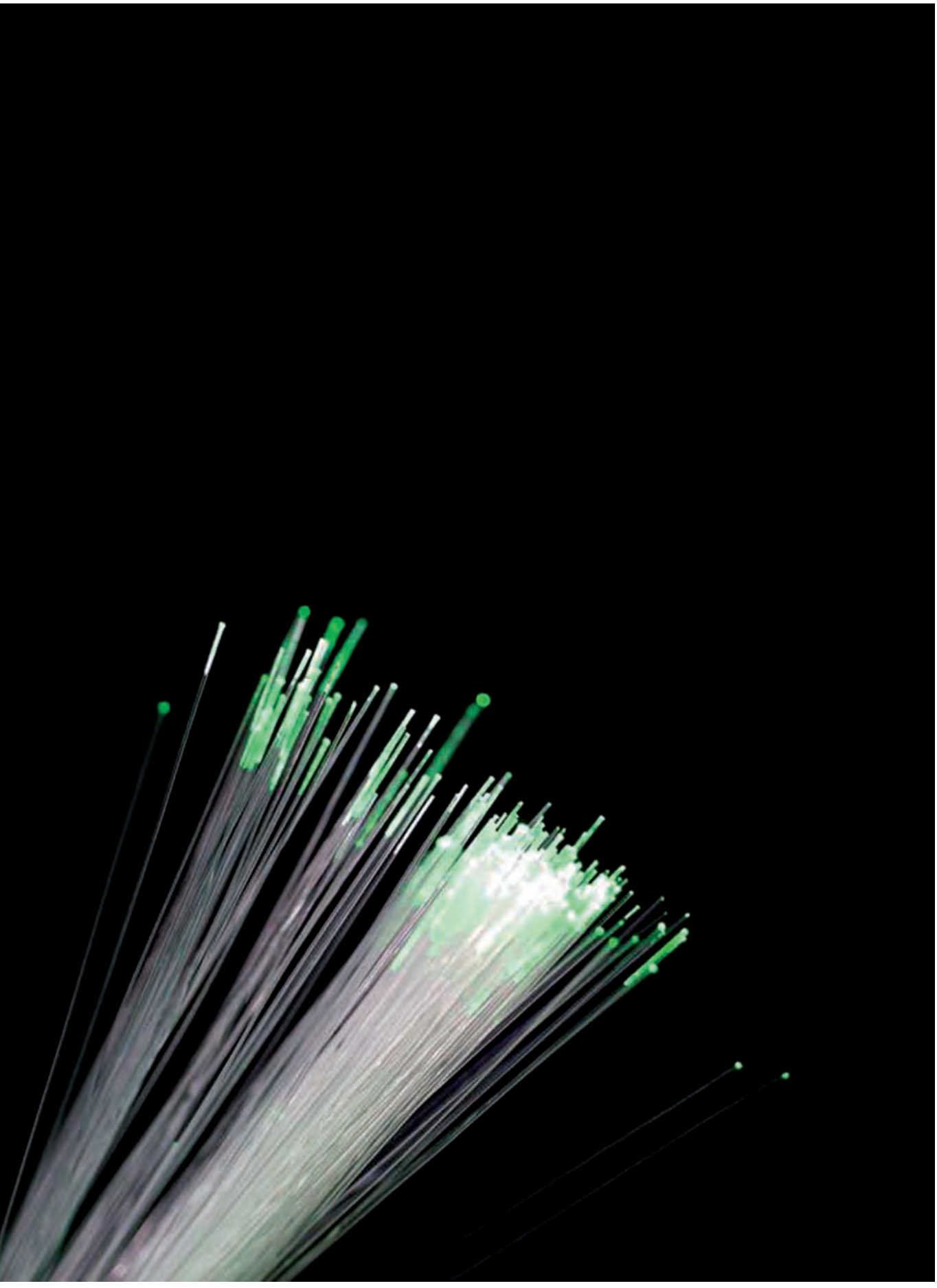
Left: Comparison of distribution time of 1H in condensed water in samples of stone from Lecce (L1), Vicenza (V10), Angera (A7) having the same amount of calcium nitrate. T1 relaxation time is correlated to pores structure.

Information & Communication

Highlights

Electronics,
Telecommunications,
Electromagnetic fields,
Computer science,
Combinatorial optimization,
Semantic web,
Bioinformatics,
Medical imaging,
Data mining,
Medical analysis,
Cosmic microwaves

Fiber optics.

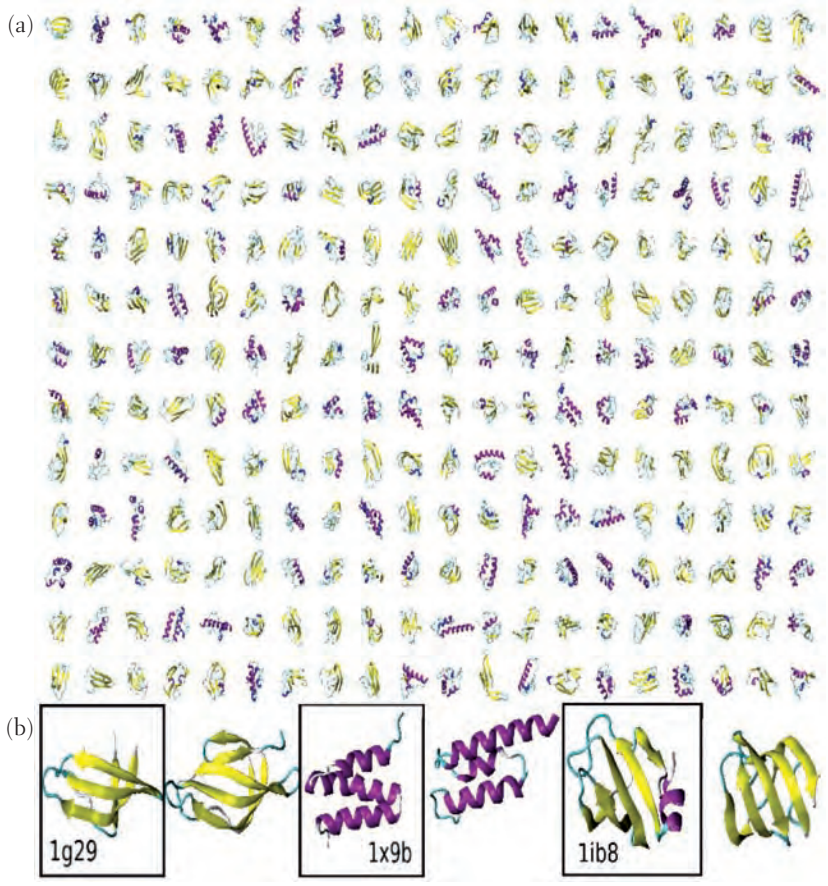


BIOINFORMATICS

Exploring the universe of protein structures beyond the Protein Data Bank

It is currently believed that the atlas of existing protein structures is faithfully represented in the Protein Data Bank. However, whether this atlas covers the full universe of all possible protein structures is still a highly debated issue.
By using a sophisticated numerical approach, bias exchange metadynamics, we performed an exhaustive exploration of the conformational space of a 60 amino acid polypeptide chain described with an accurate all-atom interaction potential. We generated a database of around 30,000 compact folds with at least 30% of secondary structure corresponding to local minima of the potential energy.
This ensemble plausibly represents the universe of protein folds of similar length; indeed, all the known folds are represented in the set with good accuracy, despite the fact that the simulation is performed for a homopeptide. However, we discover that the known folds form a rather small subset, which *cannot* be reproduced by choosing random structures in the database. Rather, *natural* and *possible* folds differ by the contact order, on average significantly smaller in the former. This suggests the presence of an evolutionary bias, possibly related to kinetic accessibility, towards structures with shorter loops between contacting residues.
Beside their conceptual relevance, the new structures open a range of practical applications such as the development of accurate structure prediction strategies, the optimization of force fields, and the identification and design of novel folds.

Cossio P., Trovato A., Pietrucci F., Seno F., Maritan A., et al., "Exploring the Universe of Protein Structures beyond the Protein Data Bank", *PLoS Comput Biol.*, (2010) 6(11): e1000957. doi:10.1371/journal.pcbi.1000957



(a): A selection of 260 out of the 30,000 structures generated by bias-exchange metadynamics.

(b): Examples of successful alignments. The structure of a protein existing in nature (labelled by its PDB code) is represented together with its VAL60 equivalent for three cases.

BIOINFORMATICS

TRStalker: an efficient heuristic for finding fuzzy Tandem Repeats

Genomes in highest eucaryotic organisms contain a substantial amount of repeated sequences. Tandem Repeats (TRs) constitute a large class of repetitive sequences that are originated via phenomena such as replication slippage and are characterized by close spatial contiguity. They play an important role in several molecular regulatory mechanisms, in several diseases (e.g. in the group of trinucleotide repeat disorders), and in parental tests. While for Tandem Repeats with a low or medium level of divergence the current methods are rather effective, the problem of detecting TRs with higher divergence (fuzzy TRs) is still open. The detection of fuzzy TRs is propaedeutic to enriching our view of their role in regulatory mechanisms and diseases. Fuzzy TRs are also important as tools to shed light on the evolutionary history of the genome, where higher divergence correlates with more remote duplication events. We have developed the algorithm TRStalker with the aim of detecting efficiently Tandem Repeats that are hard to detect because of their inherent fuzziness, due to high levels of base substitutions, insertions and deletions. To attain this goal we developed heuristics to solve a version of the problem for which the fuzziness is measured with respect to a motif string not necessarily present in the input string. This problem is akin to the "generalized median string" that is know to be an NP-hard problem. Experiments with both synthetic and biological sequences demonstrate that our method performs better than the current state of the art for fuzzy TRs and that the fuzzy TRs of the type we detect are indeed present in important biological sequences.

M. Pellegrini, M. Elena Renda and A. Vecchio, "TRStalker: an Efficient Heuristic for Finding Fuzzy Tandem Repeats", *Bioinformatics*, 26(12), pp. i358-366, 2010.

COLLABORATIONS OF THE CNR

Slow-Motion science on the football field

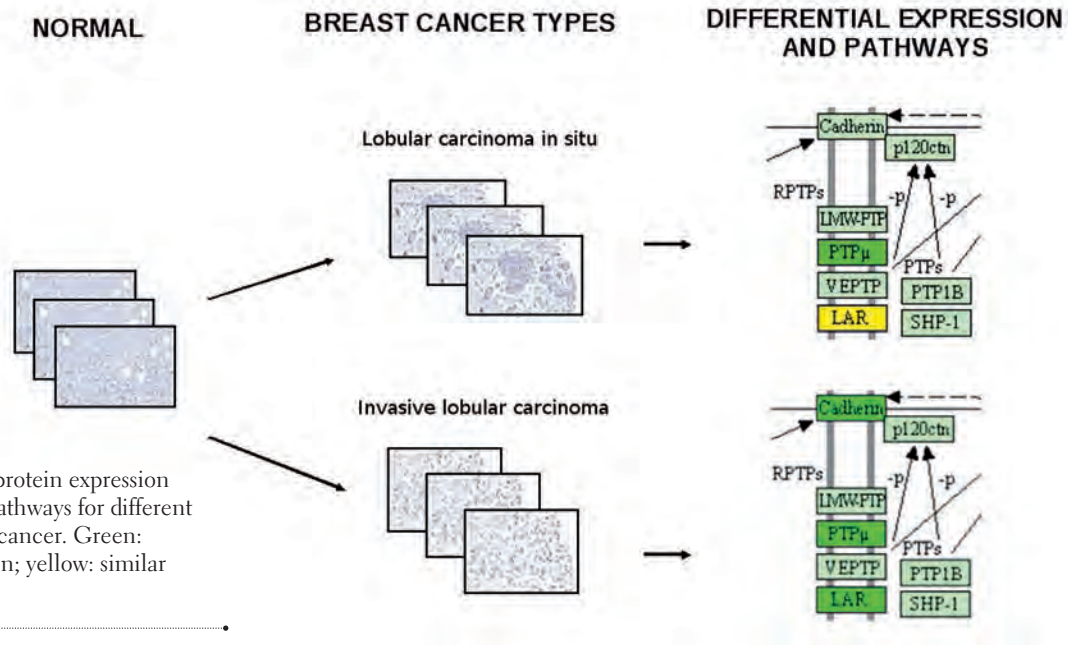
Since 2006, the Italian Football Federation (Figc) has an active agreement with the National Research Council (CNR) for the development and the testing of technologies in view of their possible introduction to the football field.
The Institute of Studies of Intelligent Systems for Automation in Bari (Issia-Cnr) has developed a technology to support the referees which can accurately determine and report the location of the ball and of the players in order to recognize phantom goals, off-sides, and can monitor events in the penalty area (Megar). The "real time" processing system captures images from particular cameras and transmits them to a computer equipped with software based on innovative algorithms in the field of vision which represents the "intelligent" component of the system. A multi-media console allows for objective evidence of the events, and a supervisory server indicates the resulting decisions to the referee. The three experimental prototypes are currently installed in the Friuli stadium in Udine.

BIOINFORMATICS

A multilevel data integration resource for breast cancer study

Breast cancer is one of the most common cancer types: approximately, it affects 1 out of 10 women and represents the 25% of all the tumours that hit women. From a scientific point of view, it is increasingly believed that using a system perspective it is possible to develop better strategies for cancer treatment; this consideration is due to the fact that the (complex) behaviour of living systems can be hard to predict from the properties of individual parts (such as genes, proteins, cells).
In this context, the integration of the current, available knowledge regarding biological components and biological systems is a crucial operation. We carried out this task focusing on the breast cancer, and, in particular, we implemented a freely available web resource named *"Genes-to-Systems Breast Cancer (G2SBC) Database"*, where the results of our work can be interactively explored. The G2SBC Database collects data about genes, transcripts and proteins reported in the scientific literature as *altered* in breast cancer cells; alterations encompass, for instance, different types of mutations and protein expression variations. These data are integrated in a *multilevel* knowledge base (from genes, transcripts and proteins to molecular networks, cell populations and tissues), which includes a series of analysis tools concerning cellular biochemical pathways, protein-protein physical interactions, protein structure and mathematical models of cell behaviour.
Coupling the multilevel knowledge base with the analysis tools, the G2SBC Database overcomes the limits of reductionist resources, enabling predictions that can lead to new experiments.
The resource is freely available at www.itb.cnr.it/breastcancer.

E. Mosca, R. Alfieri, I. Merelli, F. Viti, A. Calabria and L. Milanesi, "A multilevel data integration resource for breast cancer study", *BMC Systems Biology*, 4:76 (2010).



Integration of protein expression with cellular pathways for different types of breast cancer. Green: down-regulation; yellow: similar expression.

BIOINFORMATICS

Knotted vs unknotted proteins: a comparative survey

For decades the existence of knotted proteins was not deemed possible on the ground that viable biomolecules should not be "badly" entangled. This hypothesis, contrasted with expectations, based on general polymer physics arguments, that equilibrated polymer configurations should be highly knotted.

In recent years, among the increasing number of protein structures deposited in the protein data bank (PDB), several knotted proteins were found. The discovery held surprises both for biologists and physicists. In fact, knotted proteins turned to be both abundant and diverse: they presently make up for a few percent of the PDB and cover 4 distinct knot families.

Furthermore, the fact that each of these molecules can fold reversibly and reproducibly ending up with the same knot in the same location indicated an unexpected degree of coordination of the folding process.

Several theoretical and experimental studies accordingly tried to characterize the folding process of knotted proteins.

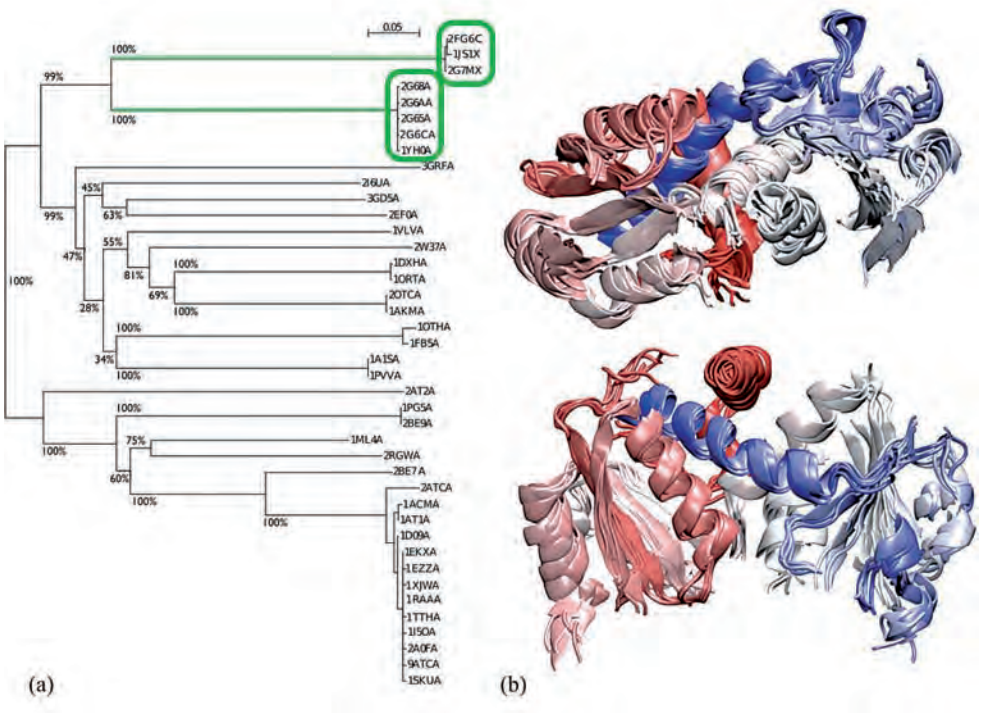
In the study of Potestio et al. a completely different approach was followed. Specifically, the authors aimed at gaining insight into the knot formation mechanisms by systematically comparing all knotted and unknotted proteins present in the PDB.

By these means, the evolutionary relationships of some protein families were reconstructed. The gathered evidence suggested that proteins diverged from unknotted "relatives" following the insertion of a specific segment of amino acids in the primary sequence.

This most interesting result indicates that a small part of the protein can encode the global topological state, i.e. the knottedness, of the protein.

The hypothesis can be verified by synthesizing mutant proteins lacking the "knot-promoting segment".

R. Potestio, C. Micheletti, H. Orland, "Knotted vs unknotted proteins: evidence of knot-promoting loops", *PLoS Comput. Biol.*, 6 e1000864 (2010), pp 1-10. doi:10.1371/journal.pcbi.1000864



(a) Phylogenetic tree of SOTCase proteins; the green branches involve knotted proteins. (b) Common structural core of six SOTCase proteins including one knotted and five unknotted proteins. From Figure 1 of Potestio et al. PLoS (2010).

BIOINFORMATICS

Tag SNPs selection and reconstruction

Genetic variation among different individuals is limited to a small percentage of positions in DNA sequences (99% of two DNA molecules being identical), called Single Nucleotide Polymorphisms (SNPs), that are characterized by the fact that two possible values (alleles) of the four bases (T, A, C, G) are observed across a population at such sites, and that the minor allele frequency is at least 5%. The knowledge of such polymorphisms is crucial to identify common genetic factors that may determine diseases; but the computational costs to analyze these prohibitively large data sets have suggested to look for a selected set of SNPs (Tag SNPs) that represent all the others, taking into account that DNA molecules have a block structure, where blocks are "rigid" subsequences of DNA transmitted without splits in the sequence during evolution. The information of a whole block may be redundant, but few representatives of the SNPs may convey the right information and become the object for a deeper analysis.

This problem, called Tag SNP Selection, is solved through an integer optimization problem (set covering) that identifies the Tag SNPs, followed by a reconstruction phase that derives unknown SNPs from the value of Tag SNPs. For this second step we test two reconstruction methods, one based on majority vote, and the other on a machine learning approach. We test our algorithm on two public data sets of different nature; the results are, when comparable, in line with the related literature. The important contribution of the proposed method is its capability to deal simultaneously with very large SNPs sets, and, in addition, to provide highly informative reconstruction rules in the form of logic formulas.

P. Bertolazzi, G. Felici, P. Festa, "Logic based methods for SNPs tagging and reconstruction", *Computers & Operations Research*, 37, 1419-1426, (2010).

IMAGE MEDICAL ANALYSIS

A local approach based on a Local Binary Patterns variant texture descriptor for classifying pain states

Nowadays pain is considered the 5th vital sign, and there has been a movement to devise better methods of pain assessment. One development has been to move away from the gold standard of self-assessment and include objective measurements. For many patient populations, for example, the elderly and neonates, pain must be assessed through proxy judgments. Current pain assessment instruments developed for newborns utilize physiological (e.g. heart and respiratory rates, blood pressure) and behavioral information (e.g. body movement, crying, and facial expressions). The best source of information for inferring pain is to examine the infant's facial expressions. Facial responses to pain are more specific and consistent than behavioral and physiologic responses. Fig. 1 illustrates some of the known facial patterns that are strongly associated with pain—prominent forehead, eye squeeze, nasolabial furrow, taut tongue, and an angular opening of the mouth. A practical approach would be to use these cameras and develop machine vision systems that unobtrusively and constantly scan a neonate's face for signals of pain.

One of the problems encountered with neonatal pain detection involves the unusual amount of noise in the faces of neonates: the surface of these faces are covered with wrinkles and dimples (Fig. 2). In this work, we propose a machine learning approach based on local texture descriptors. As illustrated in Fig. 3, our approach can be divided into four main steps: (1) preprocessing, eyes alignment and tessellation, (2) feature extraction, (3) selection and (4) classification.

Our experiments on a large dataset of neonatal facial images show that a local approach based on the combination local texture descriptors produces a very reliable system.

L. Nanni, S. Brahnam and A. Lumini, "A local approach based on a Local Binary Patterns variant texture descriptor for classifying pain states", *Expert Systems With Applications*, vol.37, no.12, pp. 7888-7894, December 2010.

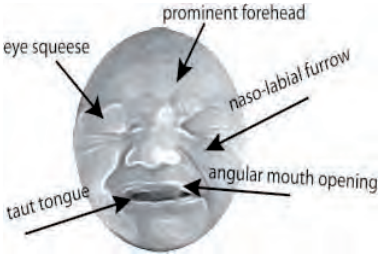


Figure 1. Main characteristics of neonatal facial expression of pain.

Figure 2. The top images were produced by the pain stimulus. The bottom images were produced by the nonpainful obnoxious stimuli.

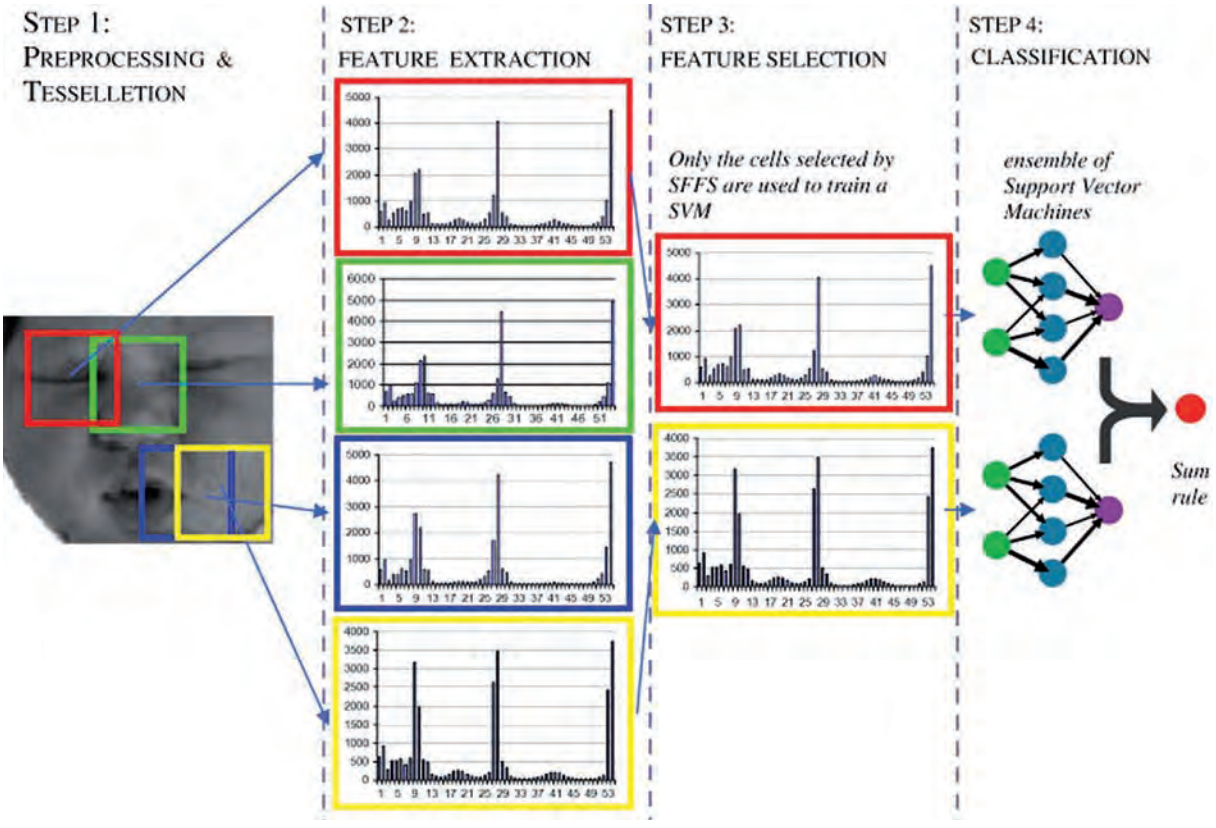


Figure 3. Schema of the method.

MEDICAL IMAGING

Measuring the size of lung nodules

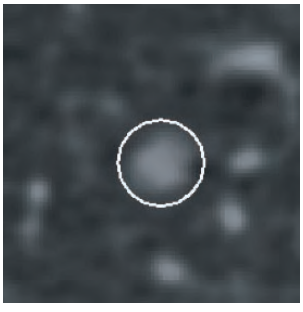
Early diagnosis of lung cancer has an important prognostic value and a huge impact on treatment planning. For this reason, screening trials using low-dose computed tomography (CT) are conducted worldwide. Nodule growth as observed in CT scans acquired at different times is the primary feature to characterize potential malignancy of indeterminate small lung nodules. Accuracy and reproducibility of such a measurement are crucial. We proposed to estimate the size of nodules by a scale-space representation that needs no segmentation.

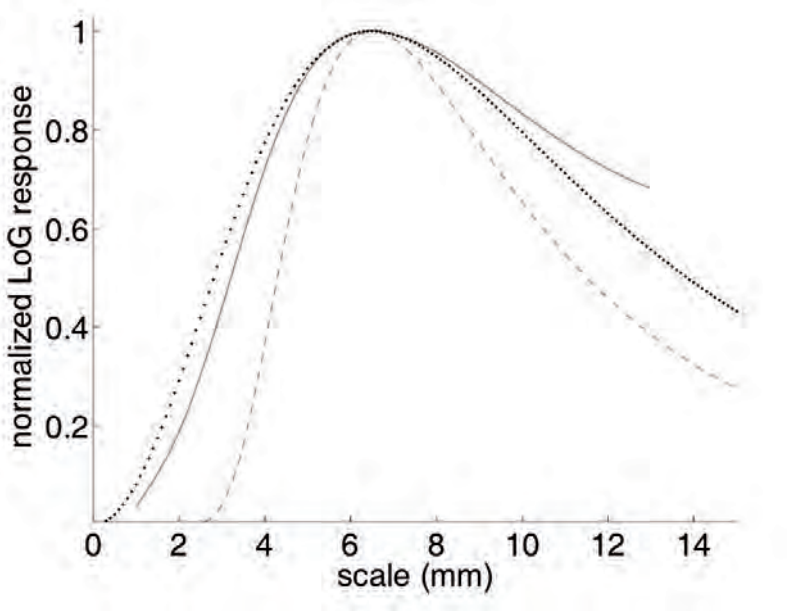
Lung nodules usually appear in CT images as 3D blobs and can be analyzed in the scale-space by Laplacian of Gaussian (LoG) kernels. Given a nodular pattern the LoG scale-space signature, i.e. the plot of LoG response against LoG scale (Figure 1), is computed. The plot exhibits a peak corresponding to the scale (characteristic scale) of the LoG kernel that best matches the nodule. The characteristic scale was adopted as measurement of nodule size.

Both in vitro and in vivo validation were carried out. The in vivo validation was performed on CT scans collected from the ITALUNG screening trial and from the LIDC public data set. The Pearson correlation coefficient between characteristic scale and equivalent diameter was high. Moreover, intra- and inter-operator reproducibility of characteristic scale was excellent. Results of our experiments indicate that characteristic scale is well correlated with volume-based measurements and is robust against statistical variability of CT imaging procedure. Moreover, the method is computationally inexpensive as compared to segmentation-based methods. Characteristic scale represents a valid alternative to diameter or volume to evaluate the growth of nodules detected in lung cancer screening trials.

Diciotti S., Lombardo S., Coppini G., Grassi L., Falchini M., Mascalchi M., "The LoG Characteristic Scale: A Consistent Measurement of Lung Nodule Size in CT Imaging", *IEEE Transactions on Medical Imaging*, 29 (2010), pp. 397-409.

Figure 1. The solid line is the scale-space signature of a lung nodule (on the left side). Dotted and dashed lines refer to Gaussian and spherical models respectively.





COMPUTATIONAL SCIENCE

New advances to link computer-aided design and numerical simulation

Industrial design and manufacturing relies on virtual prototyping for the development of new products. Before constructing a physical prototype of the product, a virtual model is generated with the help of computer-aided design (CAD) software. This virtual model is then passed to a computer-aided engineering (CAE) program to simulate the behavior of the product under real conditions (e.g., the wind resistance of a car, or its deformation during a crash). Working with virtual models allows to test many different designs and ideas before the physical prototype is created. It also allows to reduce the total time and cost from design to manufacture, since creating the virtual model is faster and cheaper than constructing a physical one. Most often, the results obtained by CAE are used to modify the original design within CAD, in a process that must be repeated until a satisfactory model is achieved. A time bottleneck is found during this process in passing the information from one software package to the other. The reason behind this is that the mathematical building blocks used by CAD to design the product are different from the functions that CAE uses to simulate its behavior, and an approximation of the original geometry must be created in the middle.

Isogeometric analysis is a new simulation method, its main novelty being that it is based on the same functions that are employed in CAD. Its use simplifies the communication between the two software packages involved in virtual prototyping, saving time during the design process. In our work, fruit of a collaboration between IMATI-CNR and the University of Pavia, we have defined a generalization of isogeometric analysis that extends the method to electromagnetic applications such as, e.g., the design of antennas or waveguides.

A. Buffa, G. Sangalli, R. Vázquez, "Isogeometric Analysis in electromagnetics: B-splines approximation", *Computer Methods in Applied Mechanics and Engineering*, 199 (2010), pp. 1143-1152.

COMPUTER SCIENCE

Detecting chains of vulnerabilities in industrial networks

In the last years the protection of critical infrastructures has become a highly topical issue in the scientific community. Governments and international organizations, in fact, keep the information security as one of their priorities and invest large amounts of both human and financial resources in this field. Everyday a lot of security updates are released and installed on personal computers by software providers in order to solve potential vulnerabilities deriving from newly discovered errors and flaws. A rigorous estimation of the exposure to attacks is therefore the first step in the process of solving these issues efficiently.

A new software tool has been conceived by the IEIIT-CNR of Turin in order to evaluate in a semi-automatic way the level of exposure to cyber attacks of large distributed systems. The aforementioned tool contributes in a substantial way to the vulnerability assessment of a system.

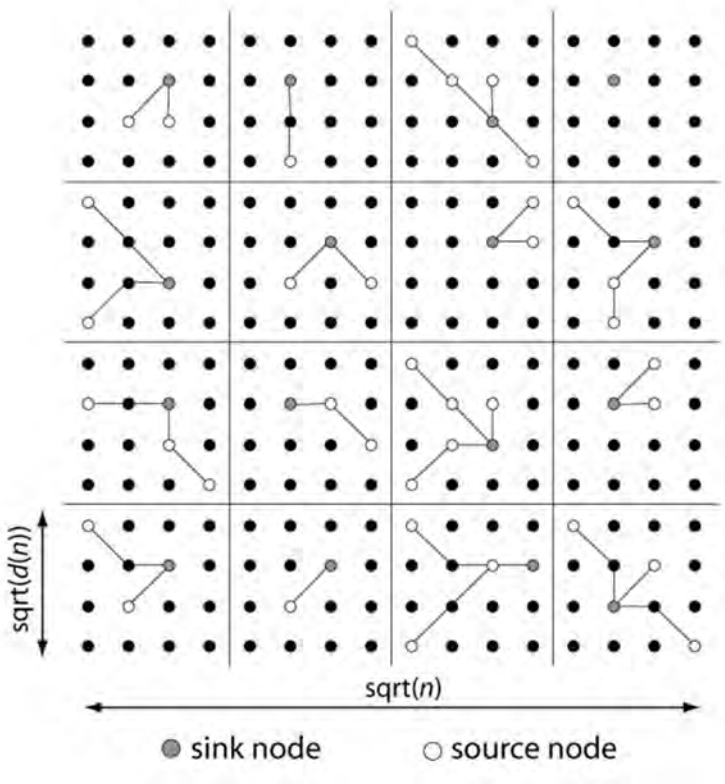
The systems that can benefit from this analysis are, for instance: industrial communication systems, critical infrastructures (e.g. the energy, gas, fuel and water providers), air, railway and metropolitan transport networks, telecommunications and financial services systems. The software tool developed by the IEIIT institute allows to assess the vulnerabilities affecting the analysed system. In this context a vulnerability is a flaw or weakness that can cause pathological behaviours in the system if it is accidentally triggered or intentionally exploited.

M. Cheminod, I.C. Bertolotti, L. Durante, P. Maggi, D. Pozza, R. Sisto, A. Valenzano, "Detecting Chains of Vulnerabilities in Industrial Networks", *IEEE Transactions on Industrial Informatics*, Vol. 5, pp. 181-193, 2009.

COMPUTER SCIENCE

On the data gathering capacity and latency in a wireless sensor network

Wireless sensor networks are networks composed of a large number of wireless devices, each of which includes environmental sensors (e.g., temperature, light intensity, etc.) and an interface for short-range radio communication. By exchanging and reporting environmental data to a central server (sink), wireless sensor networks enable fine-grained environmental monitoring, up to a level which is not possible or prohibitively expensive with wired solutions.
Wireless sensor networks are a promising technology for improving quality and/or reducing costs of environmental monitoring and process control. However, fundamental questions are yet to be answered for what concerns their potential to fulfill these promises. The goal of this work is studying the performance of a wireless sensor network when the size of the network becomes very large, and the network is used to collect and report gathered data to one/few sinks. In particular, the study characterizes network performance with respect to two fundamental communication parameters: the *capacity*, defined as the aggregate amount of data per time unit delivered to sinks; and the *latency*, defined as the time elapsing between the generation of a data packet at a wireless node and its reception at a sink. Informally, capacity refers to the network ability of collecting large amounts of data from the field, while latency refers to its ability of quickly reporting data to the sinks, as needed e.g. in real-time applications.
The main finding of our study is that optimal capacity and latency in data gathering can be simultaneously achieved in a wireless sensor network, thus confirming that this technology has the potential of revolutionizing environmental monitoring and process control.



Example of optimal data gathering pattern in a large wireless sensor network: data is generated by source nodes, and collected by sinks.

P. Santi, "On the Data Gathering Capacity and Latency in a Wireless Sensor Network", *IEEE Journal on Selected Areas in Communications*, Vol. 28, n. 7, pp. 1211-1221, (Sept. 2010).

COMPUTER SCIENCE

MARIA: a universal language for service-oriented interactive applications in ubiquitous environments

An innovative and useful support for designers of interactive software applications is available. It is 'MARIA', a universal language, developed by the HIIS Laboratory at ISTI-CNR, for service-oriented applications in ubiquitous environments, and a set of automatic tools that exploit it in various contexts. The language allows designers to specify interactive applications at abstract level, which is independent from the interaction platform, and refine such descriptions at concrete level, which is platform-dependent. From the concrete descriptions it is possible to generate implementations for various existing languages, such as XHTML, VoiceXML and Java (Figure 1). This solution makes easier the design of applications accessible from a variety of interactive devices because it allows designers to concentrate on the main logical decisions without having to deal with a plethora of low-level implementation details. In the ServFace European Project we have created an environment to support the design and development of service-based interactive applications starting with the development of a task model describing the activities to accomplish in order to reach the users' goals, from which it is possible to obtain first MARIA descriptions and then implementations for various devices.

In the OPEN European Project an intelligent environment able to exploit the MARIA language to obtain migratory user interface (Figure 2) has been developed. Such interfaces allow users to start a work session with any Web application in one device, e.g. a desktop PC, and then to continue it in a new device, e.g. an iPhone, from the point they left off. For this purpose, the user interface moves automatically to the new device in such a way to adapt to its features while preserving the state of the user interactions. This environment can be useful for service providers in order to allow their users to freely move about and continue their activities across various interactive devices.

F. Paternò, C. Santoro, L.D. Spano, "MARIA: A Universal Language for Service-Oriented Applications in Ubiquitous Environment", *ACM Transactions on Computer-Human Interaction*, Vol.16, N.4, November 2009, pp.19:1-19:30, ACM Press.

Figure 1 The Universal MARIA Language

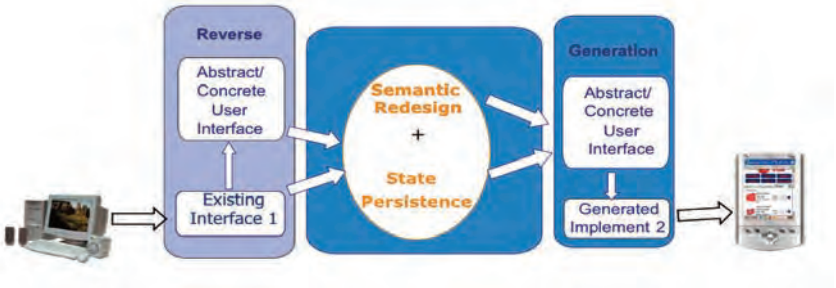


Figure 2 Software Architecture Exploiting MARIA to Obtain Migratory Interfaces.

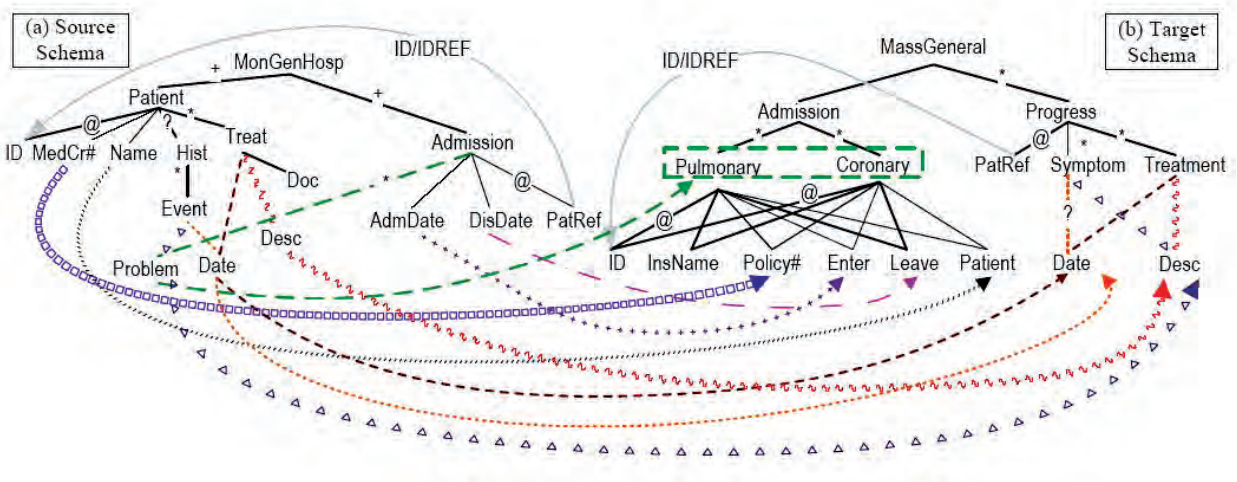
COMPUTER SCIENCE

Schema mapping and query translation in heterogeneous P2P XML databases

Nowadays, there is a tremendous blow-up of data formats and content, that is mainly due to the development of the Web and of new distribution paradigms, such as peer-to-peer networks. In this paper, we consider peers in a peer-to-peer data management system (PDMS), which often exhibits heterogeneous schemas and no mediated global schema. As a practical example of such an heterogeneity, one can think of data and schema of patients and treatments in different healthcare institutions or data and schema of customers of financial institutions. Such data can be organized quite differently from one institution to another, each of which represents a peer. To translate queries across peers, we assume each peer provides correspondences (or arrows) between its schema and a small number of other peer schemas. We focus on query reformulation in the presence of heterogeneous XML schemas, including data–metadata conflicts. We develop an algorithm for inferring precise mapping rules from informal schema correspondences. We define the semantics of query answering in this setting and develop a query translation algorithm.

Our translation handles an expressive fragment of the standard XML Query (www.w3.org/XML/Query/) and works both along and against the direction of mapping rules, i.e. high-level assertions that express the semantics of the correspondences between the source and target schemas. The impact of the presented research is highly significant, as it affects the area of data integration, which is one of the most studied ones in databases. Moreover, the current systems do not support an efficient and targeted query reformulation, as our system does. Moreover, it scales gracefully with respect to the number of peers, thus fitting increasingly high sizes of networks.

A. Bonifati, E. Qing Chang, T. Ho, Laks V.S. Lakshmanan, R. Pottinger, Y. Chung, "Schema mapping and query translation in heterogeneous P2P XML databases", *The VLDB Journal*, 19 (2) (2010), pp. 231-256.



Mapping schemas Montreal General Hospital and Massachusetts General Hospital: an example of heterogeneity in the Health-care.

TELECOMMUNICATIONS

Random matrix analysis for radio communications

The increasing demand for higher capacity, required by the recent applications in the field of Communication Technologies, has generated interest in the design of multiple-input multiple-output (MIMO) systems, which are characterized by the presence of multiple antennas at both transmit and receive sides.

Such systems can provide high spectral efficiency in rich and quasi-static scattering environments. The importance of such systems is witnessed by their implementation in recent standards such as WiMAX and Long Term Evolution (LTE). In particular, random matrix analysis plays a key role in the performance evaluation of MIMO systems. It is well known in the research community that the propagation channel, which has a significant impact on the MIMO performance, can be modelled by means of random matrix (i.e. the channel matrix) with some distribution. Recent works have shown that the performance of MIMO systems depend on the distribution of the singular values of the channel matrix. As a consequence, the knowledge of the distribution of the singular values allow researchers to characterize the performance of such systems.
A specific research carried out by the Institute IEIIT-CNR in the field of the distribution of the singular values of Gaussian random matrices (which find applications in many environments of interest) has led to the derivation of a closed-form expression for the probability density function of an arbitrary singular value. The joint distribution of consecutive singular values was also obtained.

A. Zanella, M. Chiani, Moe. Z. Win, "On the Marginal Distribution of the Eigenvalues of Wishart Matrices", *IEEE Transactions on Communications*, Vol. 57, 4, pp. 1050-1060, (April 2009).

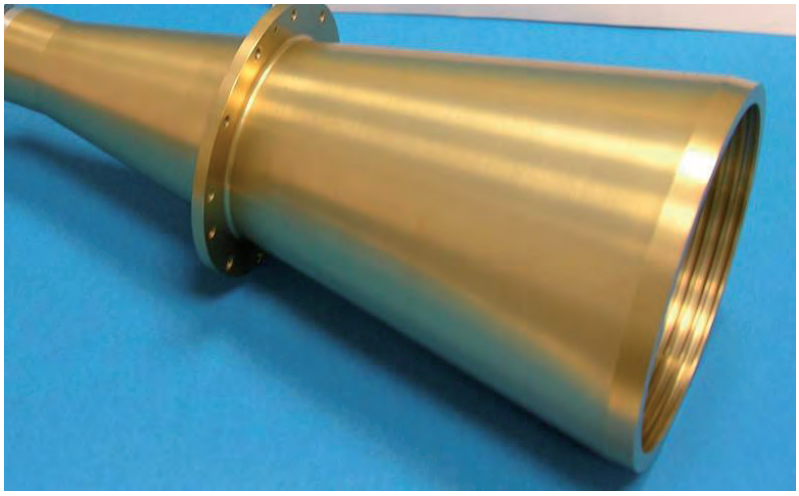
EDUCATIONAL PROJECTS

Smart inclusion: the CNR for children

The Minister for Public Administration and Innovation under the supervision of the Institute of Organic Synthesis and Photo reactivity of the CNR (CNR-Isof) of Bologna and with the support of Telecom Italia, initiated the project "Smart Inclusion," in order to guarantee educational service to long-term patients of paediatric onco-hematology. Since the first installation in 2009 at Saint Orsola Malpighi Hospital in Bologna, the national extension plan of the initiative has reached the Institute of Giannina Gaslini in Genoa and the Children's Hospital of Regina Margherita in Turin. Thanks to a platform on video-based touchscreen terminals equipped with a camera and a location on the headboard of the bed and installation in the classrooms that connect them, using multimedia interactive whiteboards and ergonomic poles, young patients can follow the lessons and interact with the class, view the recordings of the lessons, complete exercises, benefit from individual self-taught courses and get access to entertainment programming *on demand*. In line with the guidelines of the European Union, the project is based on *open source* technology, and as such, combines enhanced performance with cost-saving techniques.

TELECOMMUNICATIONS

New technology for satellite communications



In modern communication satellites, the allocation of different services such as point to point, broadcasting, internet and mobile communications on the same antenna system represents an interesting design solution in terms of cost, dimension and weight reduction.

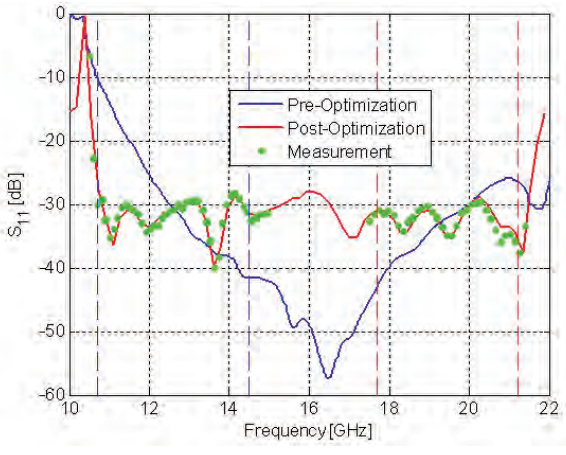
In order to achieve these features, the single antenna components have to both satisfy very strict requirements in terms of electromagnetic performances and permit the employment of a considerable number of high power carriers. Particular care has to be taken in order to avoid the electric breakdowns and to minimize the spurious intermodulation products, related to oxidations phenomena, between signals operating in different frequency bands.

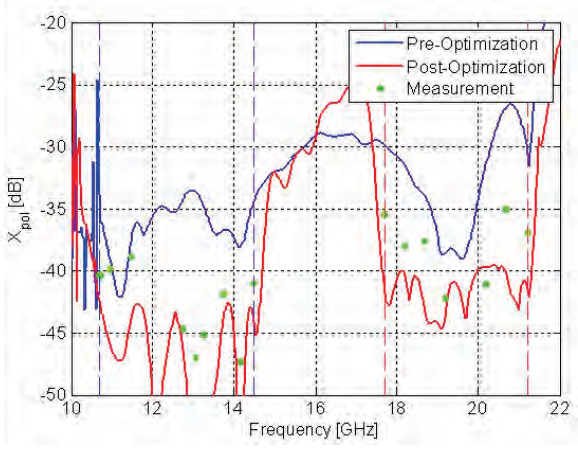
For their excellent potential characteristics, corrugated horns represent an interesting choice for the illuminators. Such antennas present a circular truncated cone shape where suitable corrugations are manufactured on the metal wall to maximize the electromagnetic performances.

In the framework of the research activities in "Systems and Devices for Telecommunication Technology" *of the CNR-ICT Department, a* novel design technique for corrugated horns has been developed in order to rapidly and directly obtain an high performance configuration, stable to the mechanical tolerances and with high-power capabilities as required from the practical applications.

The effectiveness of the proposed synthesis techniques has been shown by the considerable agreement of theoretical and measured results on corrugated horns operating in the Ku and K bands designed in the framework of a research contract between the IEI-IT-CNR Institute and Thales Alenia Space Italia.

G. Addamo, O.A. Peverini, R. Tascone, G. Virone, P. Cecchini, R. Orta, A. Ku-K, "Dual-Band Compact Circular Corrugated Horn for Satellite Communications", *IEEE Antennas And Wireless Propagation Letters*, vol. 8, 2009.



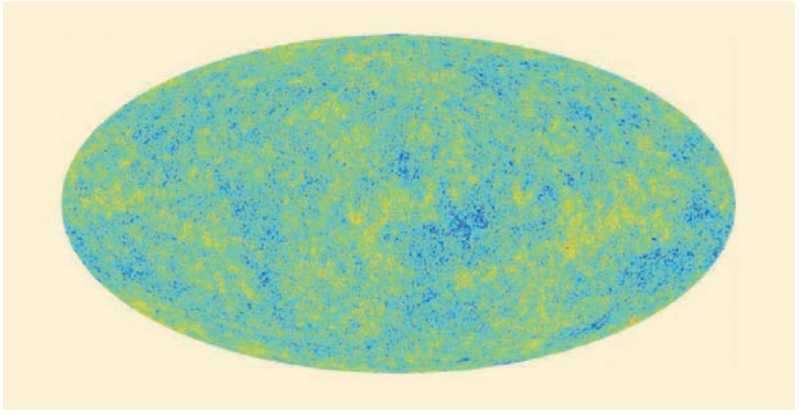


COSMIC MICROWAVES

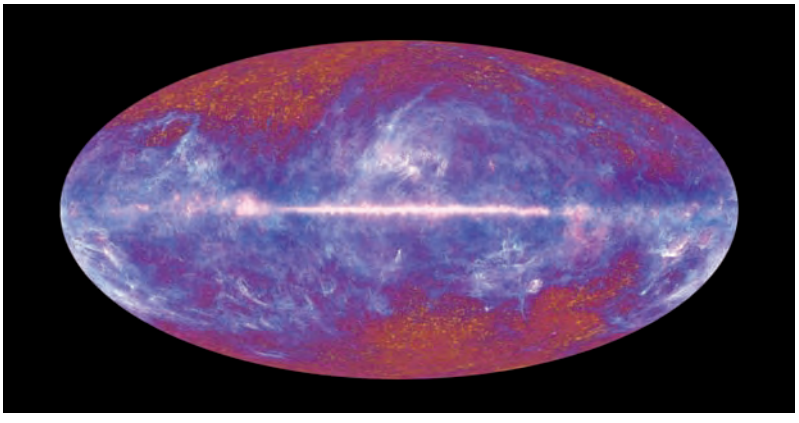
Bayesian source separation for cosmology

One of the most important discoveries of the last century was undoubtedly the observation of Cosmic Microwave Background (CMB) radiation by Penzias and Wilson in 1964. Their accidental discovery provided the proof for the hot big bang theory. The hot big bang model, which aims to provide an explanation for the formation of our Universe, asserts that the Universe evolved into its current state expanding and cooling from an initially much denser and hotter Universe. CMB is the first light released 379000 years after the big-bang, which since then has cooled down to 2.7K. The Planck satellite mission has the main objective of measuring this fossil radiation, which will give us information not only about the past of our universe, but also about its present and its future. The cosmological components to be calculated from CMB measurements will help us decide between competing theories, such as whether the expansion will continue forever, whether it will stabilize or whether the big bang will be followed by a big crunch.

Unfortunately, CMB does not present itself plainly to the antennas but is measured in a mixture with other cosmological sources originating from within or outside our galaxy. It is our task, as information scientists, to design methods to uncover CMB from microwave observations. To this end, we developed sophisticated novel techniques in the framework of Bayesian estimation which allow us to incorporate rich cosmological prior information in the estimation process. In this paper, we give a full exposure to the Bayesian formulation of cosmological source separation and present pioneering methods for separation in 2D using image structure information rather than in 1D, for separation of dependent sources and for speeding up numerical Bayesian methods.



A simulated CMB map at the resolution of Planck maps.



1st year Planck sky survey obtained after publication of our paper.
We are now applying the techniques described in the paper to obtain CMB as in the figure above.

E.E. Kuruoglu, "Bayesian source separation for cosmological component estimation", *IEEE Signal Processing Magazine*, vol. 27, no. 1, January 2010, pp. 43-54.

ELECTROMAGNETIC FIELDS

Innovative applications for diagnostics and therapy

The adaptive response is a phenomenon for which cells or organisms, exposed to a sub-toxic dose of a DNA damage inductor, become resistant to the damage induced by a subsequent higher dose, of the same or another agent. The investigations carried out so far on the adaptive response have been performed by using ionizing radiation and chemical mutagens. A study, in collaboration between the CNR-IREA of Naples and the University of San Antonio, Texas, indicated that exposures to non-ionizing electromagnetic fields at the frequency in use for cell phones (radiofrequency), were able to induce adaptive response.

Twenty hours radiofrequency radiation exposure was able to strongly reduce the DNA damage induced in human lymphocytes from peripheral blood by a subsequent treatment with Mitomycin-C, a known genotoxic agent.

Most of the scientific community believes that exposure to radiofrequency radiation does not induce DNA damage. The interesting result of this study is that, for the first time, a non-genotoxic agent has been demonstrated to induce adaptation without induction of significant cumulative effects as in the case of ionizing radiation. This observation suggests novel applications in diagnostics and therapy. As a matter, the ability of radiofrequency to induce protection against DNA damaging agents could be effective in protecting individuals against damage induced by exposure to mutagens (X-rays). Also, the possibility to modulate the adaptive response in normal and cancer cells offering protection for normal cells instead of cancer cells could be a valid tool to support the cancer therapy.

A. Sannino, M. Sarti, S.B. Reddy, T.J. Prihoda, Vijayalaxmi, M.R. Scarfì, "Induction of Adaptive Response in Human Blood Lymphocytes Exposed to Radiofrequency Radiation", *Radiation Research*, vol.171, pp. 735-742 (2009).

COMBINATORIAL OPTIMIZATION

An exact algorithm for hard optimization problems

A cut is a minimal set of edges whose removal disconnects a graph. When each edge of the graph is given a weight, the weight of a cut is the sum of the weights of all its edges. One of the most studied combinatorial optimization problems is the one that calls for a cut of maximal weight in a graph. This problem is known as Max-Cut and is one of the most studied in combinatorial optimization not only for the connections with other problems in discrete mathematics but also for the number of its applications. The Max-Cut problem arises, for example, in the study of magnetic materials to compute the ground state of spin-glass configurations. Typical resource allocation problems like the one of assigning one of two available frequencies to each TV repeater of a given set, with the objective of minimizing the overall interference, also demand for the solution of a Max-Cut. The theory that studies the complexity of problems arising in discrete mathematics classifies Max-Cut as NP-hard. For this reason, it is typically solved with heuristic methods. Unfortunately, with these techniques one cannot guarantee that the solution produced is optimal neither can one provide an estimate of how far the weight of such a solution is from the optimum. On the other hand, there are applications where the true optimum is required. In this cases the task becomes much harder: a simple enumerative procedure would not be able to do the job, as actually even with the fastest computer available today one can only treat graphs of at most 30 nodes. The most effective techniques used today for larger graphs are based on two possible relaxations to the problem: the polyhedral and the semidefinite relaxation. The former is particularly suited for very sparse graphs while the latter is preferable for denser instances. A joint research project run by researchers from IASI-CNR and from the University of Klagenfurt has produced a new exact algorithm that combines and integrates the two relaxations. The algorithm, called BiqMac, can be accessed at the site biq-

mac.uni-klu.ac.at. The effectiveness of exact algorithms for NP-hard problems is currently measured on sets of benchmark instances collected in some electronic archives. BiqMac was able to produce a certified optimum for a number of such still unsolved instances, the largest being on a complete graph of 250 nodes. Most probably, this is the fastest today available algorithm for the exact solution of Max-Cut in dense graphs.

F. Rendl, G. Rinaldi, and A. Wiegele, "Solving Max-Cut to Optimality by Intersecting Semidefinite and Polyhedral Relaxations", *Mathematical Programming*, (121) 307-335, (2010).

DATA MINING

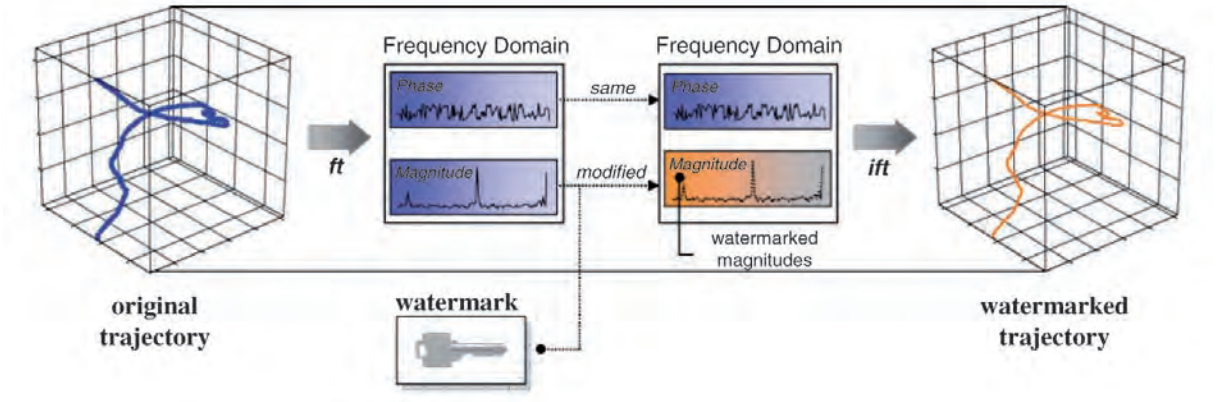
Rights protection of trajectory datasets with nearest-neighbor preservation

Data sharing is an important aspect of scientific or business collaboration. However, data owners are also concerned about the protection of their rights on the datasets, which in many cases have been obtained after expensive and laborious procedures. This work presents a way of convincingly claiming ownership rights over a trajectory dataset, without, at the same time, destroying the salient dataset characteristics, which are important for accurate search operations and data-mining tasks.

The digital watermarking methodology that we present distorts imperceptibly a collection of sequences, effectively embedding a secret key, while retaining as well as possible the neighborhood of each object, which is vital for operations such as similarity search, classification, or clustering. A key contribution in this methodology is a technique for discovering the maximum distortion that still maintains such desirable properties. We demonstrate both analytically and empirically that the proposed dataset marking techniques can withstand a number of attacks (such as translation, rotation, noise addition, etc) and therefore can provide a robust framework for facilitating the secure dissemination of trajectory datasets.

The technical contributions of the paper are: (1) we present a novel rights protection and watermarking framework with NN-preservation; (2) we provide bounds on the power of the embedded watermark, so as to guarantee that the nearest-neighbor(s) does not change for each of the watermarked objects; (3) while the naive algorithms for determining the said watermarking power are costly, we show efficient ways of speeding up the process making it more than 2 orders of magnitude faster, thus allowing the technique to be applicable to large datasets.

C. Lucchese, M. Vlachos, D. Rajan, Philip S. Yu, "Rights protection of trajectory datasets with nearest-neighbor preservation", *VLDB J.*, 19(4): 531-556 (2010).



Overview of watermark embedding technique.

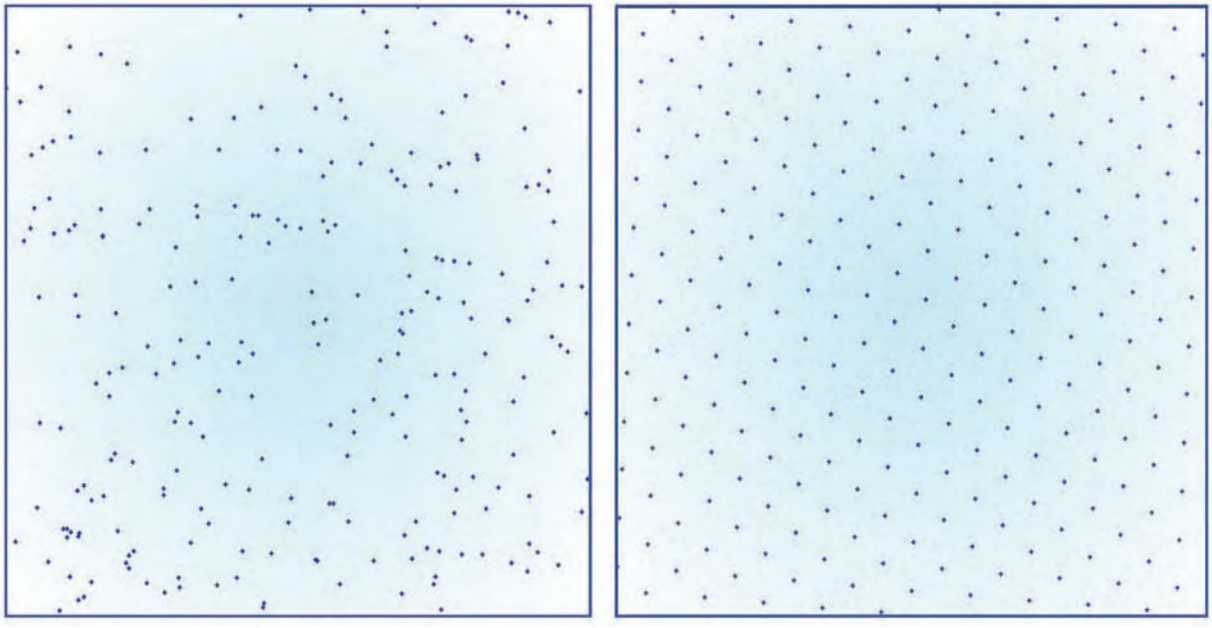
ARTIFICIAL INTELLIGENCE

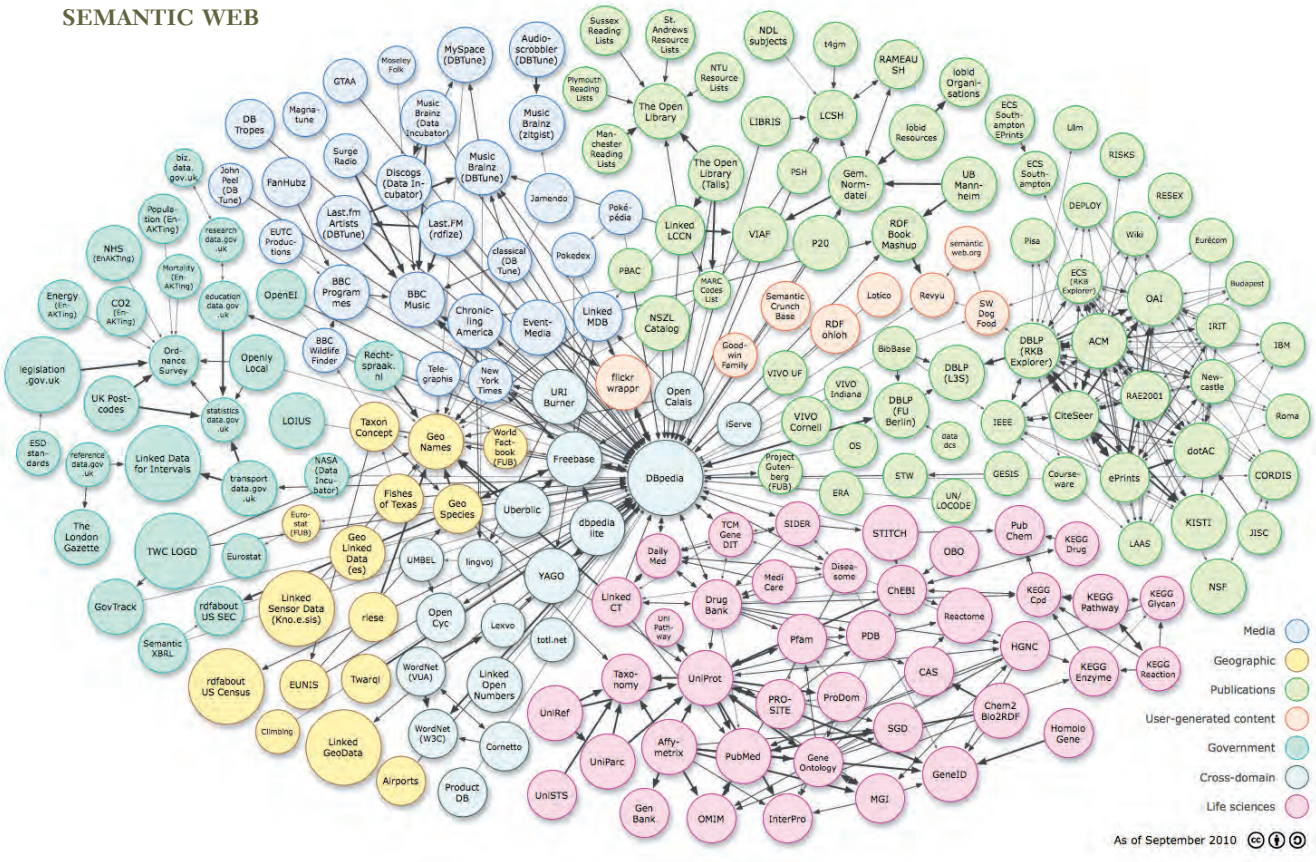
An efficient sampling scheme for machine learning problems

Many problems relevant to different fields such as engineering, physics, statistics, economics require the estimation of unknown functions and/or the derivation of optimal policies. Finding the density function underlying a physical process, deciding the best strategy in a financial market, controlling a power plant are all instances of this paradigm. Problems of this kind can be effectively faced using machine learning techniques, tools from artificial intelligence that automatically learn the behaviour of an unknown system through observed data and suitable mathematical models (like neural networks or kernel structures). When the function to be learned is complex, many observations may be needed to guarantee acceptable accuracy. This generally leads to computational issues in a computer implementation, due to the involved demanding optimization routines. Then, in cases where we can observe the function in points of our choice, there arises the problem of sampling the multidimensional input space in such a way that good accuracy can be obtained, without requiring too many observations. This work investigates sampling of the input space through lattice rules, sets of points endowed with a very regular structure, introduced in the last century for numerical integration problems. It is proved that a lattice sampling scheme can lead to a fast convergence of the estimation error in an empirical risk minimization context, typical of machine learning methods. The convergence rate is actually much faster than the one provided by random sampling, that is the most commonly employed technique. The theoretical analysis is then confirmed by simulation experiments, also pointing out the robustness of the procedure with respect to perturbations in the lattice structure.

C. Cervellera, "Lattice Point Sets for Deterministic Learning and Approximate Optimization Problems", *IEEE Transactions on Neural Networks*, 21 (2010), pp. 687-692.

Sampling of a bi-dimensional input space by a random set (left) and a lattice scheme (right).





The Linked Open Data Cloud: bubbles represent datasets, arrows represent that two datasets are linked at some degree, colors represent the topic of datasets.

Towards a pattern science for the semantic web

Our work aims at discovering knowledge patterns in the Web of Data, a large part of the Semantic Web.

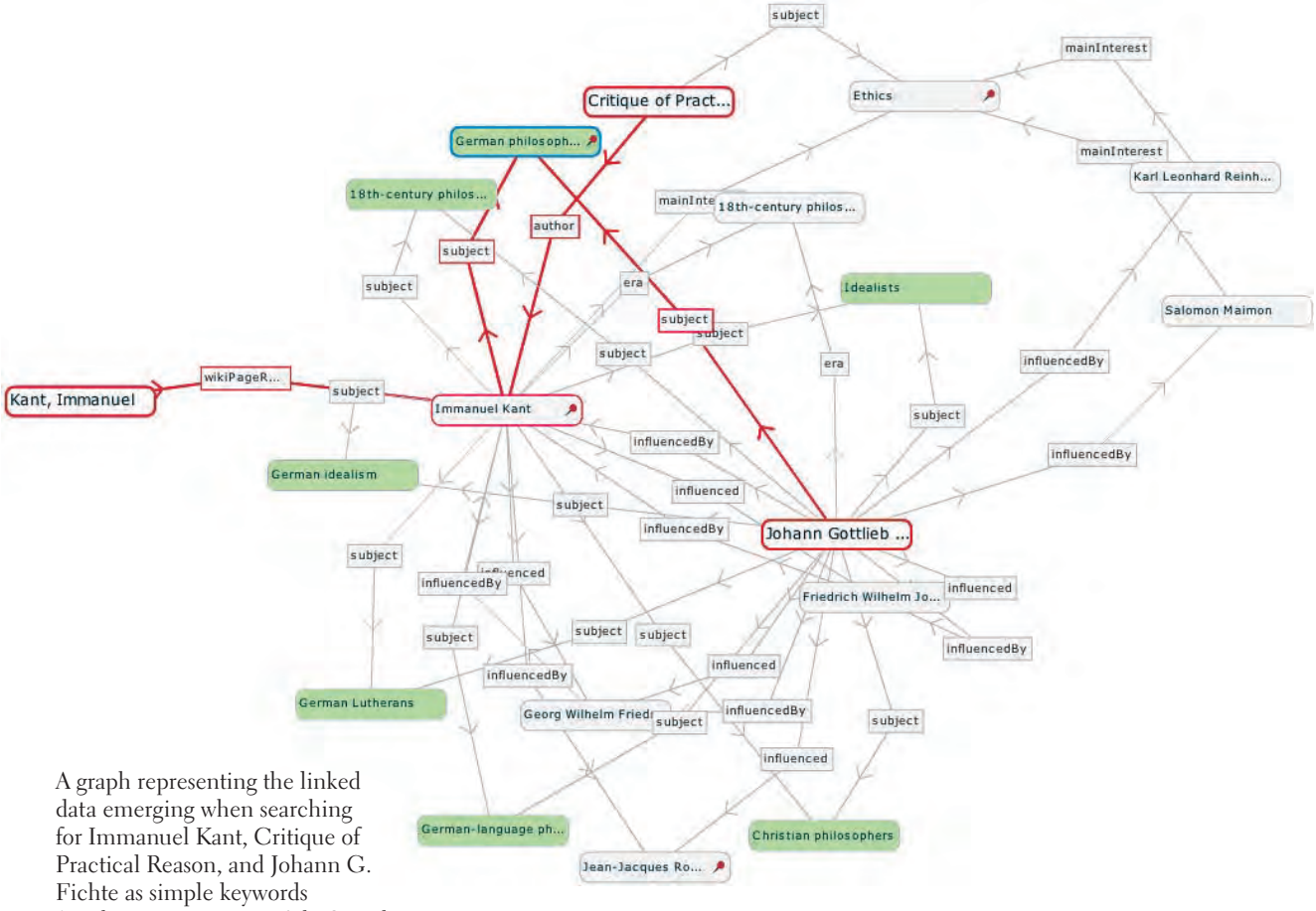
The Web of Data, consisting of so-called Linked Data, is a giant graph of knowledge extracted from diverse sources (Wikipedia, governmental, scientific and multimedia databanks, social network applications, sensor devices, etc.), transformed into a format, called the Resource Description Framework (RDF), where information items are linked one another, and openly published where applicable, with the possibility of issuing complex queries to such a global knowledge repository. For example, we can ask what genes are supposed to be involved in a certain disease or what researchers work on a certain topic in Rome. This way of interacting with global knowledge creates the potential of a huge impact on scientific, commercial, governmental, and personal activities.

Full exploitation of Linked Data is not trivial, because it requires a cognitive layer where the knowledge is conceptualized in heterogeneous, arbitrary ways, but we can experiment with logical and mathematical tools, revealing the patterns used to organize that knowledge. These can emerge as data patterns, linguistic frames in textual data and cognitive schemas are enriched with automated reasoning.

We integrate different research domains, methods and techniques: from knowledge engineering, graph mining, complex systems science, logic, linguistics, and cognitive semantics, to develop solutions able to carve out a "bound-

ary" from the continuum of knowledge. That process is similar to pattern recognition or discovery in images, sounds, or words, but it needs to address special problems due to the nature of knowledge, which is built by humans for their purposes, and in general does not depend on specific physical or information objects.

A. Gangemi, V. Presutti, "Towards a Pattern Science for the Semantic Web", *Semantic Web*, 1,1-2 (2010), pp. 61-68.



A graph representing the linked data emerging when searching for Immanuel Kant, Critique of Practical Reason, and Johann G. Fichte as simple keywords (try this at wit.istc.cnr.it/PhpSearchAllThingsV02/#).

NOTIFICATION OF NATURAL EMERGENCIES

Following the path of the volcanic clouds

The Institute of Methodologies for Environmental Analysis of the CNR (Imaa-CNR) has been entrusted with the coordination of the project called European Aerosol Research Lidar Network (Earlinet) which is composed of a network of 26 *Lidar* (Light Detection and Ranging) stations and was established in 2000 and spread throughout Europe with the Italian stations of Aquila, Naples, Potenza e Lecce.
The objective of Earlinet is the systematic measurement of *aerosol* (airborne particles) profiles in the atmosphere in order to study their role in the balance of radiation and for data collection on air quality (dust transportation, observations of the causes and effects). In case of unique events, such as the eruption of the Icelandic volcano, Eyajafjallajokull, the network enters a state of alert and is capable of providing information on the altitude reached by the clouds.

SEMANTIC WEB

Semantic web technologies to model students' competences in Web 2.0 informal learning environments

The Information Society dramatically changes the way of experiencing learning activities, and the structured training activities, designed by specialists, are more and more connected to the increasing number of educational opportunities in the social networks. Students interact and collaborate using new learning environments which are structurally different from traditional e-learning environments. Web 2.0 applications and social networks allow users to collaborate in new ways thus leading to the definition of learning opportunities in which the boundaries between the learning contexts and other social spaces tend to disappear. In these unstructured learning contexts, modeling learner profiles through the definition of the skills and competences acquired by the users is a central objective.

Our studies are addressed to the use of a semantic web approach in order to create the basis for a software platform to model learner profiles. In particular we propose to extend the FOAF ontology, used to describe people and their personal relationships, with an ontology related to the e-Portfolio used to model students' competencies. The pedagogical objectives of e-portfolios are various: they allow students to describe their learning path, increase awareness of their strengths and weaknesses, take responsibility, increase their autonomy and present their competencies in a unified way. Enriching the description of social networks through semantics can provide precious information to support teachers in leading to a more efficient use of the network for educational purposes. This ontology could be a fundamental layer for a new Web 2.0 learning environment in which students' informal learning activities carried out in social networks can be managed and evaluated.

Taibi D., Gentile M., Fulantelli G., Allegra M., "An Ontology to Model e-portfolio and Social Relationship in Web 2.0 Informal Learning Environments", *International Journal Of Computers Communications & Control*, 5(4), 578-585, November 2010.

ELECTRONICS

Detection technique for structural monitoring of large civil infrastructures

A novel detection technique has been developed, capable of structural health monitoring of large civil infrastructures such as bridges, highways, railways, pipelines and dams. The technique, developed at IREA-CNR, is based on the stimulated Brillouin scattering between two optical pulses and permits to analyze the dynamic strain induced in an optical fiber.

The measurements are carried out using a configuration based on the use of two counter-propagating time-delayed optical pulses. The analysis of the interaction between pulses permits to carry out dynamic measurements of the Brillouin frequency shift. By properly setting the time delay τ between pulses, it is possible to choose the sensing region along the fiber, i.e. the region in which the pulses overlap. Real-time modulation of the Brillouin frequency shift induced in the sensing region by a dynamic strain is detected as an intensity variation of the probe pulse peak intensity, as it emerges from the sensing fiber.

The technique can be applied for measurements of vibrations with frequencies up to hundred of kHz over hundred meters long structure, with 3m spatial resolution. An experimental set-up has been realized in our laboratory for measuring vibration up to 100Hz along a 30m-long fiber, with 3m spatial resolution. The proposed technique makes use of a standard optical fiber and permits to measure the static strain profile along the fiber or the dynamic strain in a specific location of the fiber. In this case the position of the sensing location can be dynamically moved along the sensing fiber by simply varying the time delay between the optical pulses, so as to monitor different fiber regions.

R. Bernini, A. Minardo, L. Zeni, "Dynamic Strain Measurement in Optical Fibers by Stimulated Brillouin Scattering", *Optics Letters*, Vol. 34, Issue 17, pp. 2613-2615, 2009.

Culture & Society

Highlights

Archaeology,
Archaeology computing,
Landscape archaeology,
Epistemology, Lexicology,
Learning technology,
Cognitive sciences,
Art restoration, Art diagnostics,
Linguistics, Landscape archaelogy,
Energy policies, Urbanization,
Demography, Psychology

Virtual exploration of Giotto's scene "The Rule Confirmation" through natural interaction.

ARCHAEOLOGY

The Sabines of the Tiber Valley and the "Colle del Forno" necropolis

The Sabines are well known in the legendary history of Rome for the role they played in the early days of Rome, just after its foundation. Everyone has heard of the Rape of the Sabine women which led to a war between the Romans and the Latins and Sabines, who lived in the towns of the lower valley of the River Tiber. When peace was finally reached two kings reigned in Rome: Romulus, the founder of the city and Titus Tatius, who led the Sabine troops.

Archaeological research that has been carried out over the last thirty years has enabled us to identify the civilization and culture of these people. As luck would have it the Area of Research Rome 1, CNR, Montelibretti is actually situated on the site of the necropolis of the ancient Sabine city of Eretum called "Colle del Forno" Necoprolis. ISCIMA, (Istituto di Studi sulle Civilità italiche e del Mediterraneo Antico) CNR has entirely excavated this area. Eretum, is the only example that exist of a sabine settlement whose archaic history and civilization has become known to us through excavation findings.

At the beginning of the sixth century B.C. there existed a "*homoioi*" community (promoted equality among its members). In this society a princely tomb was lavishly furnished with grave goods comprising a horse drawn chariot adorned with laminated bronze, horses wearing rich elaborate bronze harnesses and bronze and bucchero vessels, spit and firedogs associated with the ritual of banqueting. In the second half of the century monumental tombs appear. These tombs were of the great noble families, who held political and religious positions of great importance, as is evident from the presence, in some male tombs, of the Lituo, a symbol of the religious power of the augurs. Towards the end of the sixth century B.C. a monumental tomb was unearthed believed to be the tomb of a king judging from the burial ritual which included the sacrifice of his horses and the grave goods which also comprised an earthenware throne.

P. Santoro, Colle del Forno (Montelibretti, RM), "Le ultime campagne di scavo: Lazio e Sabina", *Scoperte scavi e ricerche*, Vol. 5, (2009).

The horse harness of the "Colle del Forno" Chariot.

ARCHAEOLOGY

Prehistory of fire: experience of time and symbols of light in the ancient mediterranean cultures

According to the Greek mythological sources, Prometheus, son of the Titan Iapetos, is the rebel hero par excellence who displays great intelligence giving back to humanity the fire which Zeus had deprived them. Prometheus is the rejection of obscurity, of an earth from which fire and light would be absent. The hero, bringing the fire and other gifts to him attributed as metallurgy, the computation of time, the science of prediction and navigation, he bought all the foundations of civilization. Looking back on prehistoric times, Prometheus is the metaphor of the close link between the discovery of fire and the human work. In the Paleolithic Age, when the oldest sporadic use of fire are dated back to some 1,500,000 years ago, the domestication of fire by hunter-gatherers communities required constant attention and permanent feeding with fuel. This activity may well required a precise perception of time, in terms of capacity to estimate duration because the fire, if not sufficiently fed, would irreversibly go out. The domestication of fire also presumes, for cooking of food, the emergence of a collective time that organizes communal activities. The paper explores the technical and multi-varied functions of fire among the first emerging communities in the central Mediterranean during the Neolithic Period (7000-4500 BC ca.), focusing on Greece and South Italy. Both areas provide us important information on the symbolic role of fire among the Neolithic peoples. The large use of cremation in funeral practice of Neolithic Thessaly, as well as in South Italy, show deep changes in beliefs, or more inclusively ideology, about death. The fire, perceived as an irreversible and destructive power, destroys the body of dead and reduces the dangerous path towards a new life.

A further accurate investigation of the archaeological record from Greece Neolithic communities provides many signs and symbols, as artistic representations of sun, which help us in understanding what position the fire played in the religious and social behaviours of the first human community in ancient Europe.

M. Cultraro, "Una forza distruttiva e irreversibile: fuoco, calore, luce nelle culture neolitiche del Mediterraneo centrale", in C.D. Fonseca, E. Fontanella, C. Strinati (eds.), *Anima del Fuoco* (catalogo della Mostra, Milano marzo-giugno 2010), Milano DNArt Edizioni (2010), pp. 102-110.

The punishment of Prometheus, Lakonian Black-figure kylix by Arkesilas Painter (ca. 550 BC), Vatican's Gregorian Etruscan Museum, Rome.

Vase containing burnt bones of a child, Dimini, North Greece (Late Neolithic 5300-4500 BC).

ARCHAEOLOGY

Investigations on Neolithic landscapes and settlements in Southern Italy by integrated methods of remote sensing

M. Ciminale, D. Gallo, R. Lasaponara, N. Masini (2009), "A Multiscale Approach for Reconstructing Archaeological Landscapes: Applications in Northern Apulia (Italy)", *Archaeological Prospection*, 16, pp. 143-153 [doi: 10.1002/arp.356]

D. Gallo, M. Ciminale, H. Becker, N. Masini, "Remote sensing techniques for reconstructing a vast Neolithic settlement in Southern Italy", *Journal of Archaeological Science,* (2009), 36, pp. 43-50 [doi:10.1016/j.jas.2008.07.002]

Human frequentation and geographical setting interact each other according to spatial and temporal dynamics, geo-morphological and topographical constrains namely *physical landscape*. Therefore, complex relations between environmental changes and adaptation strategies of the human being, create the cultural landscapes. Since 2008 CNR (IBAM and IMAA) and University of Bari have been starting some scientific investigations based on the integration of remote sensing methods in the Foggia plain. The aim has been the reconstruction of a settlement pattern, mostly dating back to the Neolithic age, already investigated by Bradford after the WW2. Aerial images captured during the spring season, when crop-marks are visible, allowed us to perform a preliminary identification of two large ditched villages with curvilinear shape, including the typical circular or C-shaped compounds. Geomagnetic prospection confirmed these archaeological features and they also added new information on the archaeological pattern. A further contribution has been provided by very high resolution satellite data which were properly processed by using geospatial statistical analysis and image enhancement methods, in order to emphasize archaeological features and facilitate the identification of palaeoriverbeds. As whole, the data allowed us to evaluate the consistency and the diachronic development as well as the paleo environmental setting. In the future, these technologies will be wider used for evaluating risk and monitoring archaeological settlements and landscapes to preserve rich and remarkable witnesses of ancient civilizations still fossilized into subsoil strata.

NATIONAL HERITAGE

Italy in the restoration of the nativity

An international team, coordinated by Claudio Alessandri from the University of Ferrara and from the Consorzio Ferrara Ricerche (Ferrara Research Consortium), in collaboration with the Institute for the Development of Wood and Tree Species of the CNR (Ivalsa-CNR) is overseeing the restoration of the Church of the Nativity (Bethlehem), one of the oldest in the world and a place symbolic of the birth of Jesus. UNESCO had reported a serious deterioration of the coverage which put the wooden paintings and structures inside at risk with evident drips of water down the sides of the walls signalling the deficiencies of the estate. The task of the researchers from the Ivalsa-Cnr consists of the structural diagnosis of the wooden elements, the dating of them using dendrochronology and assessing the state of conservation of the fixtures. The analysis of the materials and of the data collected, entrusted to the laboratories of Sesto Fiorentino (Fi) and of San Michele in the Adige (Tn), supplemented with information obtained from other operational units, will enable the development of the restoration plan.

LANDSCAPE ARCHAEOLOGY

Pollen from archaeological layers and cultural landscape reconstruction

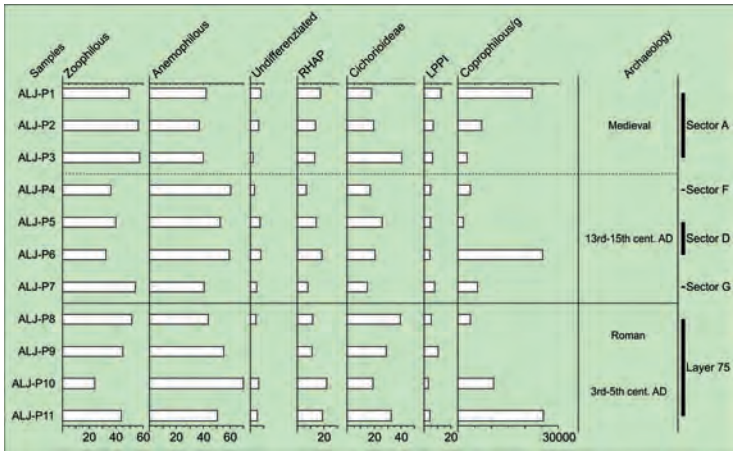
The research aims at presenting some aspects of environmental reconstructions through pollen analysis from archaeological contexts. The anthropogenic pollen transport into archaeological sites can be regarded as an interesting tool to improve knowledge on flora and vegetation living in the area of influence of studied site. Moreover, pollen from archaeological contexts are mainly a result of the cultural landscape shaped by human activities. Currently, this research program is enshrined in the fruitful synergy between IBAM-CNR, the post-graduate School of Archaeology of Matera (UNIBAS) and the Laboratory of Palynology (University of Modena, PICAR Project), in the frame of a landscape archaeology research in the Bradano Valley area. Archaeological surveys are carried out in the territories of Altojanni (Altojanni Project: since 2005) and of Montescaglioso (BIOTOS Survey Project: since 2007). Difesa San Biagio and its surroundings are some of the settlements of the Montescaglioso area, settled from 10th/ 9th to the 1st cent. BC. Altojanni is an extended area mainly frequented in Hellenistic, late Imperial Roman and Medieval times. The whole of data from the two sites, shows that the plant landscape has been a very open landscape at least during the centuries covered by the pollen samples. Clear signs of plant exploitation and cultivation, breeding and settlements were present in the two sites. Herb pollen are prevalent. Particularly, high percentages of Poaceae and Cichorioideae, together with coprophilous fungal spores, strongly suggest a long tradition of pastoral activities in this territory. These case study examples suggest that human activities would have produced a fairly xeric environment.

A.M. Mercuri, A. Florenzano, I. Massamba N'siala, L. Olmi, D. Roubis and F. Sogliani, "Pollen from archaeological layers and cultural landscape reconstruction: Case studies from the Bradano valley (Basilicata, southern Italy)", *Plant Biosystems*, 144: 4 (2010), pp. 888-901.

The Bradano river valley, view from Altojanni top hill.

Location map of the Basilicata region in southern Italy, including the Bradano valley.

Percentage pollen diagram from Altojanni including pollen indicators of human activities and coprophilous fungi concentration.



ARCHAEOLOGY

Patterns of mobility: mediterranean interrelations in the second millennium BC Bronze Age

The relationships which at different levels characterized the Central Mediterranean and the Aegean in the Late Bronze Age, are emphasized by two categories of pottery found in Greece and Crete. The first one is a handmade "*impasto*" of clay and little pieces of stones, similar to the Italian Bronze Age pottery. The second one is a wheel-thrown grey pottery not new to the Aegean area from a technological point of view. This particular category of pottery is also very widespread among the Italian communities settled along the Adriatic and Ionian coasts in the Late Bronze Age. The shapes of vases replicated both Mycenaean and Indigenous models, mostly carinated cups and bowls, in the same way as in Greece. In the Aegean both of these potteries have been found in the same sites, often together with bronze objects of Italian type. The first appearance of *impasto* pottery of Italian style was recorded in the important harbour site at Kommos, Crete, in the Late Minoan IIIB (ca. 13th century BC). A group of typical Nuragic ceramics imported from Late Bronze Age Sardinia has been found. From the end of Late Minoan/Late Helladic IIIB and the Late Minoan/Late Helladic IIIC (end of 13th-12th century sec. BC) *impasto* and grey pottery are attested again in Crete, at Khania and Knossos, as well as in Mainland Greece, at Tiryns (Argolid) and Dimini (Thessaly). In these settlements the shapes of the *impasto* pottery are similar to those widespread in the Adriatic side of the Italian peninsula. Archaeometric analysis of some of these vases suggests a local production. It is almost clear that this switch could be linked to the collapse of the palatial organization in Greece which occurred at the end of the Late Helladic IIIB. After this period, the new ruling class, probably belonging to the most influential families in each Mycenaean settlement, needed to develop new market opportunities and to improve various kinds of economic interrelations with the neighboring regions.

Impasto "cup" in Italian style from Lefkandi (Eubea) (ca. 12th century BC).

Bronze fibulae of "Italian" type discovered in Greece (ca. 12th century BC).

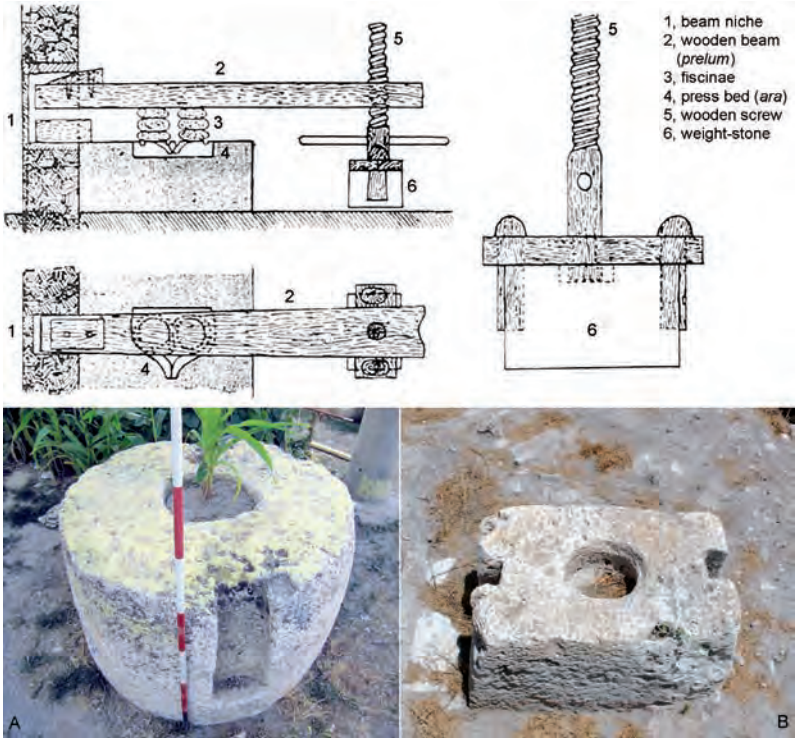
M. Bettelli, "Italia ed Egeo prima e dopo il crollo dei palazzi micenei: le ceramiche d'impasto e grigia tornita in Grecia e a Creta alla luce delle più recenti scoperte", in F. Radina, G. Recchia (a cura di), *Ambra per Agamennone. Indigeni e Micenei tra Adriatico, Ionio ed Egeo*, (2010), Bari, 95-103.

ARCHAEOLOGY

Olive oil and wine production at Hierapolis of Phrygia (Turkey) in Roman and Byzantine Age

Hierapolis: convex mill stones along the Frontinus Road.

The work concerns the results of research activities carried out by the Institute for Archaeological and Monumental Heritage (IBAM-CNR) in cooperation with the Italian Archaeological Mission at Hierapolis of Phrygia (south-western Turkey). The archaeological excavations carried out in the urban area and the surveys in the territory of Hierapolis have allowed the discovery of numerous ancient remains referable to facilities for olive oil and wine production, dating to the Imperial Roman and Byzantine periods. Particularly in the large territory of the city, in the areas of ancient farms and rural settlements depending form Hierapolis, were found large monolithic round crushing basins for olives with cylindrical or more frequently convex (*orbes*) mill stones (like in the *trapetum* described by Cato), and stone parts of presses for oil and wine, such as slotted piers (*arbores*), press beds (*arae*), large upright stones with a niche for anchoring the fixed end of the press beam (*prelum*) and many cylindrical and rectangular screw weights, respectively pertaining to the so-called "Samaria" and "Arginunta" types; these remains are connected to lever and screw presses described by both Pliny the Elder and Hero of Alexandria, used in the Mediterranean basin during Roman and Byzantine periods. This rich documentation discovered during the research allowed to enlarge the our knowledge about the ancient economy of the southern Phrygia (the Roman Province of Asia and the Byzantine Phrygia Pacatiana) and this type of installations for oil and wine production; in fact, before this research, they are not much attested in the Anatolia Peninsula.



Scardozzi G., "Oil and Wine Production in Hierapolis of Phrygia and its Territory During Roman and Byzantine Age: Documentation from Archaeological Excavations and Surveys", in Ü. Aydinoğlu, A.K. Şenol (éd.), "Olive Oil and Wine Production in Anatolia During Antiquity", *International Symposium Proceedings (06-08 November 2008, Mersin, Turkey), Istanbul*, (2010), p. 277-302.

The lever and screw press and examples of the "Samaria" and "Arginunta" weights from the territory of Hierapolis.

ARCHAEOLOGY

Etruscan funerary landscape around Norchia (Viterbo, Italy): a multi-varied project in defense of cultural heritage

The necropolis of Norchia, in the area of Viterbo (80 km to North of Rome), with its rock-cut tombs, is one of the most important archaeological sites of southern Etruria. This is an impressive and rare example of rock architecture, one of the better preserved in Italy, and is comparable with the rock-cut tombs of Kaunos and Demre in ancient Caria and Lycia (modern Turkey). The town of Norchia lies on the Via Clodia approximately midway between Blera and Tuscania, at the intersection with an ancient Etruscan road that led from Tarquinia to Orvieto. The Etruscan settlement was probably on the central part of a plateau. The most flourishing period of the city was from the late fourth to mid-second century B.C., a period in which the city certainly belonged to the Tarquinia State. An imposing and impressive number of rock-cut tombs, dating back to the fourth century B.C., are to be found throughout the three valleys of Pile, Acqualta and Biedano, which surround the city. Along the "Fosso dell'Acqualta" the rock-cut temple tombs (Fig. 1) have facades that imitate those of a Doric temple with pediments, friezes, protomi and acroteria carved into the tufa. Thanks to the drawings by Canina in 1842 and by Ainsley in 1849, not only the original design but also the state of conservation of the monuments in the 19th century is known. This is of the utmost importance seeing the poor state of conservation of the monuments nowadays. The tombs are spread out over several terraces reached by winding paths that rise up from the valley. The uppermost terrace includes the monumental tombs; the middle terrace the dado tombs, while the bottom terrace, the most modest tombs.

The project, currently being carried out by the Institute for Studies on the Italic and Ancient Mediterranean Civilization (ISCIMA), in collaboration with the Superintendence for Archaeological Heritage for Southern Etruria and the Italian Geographic Society under the patronage of the Department of Cultural Heritage of the National Research Council of Italy, initially involved a complete study of the tombs, excavated in the period 1971-1974, along the "Fosso del Pile" (south east of the city), in the central area, known as Pile B (Fig. 2), and all the archaeological remains found there, but was later enlarged to include the archaeological, historical and territorial stratification of the entire province of Viterbo. Thanks to photographs taken at the time of excavation, can the landscape, which has greatly deteriorated over time, be re-constructed. It is well known that the need to promote

Figure 1 Norchia (Viterbo), Pile B Necropolis. Detail of rock-cut tombs. (Photo: Laura Ambrosini)

Figure 2 Norchia (Viterbo), Fosso dell'Acqualta. The temple-tombs (the Doric tombs). (Photo: Laura Ambrosini)

geo-environmental studies to conserve and to safeguard archaeological heritage is increasingly more urgent nowadays in Italy if the country's valuable cultural and environmental heritage is to be protected. The aim of this multivaried research is to propose innovative methods and tools necessary for the conservation, maintenance and exploitation of the site. It is hoped that as a result of these studies and with the synergy of several experts the reconstruction of the necropolis of the ancient landscape of Norchia (an attempt of a two dimensional drawing of which is attached) can be achieved.

L. Ambrosini, "The rock-cut tombs of the necropolis of Norchia (Viterbo - Italy): an important example of ancient architecture that must be preserved", in A. Ferrari (ed.), *Proceedings of the 4th International Congress "Science and Technology for the Safeguard of Cultural Heritage of the Mediterranean Basin",* Cultural Heritage - Cairo 2009, Cairo, Egypt 6th - 8th December 2009, Vol. II, Napoli (2010), pp. 217-223.

ARCHAEOLOGICAL COMPUTING

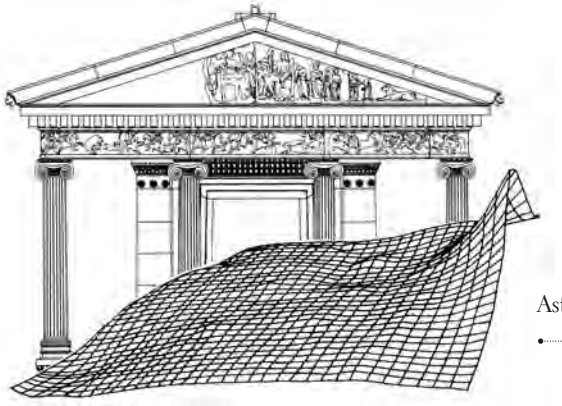
A recent discipline in constant evolution

The entry «Archeologia e società dell'informazione», published in volume 1 (*Norme e idee*) of the new Encyclopedia *XXI Secolo* edited by the Istituto Treccani, illustrates the main developments of a recent discipline in constant evolution: archaeological computing. This boundary discipline, which found its roots in the 1950s, is now facing exciting challenges in a wider scenario of integration between archaeology and information society, in a globalised context.

An overview of key methodologies shows alternative scientific routes, which give evidence of the deep influence of Computer Science on traditional archaeological methodologies. If over time computer applications have consolidated and taken up innovative forms – from databases to multimedia systems, from digital cartography to Geographical Information Systems, from computer graphics to image processing and Virtual Reality – the most fascinating future expectations are linked to the development of knowledge management tools and the true philosophy of the web, based on decentralisation and interoperability. In the meanwhile, through instrument miniaturisation and portability, new data acquisition and location techniques affecting archaeological remains gather strength within the framework of an entirely digital reconstruction of the past.

The entry is the result of a thirty-year scientific activity within the CNR, which led to the rise of a new research area focused on archaeological computing. This new area of investigation found a stable point of reference in the journal Archeologia e Calcolatori, which recently celebrated its 20th anniversary in the new format of Open Access Journal, which runs in parallel with the traditional edition.

P. Moscati, "Archeologia e società dell'informazione", *XXI Secolo*, vol. I, Roma (2009), Istituto della Enciclopedia Italiana, pp. 621-630.



Logo for "Archeologia e Calcolatori" journal.

Astract cover.

LANDSCAPE HISTORY

Seeing like a protester. Nature power, and environmental struggles

The cultural project of environmental history can be simplified as an attempt to make nature visible in the historical discourse, but there are many ways to see and understand nature.
In this article I argue that to understand nature, the study of environmental conflicts should be put at the center of historical research agenda. To substantiate my proposed methodology I use two case-studies: the first is about the end of common uses in an Italian rural community grappling with the privatization of 'its' forests (19th cent.); the second focuses on the struggles against incinerators and landfills in Naples (2010s). A forest transformed into a wood quarry, a body invaded by cancer, a mine turned into a landfill: power relations and social hierarchies are embedded into nature because society articulates itself and its dynamics in a dialectical connection between the ecology of both spaces and bodies.
Although the article is methodological and enters into the debate over the relationship between social history, environmental history and political ecology, nevertheless it has a clear relationship with the present. Focusing on conflicts means to reiterate that in dealing with environmental issues there are no technological solutions or socially neutral policies; with this article I argue that dividing the needs and stories of human beings from those of the planet has not borne fruit. It is time to change course, and history can help.
This article was the subject of an interview in the radio program Against the Grain, 01/11/2010, broadcasted by KPFA in Berkeley, California.

M. Armiero, "Seeing Like a Protester: Nature, Power, and Environmental Struggles", *Left History*, 13:1 (2009).

HISTORY

Mediterranean crossroads in the Modern Age: the case of multi-ethnic Naples

Naples, the densely populated capital of the Kingdom of the Two Sicilies, was a multi-ethnic city in the early Modern Age. In the 16-17th centuries, it was one of the biggest cities in Europe – with London and Paris - in terms of its population size. Therefore, this great marketplace was a kaleidoscope of the Mediterranean. The people who lived and worked there intertwined the events of their lives through commercial and maritime activities, identifying themselves in relation to merchant and craft guilds, religious and charitable institutions, national lodges and cultural associations, as well as family networks and economic interests. At this Mediterranean crossroads, co-existence followed complex logics affected by diverse presences and intercultural influences. An opportunity emerges from an examination of these realities from a perspective favouring extroversion: to construct a Mediterranean network among scholars and to encourage synergies among them. In this sense, Neapolitan research sources - which offer an imposing documentation often difficult to utilise – can give unexpected results. Yet what are the underlying problematic areas; what are the possible research instruments and strategies? The second half of the seventeenth century is a fertile terrain for a working theory, exemplified by and illustrated through the case of the House of Raillard. This family enterprise – international in character – intersected the history of the city, linking merchant experiences and businesses in Naples and elsewhere. From this emerge events and personalities behind which notations of activities pursued and horizons perceived wait to be explored.

G. Lombardi, "People, their Experiences and Merchant Practices in a Port-city: Naples as a Mediterranean Crossroads in the Modern Age", *The Historical Review - La Revue Historique*, VII (2010), Institut de Recherches Néohelléniques. Fondation Nationale de la Recherche Scientifique, pp. 77-97.

HISTORY

The Roman Catholic North Atlantic, 1760-1847

In the years from 1789 to 1815 the Roman Catholic church and the papacy went through one of their most difficult and controversial periods of their existence. This article shows how the French-, English-, and Gaelic-speaking Catholic community of the North Atlantic region, together with the mostly Italian-speaking Holy See bureaucracy, shared some measure of a common attitude towards the Napoleonic regime during the Consulate and the Empire. This uniformity was a direct consequence of a conservative political attitude shared by all members of the Catholic community who lived in the region of the North Atlantic. This attitude was best expressed by the clergy. This conservative attitude led them to enter into political alliances with local élites that had never been Catholic – in Ireland, Great Britain, and the United States – or that had institutionally ceased to be Catholic from 1760 onwards – in Canada and France. Indeed, church historians have often overlooked this Atlantic perspective. If, on the one hand the clergy's attitude towards the French Revolution had been completely negative right from the beginning, the relationship with Napoleon looked more contradictory. At first, the First Consul elicited some hopes as the man sent by Providence to restore the pre-revolutionary order and to return the Church to the role that God had assigned to it. The definition of Napoleon as "Cromwell de France" dates from 1800 and belongs in this early period. Later, however, especially after the Concordat of 1801, early hopes were replaced by a sentiment of hate for the despicable autocrat, the tyrant, the "consummate brigand" (1810) who had invaded the Pontifical States, occupied the Holy See, jailed the pope, created hostility within the French clergy, made Atlantic communication almost impossible, and threatened the existence of a Great Britain that had proved to be so generous towards those Catholic newcomers.

L. Codignola, "From France's Cromwell to Consummate Brigand: North Atlantic Catholics and Napoleon, 1789-1815", in *Napoleon's Atlantic. The Impact of Napoleonic Empire in the Atlantic World*, ed. C. Belaubre, J. Dym, and J. Savage, Leiden, Boston: Brill, (2010), pp. 25-44.

ARTISTIC PROJECTS

Inside the scenes of Giotto

The Institute for Technologies Applied to Cultural Heritage (ITABC-CNR) oversaw a reconstruction project in 3D of several works of art by Giotto, in collaboration with the Institute of Cognitive Science and Technologies (ISTC-CNR). Three-dimensional models were created of the painted scenes, which may be followed and explored in real time. An infrared videocamera tracks the movements of visitors, which, in this way, becomes an actual "joystick", and determines the change of the point of view, up to penetrating the scene, moving among the characters of Giotto and becoming a participating part. The work created was exhibited at the show 'I colori di Giotto' (The Colors of Giotto), organized by the Municipality of Assisi and of the Franciscan community of the Sacro Convento (Sacred Convent), in occasion for the eighth centenary of the approval of the Rule of Saint Francis.

URBANIZATION

Towards a modern view of city: processes of urbanization in Europe 1700-1870

The 19th century marks the passage of Europe from a civilization based on agriculture and the countryside to a civilization based on industry, services and cities. Urbanisation is one of the main changes taking place during the modernisation of the last two centuries.
As a result of economic modernisation the urban-rural divide began to fade and ultimately to disappear. Structural change, characterized by the diminishing weight of agriculture in terms of employment and product and the rising share of industry and services, implied the relative decline of agriculture and countryside within both the economy and society.
The period analysed in the chapter was the last phase of the old agrarian world and the beginning of the new economy. Already around 1700 urbanisation in the South had been overcome by that in the North. During the 19th century, urbanisation progressed more in the North and the Centre.

From stability to growth and from inequality towards convergence: thus we could succinctly recall the main changes in 18th and 19thcentury European urbanisation. In 1800, the geography and the levels of European urbanisation were still similar to those of the late Middle Ages, the main changes being the rise of England and Scotland and the spread from Flanders towards the Netherlands in the early modern age. Inequality between North and South had diminished for this very reason. In 1870, by contrast, both the level and geography of urbanisation were significantly different. Rise in urbanisation had occurred within the great transformations of the European economy during the first epoch of modern growth. While in 1800 the urbanisation rate was 9 percent, in 1870 it was 15. Furthermore, the dominance of the North-European countries over the Mediterranean regions was a main diversity with the past.

European Urbanisation in 1800.

P. Malanima, Urbanisation 1700-1870, in The Cambridge Economic History of Modern Europe, Ed. by S. Broadberry and K. O'Rourke. I. Chap. 10, Cambridge, Cambridge University Press, (2010), I, pp. 236-64.

DEMOGRAPHY

Size, characteristics and prospects of EU minors in Italy

C. Bonifazi, "Dimensioni, caratteristiche e prospettive dei minori comunitari in Italia", *Minorigiustizia*, 2 (2010), pp. 28-32.

The increase in foreign minors is one of the most important developments of foreign immigration in Italy. This increase is the result of the stabilisation of many immigrant communities and is fuelled by family reunions and by births by foreign couples. Foreign minors were 126,000 in 1997 and had become 862,000 by the beginning of 2009. The increase of foreigners born, or who have grown up in Italy, heavily affects the impact of immigration. In fact, needs and expectations of the second generation are higher than for the first generation and are strictly related to the increase in the years spent in Italy.

As regards EU minors, available statistical data offers a scant picture of the situation. As a matter of fact, the enlargement of the EU has brought about a huge and fast increase in the size of this component of foreign population. This growth has been particularly relevant for Romanians, that have become the largest foreign community in Italy.

Interesting data is produced by the Ministry of Education on foreign students enrolled in Italian schools. In the school year 2002-2003, only 6,000 students came from one of the countries of the EU-15 (2.5% of the total). After only five years, the number of EU-27 students arrived at 124,000, one fifth of all Italian students. A growth of 21 times in a very short time period. The growth in EU immigration is another important change in the Italian immigration scenario. It has been driven by the enlargement of the EU and has completely modified the legal status of a large part of the foreign population. In light of these changes, it should be a requirement to update our statistical tools, analysis, interpretations and policies towards foreign immigration.

ETRUSCAN STUDIES

Uncovering the secrets of the Etruscan language

The new edition of the Etruscan Language Thesaurus, edited by Enrico Benelli, researcher at the Institute for the Study of Ancient Mediterranean Civilisations (Iscima) of CNR, is enhanced with five thousand new entries in addition to the original eight thousand entries of the first edition from 1978, published by Massimo Pallottino, the father of Italian Etruscan Studies. The new acquisitions are owed to the intensification but, since the 1970's, the increase of the territorial extension of the studies as well, mostly concentrated in Southern Etruria, full of accounts from the VII through the IV centuries B.C.: especially personal names and terms drawn from the funerary and sacred lexicon. It was also possible to loosen several crucial points in the identification of verbs, adjectives, and other grammatical elements and defining the pronunciation.

ENERGY POLICY

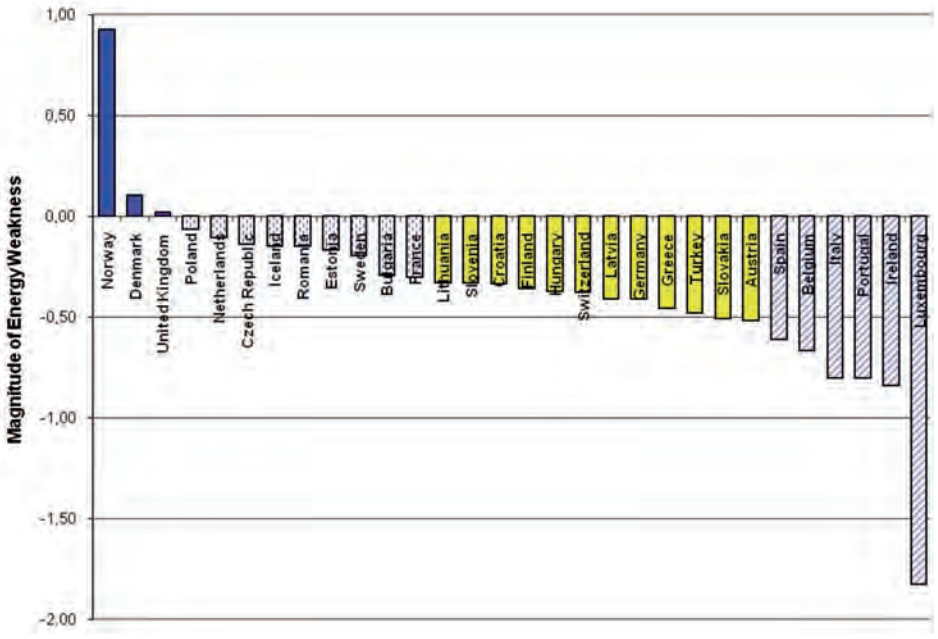
Productivity and efficiency: a new theoretical framework for measuring new energy metrics

Energy metrics is the development of a whole new theoretical framework for the measurement of energy and economic system performances, energy efficiency and productivity improvements with important political economy implications consistent with the best use of all natural and economic resources. Vital energy indicators are:

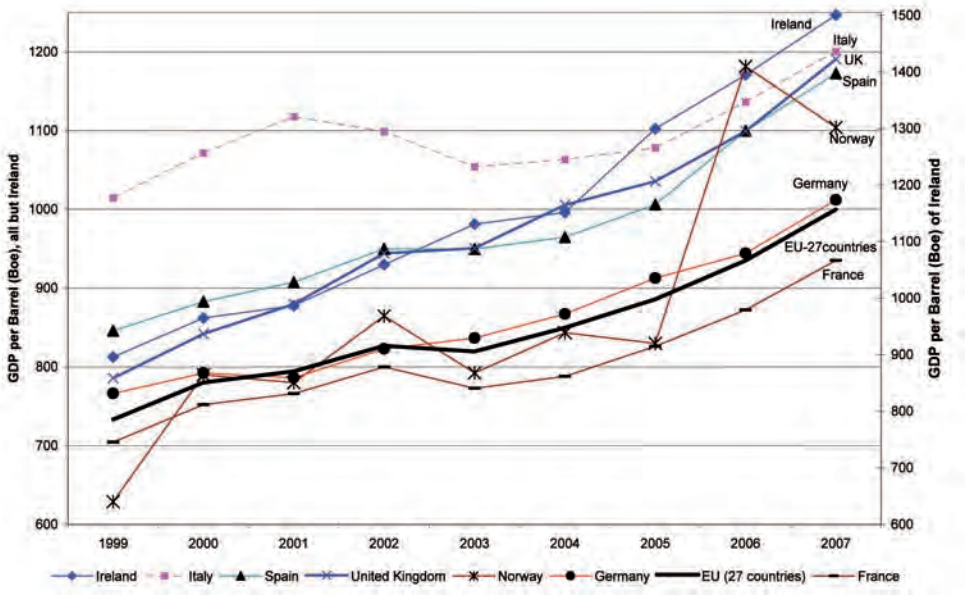
- The magnitude of energy weakness that provides vital signals about the economic stability of countries in case of energy shocks. This energy indicator shows some countries to be the strongest countries, *i.e.* Norway, Denmark and the UK, and some as the weakest countries, *i.e.* Spain, Italy, Portugal, etc. (low economic stability in case of energy shocks).
- The GDP (Gross Domestic Product) per barrel of oil: it measures the energy productivity that is high in Switzerland, Ireland, Italy, Denmark, etc. Italy is the larger country with the higher energy productivity, 1093 Euros per barrel; *i.e.* Italy has the strongest capacity to transform energy input (barrels of oil) in goods and services with high value added. Spain and the UK have lower GDP per barrel (roughly 975-988 Euros per barrel), Germany 860 Euros and France 802 Euros per barrel of oil.
- The barrels per capita that is an indicator of energy efficiency. Italy shows higher energy efficiency that is an average consumption of 21.30 barrels per capita. Spain consumes 22 barrels (of oil) per capita, Germany 28.76 barrels per capita and France with 29.75 barrels per capita.

These energy metrics monitor the performances within economic systems in order to design effective energy strategy and political economy interventions focused on the competitive-advantage increase of countries in modern economies.

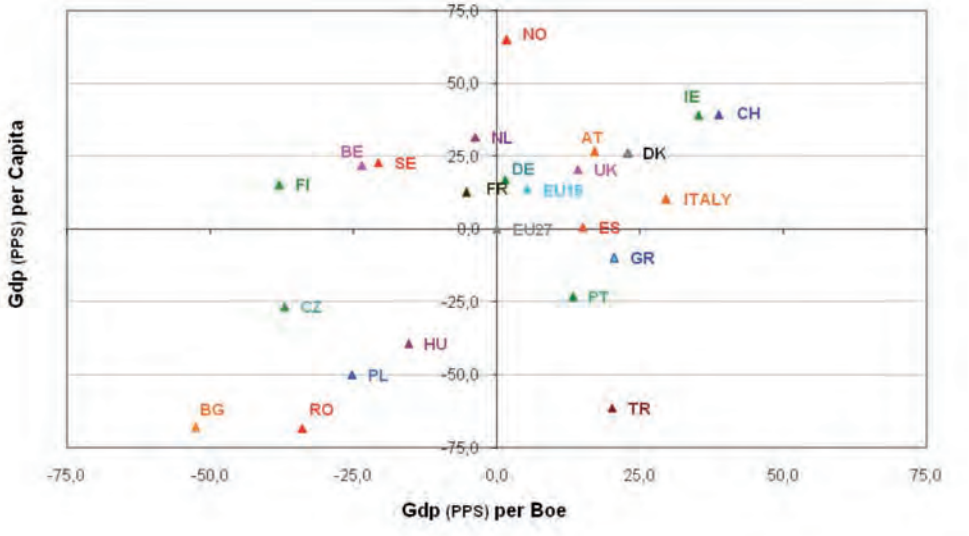
M. Coccia, "Energy metrics for driving competitiveness of countries: Energy weakness magnitude, GDP per barrel and barrels per capita", *Energy Policy*, (2010), vol. 38, n. 3, pp. 1330-1339. doi:10.1016/j.enpol.2009.11.011



Magnitude of energy weakness per European countries (+ values = stronger countries; – values = weaker countries).



Energy productivity as a function of time for some leading countries/areas.



Energy and economic strategic behaviour of European countries.

SOCIETY AND CUSTOMS

Gossiping reduces conflict

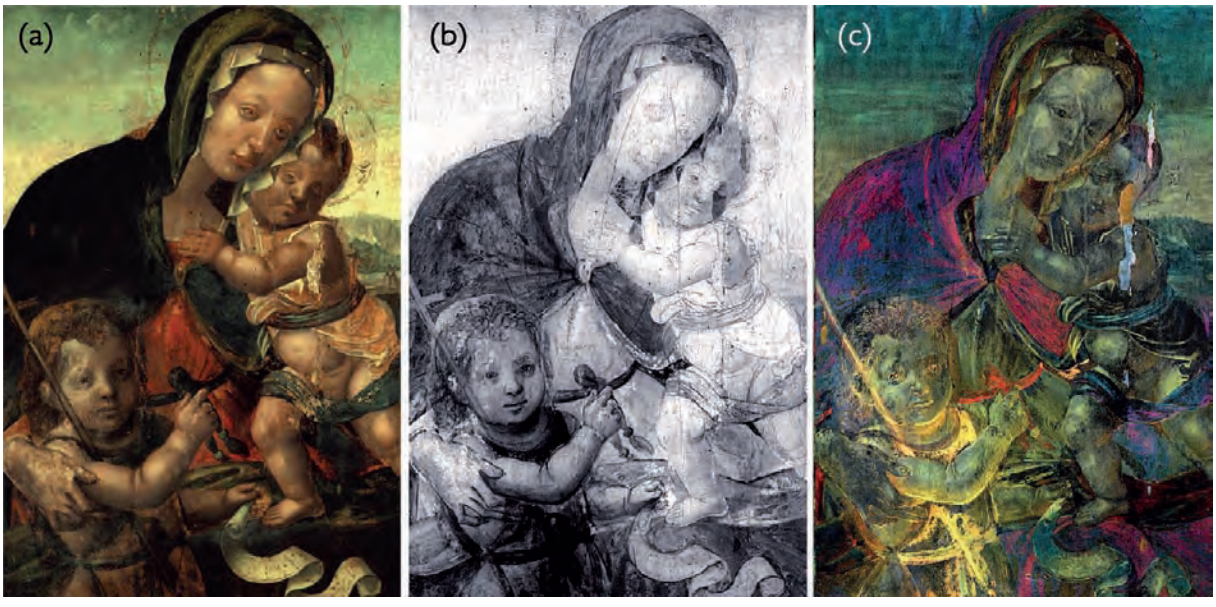
The studies by Rosaria Conte, researcher at the Institute of Cognitive Science and Technologies (Istc) of the CNR in Roma, have shown that gossip is a behaviour present in every human group and how, through the assignment of reputation, social conflicts are reduced. Transmitting a reputation through gossip, the source avoids taking responsibility for what is said and escapes from "retaliations" which could produce further aggressive behaviours. In this manner, it was possible for human groups to keep cheating under control while increasing the size of social groups at the same point in time. The presentation of findings was given at the workshops of "Ricerche a confronto" organized by the Department of Cultural Identity at the CNR.

ART DIAGNOSTICS

Spectral imaging for ancient paintings: the Scanning Multispectral IR Reflectography SMIRR

Spectral imaging, which allows the simultaneous acquisition of spectral information and high resolution images, has recently revealed a great potential in the diagnostics of ancient paintings, leading to the introduction of specific techniques such as the novel "Scanning Multispectral Infrared Reflectography" SMIRR, which was developed by CNR-INO together with the prototype device. The system is currently being experimented at the restoration centre Opificio delle Pietre Dure in Florence and is also part of the transnational mobile laboratory in the EU project CHARISMA (2009-2013).

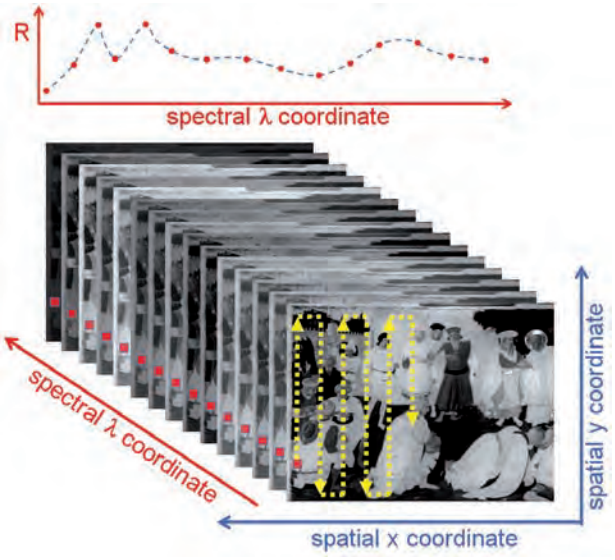
The scanner device works in the near-infrared range 800-2300 nm and is capable through a set of detectors and fiber-optic technology to acquire simultaneously, point by point, a set of images at different wavelengths. The result is an image cube providing both a stack of wavelength resolved images (multispectral reflectography) and a series of point spectra on the painting surface (spectrometry). As pigments are transparent to NIR wavelengths, this radiation allows to reveal features underlying the paint layer, such as preparatory sketches or retouching. Traditional reflectography, performed by detecting the back-scattered radiation in a single large band, is being used as a major tool for the analysis of paintings. Given the different behavior of pigments, the traditional technique is improved by the multi-band option, which allows the choice of the most effec-



XVI painting: (a) Visible, (b) IR reflectography, (c) Multispectral reflectography: false color with different wavelengths to differentiate pigments.

tive wavelengths according to the specific study. The perspectives of multispectral IR reflectography are enlarged to new applications for the study of artists' materials, identification of pigments and their spatial distribution. The results obtained on Italian masterpieces have demonstrated the potential of this novel diagnostics.

C. Daffara, E. Pampaloni, L. Pezzati, M. Barucci, R. Fontana, "Multispectral IR Reflectography SMIRR: An Advanced Tool for Art Diagnostics", *Accounts of Chemical Research*, 43 (2010), pp. 847-856.



The technique provide an image cube of the painting giving both wavelength resolved images (multispectral reflectography) and spatially resolved spectra (spectrometry).

The scanner for Multispectral Reflectography working on La Gravida, Raffaello, during the restoration at the Opificio delle Pietre Dure, Florence.

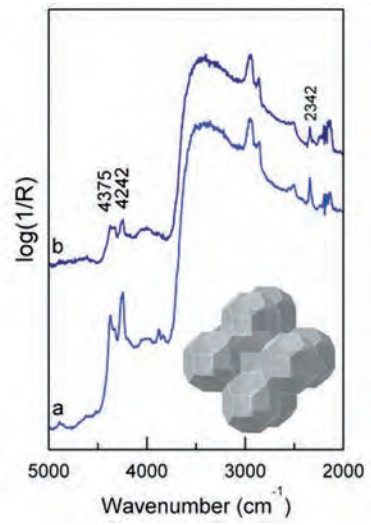
ART DIAGNOSTICS

MOLAB: a mobile laboratory for preventive conservation of artworks

Driven by the need to study precious and irreplaceable artworks without compromising their integrity, we are developing a multi-technique spectroscopic approach that can provide a chemical description of cultural heritage materials without any contact with the object.
The challenge lies in the fact that artworks are made of complex mixtures of unknown materials that are often heterogeneous and layered, whilst questions to be addressed span from the molecular identification of constituting compounds to the mapping of alteration phases.
The mobile laboratory MOLAB is equipped with an array of state-of-the-art portable and non-invasive instrumentations specifically tailored to tackle the different issues posed by archeologists, curators and conservators, and to study a variety of objects (from ceramics to manuscripts, from historical wall paintings to contemporary canvases).
The selectivity and specificity needed for the non-invasive identification of painting materials is gained combining elemental information from X-ray fluorescence with molecular and structural insights from fiber optic electronic and vibrational spectroscopies, as highlighted in the study of paintings by famous painters of XVI-XVII centuries (Jacob Jordaens, Pietro Perugino, and Raffaello), as well as contemporaneous ones (Alberto Burri).

Mobile laboratory set-up at the Gemeentemuseum, Den Haag.

The non-invasive approach permits the examinations of a very large number of artworks with a virtually infinite number of measurements, thus particular and uncommon features may be unveiled, as the case of a lead pyroantimonate yellow doped with zinc that has been disclosed by micro-Raman and X-ray fluorescence on Italian Renaissance *majolica*.
MOLAB proved to be a valuable tool also for the mapping of contaminants and alteration phases that may inform decisions on preventive conservation plans, as in the case of *David* by Michelangelo.



Reflection infrared study of the blue pigments featured in the Madonna del Cardellino (c. 1506) by Raffaello.

C. Miliani, F. Rosi, B.G. Brunetti, A. Sgamellotti, "*In situ* Non-invasive Study of Artworks: the MOLAB Multi-technique Approach", *Accounts of Chemical Research*, (2010), 43, 728.

Portable, non-invasive micro-Raman measuraments (Madonna con Cherubini by Mantegna).

ART RESTORATION

Visible to the naked eye: advances in laser cleaning of artworks

The present review work concerns recent advances in the study and application of laser cleaning to the conservation of cultural heritage. We focus on the solution of representative cleaning problems of encrusted stones, metals, and wall paintings that were achieved through the optimization of laser pulse duration. Basic mechanisms involved in the laser ablation of stratified materials and the criteria for preventing undesired side effects to the substrate, along with a set of important case studies are presented in some details. Laser interaction effects are reviewed in a schematic way, with a concise overview of the physical models needed to support intuitive interpretations of the phenomenology observed, both in laboratory tests and in practical applications. This approach aims to provide keys of generalization that will favor the rigorous application of laser cleaning, repeatability of the successful results reported in this work, and further dissemination and acceptance of the technique. The topics treated examine the ablation mechanisms along with the efficiency, gradualness, selectivity, and effectiveness of the technique as a function of the pulse duration of neodymium laser systems and the operating conditions. The sections dedicated to stones and metals also deal with the important problem of discoloration, which has significantly slowed the spread of the laser cleaning technique, and with the different approaches to its solution. Successful extensive applications on unique bronze artefacts, such as the David by Donatello and the Porta del Paradiso by Lorenzo Ghiberti, as well as on important wall paintings and a set of minor art objects, provide concrete evidence of the significant advances achieved by our group, which were unthinkable until recently.

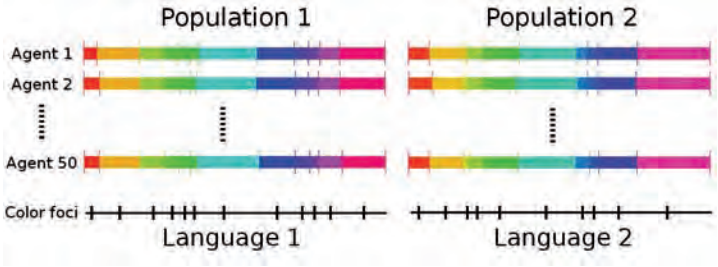
David by Donatello after the recent restoration: detail of a gilded zone of the hair, which was uncovered by means of laser ablation (courtesy of the Museo Nazionale del Bargello, Florence).

S. Siano, R. Salimbeni, "Advances in Laser Cleaning of Artwork and Objects of Historical Interest: The Optimized Pulse Duration Approach", *Accounts of Chemical Research*, (2010), 43 (6), pp 739-750.

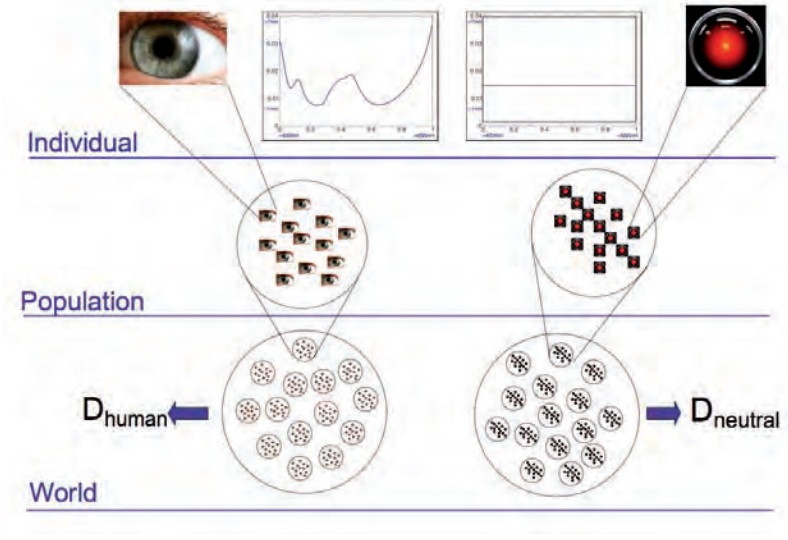
COGNITIVE SCIENCE

Explaining universal colour categories. Towards a statistical analysis

Colour categorization in human languages is an important benchmark for language evolution theories. The debate aims at the formation of linguistic categories: is their evolution be conditioned mainly by environmental and/or neuro-biological constraints, or rather by a complex dynamics taking place during the continuous interaction among speaking individuals? The empirical evidence that human colour categorization exhibits some universal patterns beyond superficial discrepancies across different cultures leads to an intermediate position between the above two extreme views. The main observation comes from the famous World Color Survey (WCS), a field research where



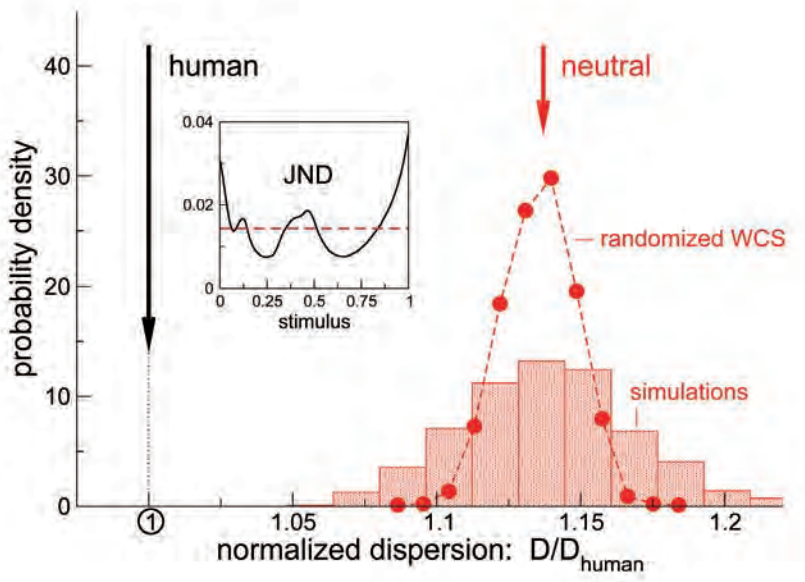
An example of the results from the simulations of two different populations. After 10000 games, categories and associated color terms are stable.



A sketch of the logical structure of the Numerical WCS. A value of dispersion D is computed for each world. A world is an ensemble of populations.

groups of individuals from more than a hundred populations were asked – through a careful interviewing protocol – to draw the "boundaries" between colour categories in their native language. That research has demonstrated that any two groups of individuals develop quite different categorization patterns, but some universal properties can be identified by a statistical analysis over a large number of populations. We asked: is it possible to devise a dynamical model where a group of individual (a population) create a simple language from scratch, reaching an asymptotic state of consensus on a small dictionary of colour names, with the same statistical properties observed in the WCS? In our research, we reproduce the WCS in a numerical model in which different populations develop independently their own categorization systems by playing elementary language games. Our result demonstrates that interaction is crucial. However we also find that a simple perceptual constraint shared by all humans, namely the human Just Noticeable Difference (JND), is necessary to trigger the emergence of universal patterns that unconstrained cultural interaction fails to produce. The JND for colours is a well known physiological property of human eye, and represents the ability of distinguishing different colour tones at a given frequency: it is roughly the same for all human individuals. We test the results of our experiment against real data by performing the same statistical analysis proposed to quantify the universal tendencies shown in the WCS [Kay P & Regier T. (2003) Proc. Natl. Acad. Sci. USA 100: 9085-9089], and obtain an excellent quantitative agreement. This work confirms that synthetic modeling has nowadays reached the maturity to contribute significantly to the ongoing debate in cognitive science.

A. Baronchelli, T. Gong, A. Puglisi and V. Loreto, "Modeling the emergence of universality in color naming patterns", *Proc. Natl. Acad. Sci. USA* 107 (2010), pp. 2403-2407.



The dispersion of the neutral worlds (histogram) is significantly higher than that of the human worlds (black arrow), as observed in the WCS data (filled circles and black arrow).

COGNITIVE SCIENCE

Motor simulation in a memory task: evidence from rock climbing

Does the acquisition of advanced sensorimotor skills, such as those possessed by elite athletes, determine changes in cognitive abilities in addition to increased performance? If this is the case, which neural mechanisms support the increased cognitive abilities, bridging a gap between motor skills and cognitive domains? We addressed these general questions by studying how expert and novice climbers observe and memorize three novel climbing routes: an easy route that both experts and novices were able to climb, a route perceptually salient but impossible to climb for both groups, and a difficult route that only expert climbers were able to climb. In a recall test, in which they had to write down the sequence of holds composing each route (without climbing them), no difference emerged between experts and novices on the easy and impossible routes. Differently, the performance of expert climbers was better than that of novices on the difficult route. In sum, experts have an edge only when they are really able to climb the route, indicating that motor performance and cognitive skills (memory, in this case) are related. In addition, we found that individuals' motor competence, not salience of climbing routes, explains better recall performance. To explain these findings, we hypothesize that seeing a climbing wall activates a *motor simulation*, which re-enacts "in simulation" the same mechanisms implied in the planning and online control of action. Thus, the same mechanisms that provide athletes with better performance give them also an advantage in cognitive processing. This study is part of a broad project in cognitive science aimed at studying if and how mechanisms of motor simulation could provide a link between sensorimotor and cognitive domains.

G. Pezzulo, L. Barca, A. Lamberti Bocconi, A.M. Borghi, "When Affordances Climb in to your Mind: Advantages of Motor Simulation in a Memory Task Performed by Novice and Expert Rock Climbers", *Brain and Cognition*, 73 (2010), pp. 68-73.

While previewing a novel route (prior to a competition), climbers often overtly "simulate" the climbing movements they will execute.

LEARNING TECHNOLOGIES

Coding procedures to analyse interaction patterns in educational web forums

Analysis of interaction patterns is one of the most important indicators of quality of learning in educational web forums. Social Network Analysis (SNA) is gradually assuming importance in the study of interaction patterns as it focuses on the analysis of the interrelationships between individuals, thus providing a holistic perspective on group performance. However, most of the studies that use SNA in computer-supported collaborative learning scenarios derive their data from server log files, on the assumption that this data source reflects the way people really interacted online. This study, the purpose of which is to better understand the communication flows that really occur among users, challenges these assumptions through an experimental study that makes a comparison between the structural method normally used to detect the posting addressees and an approach enriched with semantic coding. Results show that this new coding schema, if compared with traditional structural coding, detected a greater number of addressees, thus allowing a greater number of postings to be included in an SNA adjacency matrix.

S. Manca, M. Delfino, E. Mazzoni (2009). "Coding procedures to analyse interaction patterns in educational web forums", *Journal of Computer Assisted Learning* [1], 25(2), pp. 189-200.

LEARNING TECHNOLOGIES

Using a wiki to organize and evaluate collaborative learning

One critical issue arising in the educational use of collaborative learning concerns the teacher's difficulty in evaluating the contribution and participation of each student in group work, hence possible issues could be "Are there communication technologies to foster monitoring and evaluation of collaborative processes?" and "Are there ways to organize student's work in order to monitor it effectively and evaluate both learning and participation of each student to the collaborative process?" A contribution to the possible answers to these questions is proposed by a research project of Institute for Educational Technology (ITD) of CNR which suggests a methodological approach to collaborative study organization centred on a jointly-written wiki.

The wiki as an experimenting tool offers basic traces on the activity of each user (comments, linkers, tags, versioning, etc.), which can be used to analyse (so far only via manual analysis) both interactions among participants in the collaborative activity and the evaluation of individual products and their interconnections. The research work allowed the identification of some specific functions to be embedded in wiki engines to automate the analysis of online learning groups actions.

The research outcomes will be used to develop special purpose wikis featuring functions oriented to the evaluation of collaborative interactions to create new technologies for group learning support.

Trentin, G. (2009). "Using a Wiki to Evaluate Individual Contribution to a Collaborative Learning Project", *International Journal of Computer Assisted Learning*, vol. 25, n. 1, pp. 43-55, UK.

LEARNING TECHNOLOGIES

Pedagogical plans as communication oriented objects

This research refers to the area of Learning Design and focuses on pedagogical plans intended as objects to support human communication. A structural model for pedagogical plans is described which assists authors to design new plans as communication oriented objects and users to understand and to customize, as well as to enact and to evaluate existing plans. Last, but not least, the model may facilitate the creation of plans which are vectors of educational innovation toward the school system. This work originates in the framework of ReMath, a EU project on technology-based educational innovation in mathematics. However the model is discipline independent and is also applicable to any content area. A distinctive feature of the model is the adoption of a hierarchical representation where each plan can be represented as a hierarchical network of constituent elementary plans that focus in on more specific parts of the learning process, thus going from more general to more detailed levels. This makes it possible to approach plan authoring as a top-down process, something that presents considerable advantages. It is a valuable aid for mastering the complexity of design and at the same time represents an maieutical factor that encourages authors to establish levels of conceptualization and abstraction which would otherwise remain unexpressed. The user too comprehends the plan in terms of a top-down process, where the specific steps of a learning activity are seen as originating from more general and abstract conceptualizations. In this way communication and understanding are enhanced and facilitated. The paper provides also an easy-to-understand example of a hierarchical plan, a description of a prototype tool for managing hierarchical plans. Some preliminary experimental results are presented and discussed.

G. Olimpo, R.M. Bottino, J. Earp, M. Ott, F. Pozzi, M. Tavella. "Pedagogical Plan as Communication Oriented Objects", *Computers & Education*, 55, (2010), pp. 476-488.

LEARNING TECHNOLOGIES

Monitoring and evaluation of virtual learning environments

Today, ICT (Information and Communication Technologies) can trigger effective and high quality collaborative learning processes grounded on advanced pedagogical theories. These approaches, unlike traditional learning processes based on transmission of knowledge, rely on the participation of learners in virtual communities where knowledge is built and negotiated by the members of the community through synchronous and asynchronous interactions in a digital environment. This type of environments allow for authentic and practice-based learning, as well as in-depth understanding of content, therefore calling for evaluation processes where qualitative indicators are even more important than quantitative ones. This paper presents the results of the authors' work within a European project aimed at sharing know-how among researchers and practitioners in instructional design, monitoring and evaluation of computer supported collaborative learning processes. The authors' experience in this field has been taken advantage of, in order to identify recurring problems and their consolidated solutions, and eventually capture them into reusable schemes, called "Design Patterns". Design Patterns help capitalize on experience developed in communities of practice by researchers, teachers, designers and tutors and share them with other actors willing to make use of this experience in the design, delivery or evaluation of similar learning processes through the transformation of heuristic and qualitative work modalities into standardized indicators and procedures for their detection. In addition, Design Patterns make the automation of the solution and its transferability to other contexts much easier. The article describes and provides examples of the development, set up and validation of a number of Design Patterns concerning monitoring and evaluation of collaborative learning processes. It also supplies useful suggestions for the development of specific functions to be embedded into technological environments supporting collaborative learning processes.

D. Persico, F. Pozzi and L. Sarti, "Design Patterns for monitoring and evaluating CSCL processes", *Computers in Human Behaviour*, 25(5), 1020-1027, (2009).

LINGUISTICS

Developing new cognitive capabilities: theoretical and methodological issues for representing signed languages

This paper aims to address and clarify issues which we believe as crucial for making significant progresses in the analysis and description of Signed Languages (SL): identifying appropriate tools for representing in written form SL productions of any sort, i.e. lexical items, utterances, discourse at large. The observations here proposed involve what in our view seems to be critical and as primary requirement in research on any language: disposing of an easily readable transcription that, aside from specialist linguistic annotations, allows anyone who knows the object language to reconstruct its forms, and its form-meaning correspondences in their contexts, even in the absence of a video recording of the signed text. One would expect that a wealth of SL research focuses on the main questions posed by the notation and annotation of these languages. In contrast, in most past and current SL research, the challenges posed by the representation of SL have been largely underestimated and scarcely explored.
In this paper we aim to show how the use of existing notation devices eludes the primary requirement of a baseline transcription for SL data, introducing severe biases in the analysis which, in turn, lead to grossly misrepresent the structure of SL. We further present and discuss promising results from recent and ongoing research on Italian Sign Language (LIS), in which experienced deaf signers explore the use of SignWriting (SW) as a tool for both composing texts conceived in written form -- thereby creating a corpus of written LIS -- and for transcribing corpora of face-to-face LIS discourse.
We conclude specifying some of the major indications this research on LIS provides towards finding adequate representation tools for the study and description of SL.

E. Antinoro Pizzuto, I. Chiari, P. Rossini, "Representing sign language: Theoretical, methodological and practical issues", in M. Pettorino, A. Giannini, I. Chiari, F. Dovetto (eds.) (2010). *Spoken Communication*, Cambrige Scholars Publishing, pp. 205-240.

PSYCHOLOGY

Perceiving objects: the computational method TRoPICALS to embodied cognition

Recent evidence shows that the perception of objects automatically activates the representation of their affordances. For example, experiments on "compatibility effects" showed that categorizing objects by producing certain handgrips (power or precision) is faster if the requested responses are compatible with the affordance elicited by the size of objects (small or large). The Laboratory of Computational Embodied Neuroscience (LOCEN), in the Institute of Cognitive Sciences and Technologies (ISTC) has developed the computational model TRoPICALS ("Two Route, Prefrontal Instruction, Competition of Affordances, Language Simulation") that provides a general framework to account for compatibility effects. This model is based on four general principles: (a) in brain, visual perception and action are organised along a dorsal neural pathway (encoding affordances) and a ventral pathway; (b) within the ventral pathway, the prefrontal cortex biases action selection based on context and goals; (c) action selection results from neural dynamic competitions that cause variable reaction times; (d) words trigger "internal simulations" of their referents. The model was designed with a methodological approach (computational embodied neuroscience) that aims to provide increasingly general accounts of brain and behavior (4 sources of constraints are used to build the models: neuroscientific data, behavioral data, embodied systems, reproduction of learning processes). TRoPICALS reproduces and explains 3 types of compatibility effects and showed its heuristic power by producing 2 testable predictions. The explicative power of the model is also assessed by comparing it with related models and by showing how it can be extended to account for other compatibility effects.

D. Caligiore, A.M. Borghi, D. Parisi, G. Baldassarre, "TRoPICALS: A Computational Embodied Neuroscience Model of Compatibility Effects", *Psychological Review*, 117 (2010), pp. 1188-1228.

LEXICOLOGY

Ariadne's thread: aspects of the Mycenaean textile terminology

From the 3rd to the 1st millennium BC, the Near Eastern and Mediterranean written sources attest complex textile terminologies. During this period, on the basis of a division of labour, textile manufacturing developed from a household production to a State organized industry. The study of the various textile terminologies can provide valuable information, not only on the modes of production and the technical innovations, but also on contacts and trade routes. This article, which is a contribution to the proceedings of an international conference dedicated to the comparative and diachronic study of ancient textile vocabularies, provides an overview of the Mycenaean Greek terminology. The terms, attested in the Linear B tablets (14th-13th century BC) and directly or indirectly related to the textile production (fibres, cloths, garments, decorations, occupational designations), are studied following the "chaîne opératoire", from fibre to finished fabric. Some of them are obscure and probably of Minoan (pre-Greek) origin, others are Semitic loanwords, whereas many of them have an Indoeuropean etymology and are partly preserved in later Greek. Special attention is paid to synonyms and antonyms, as these can provide interesting clues about the technical characteristics of textiles. In order to record textile fibres and products, Mycenaean scribes also used logographic notations, sometimes with acrophonic abbreviations. These logograms are also examined and compared to those attested in the Minoan Linear A documents (datable for the most part to the 15th century BC). The comparison shows the continuity between the two administrative systems and suggests, among other things, that the Linear B logograms for "wool" and "cloth" had their origin in Linear A.

M. Del Freo, F. Rougemont, M.L. Nosch, "The Terminology of Textiles in the Linear B Tablets, including Some Considerations on Linear A Logograms and Abbreviations", *Textile Terminologies in the Ancient Near East and Mediterranean from the 3rd to the 1st millennia BC*, Oxford, (2010), pp. 338-373.

Linear B tablet from Mycenae recording quantities of wool.

Detail of fresco from Akrotiri, Thera (Santorini).

LEXICOLOGY

The first Historical Dictionary of Early Italian (from the origins up to the end of 14th Century)

The paper is a presentation of the Tesoro della Lingua Italiana delle Origini (TLIO), the historical dictionary of Early Italian edited by the Opera del Vocabolario Italiano. It focuses on methods and tools, and gives an example of how an entry is redacted.
An historical dictionary records the words of a language that are documented in writing, using quotations to illustrate their different meanings throughout history. In doing this, it is of the greatest importance to interpret the texts correctly, to check editions for reliability and to pay attention to the chronology. As models for the TLIO, OVI considers the Oxford English Dictionary and the Trésor de la Langue Française.
TLIO is the first historical dictionary of Early Italian, from its origins up to the end of the 14th Century, dealing with all Early Italian varieties (i.e. today's dialects). Though dictionaries normally focus on the national language, an historical dictionary must take into account the fact that before the 16th century the Italian linguistical situation was polycentric.
The core of the system is the TLIO Early Italian Database, powered by software designed by the OVI. This reference corpus includes ca. 2000 texts (ca. 22 million words). Tags allow to choose selectively the various linguistical varieties as well as texts which may be considered as reliable representations of these (the most reliable texts being the nonliterary ones). The lemmatisation, whose method is presented in the paper, allows to retrieve, through a single search, all written forms related to a headword (i.e. 54 written forms of the verb *dettare*).
The TLIO (which today contains more than 21,000 entries out of 50,000) and the database are open to the public at the website www.vocabolario.org.

P.G. Beltrami, *The Lexicography of Early Italian: its Evolution and Recent Advances (Tesoro della Lingua Italiana delle Origini). Perspectives on Lexicography in Italy and Europe*, ed. by Silvia Bruti, Roberta Cella and Marina Foschi Albert, Newcastle upon Tyne, Cambridge Scholars Publishing, (2009), pp. 27-53.

EPISTEMOLOGY

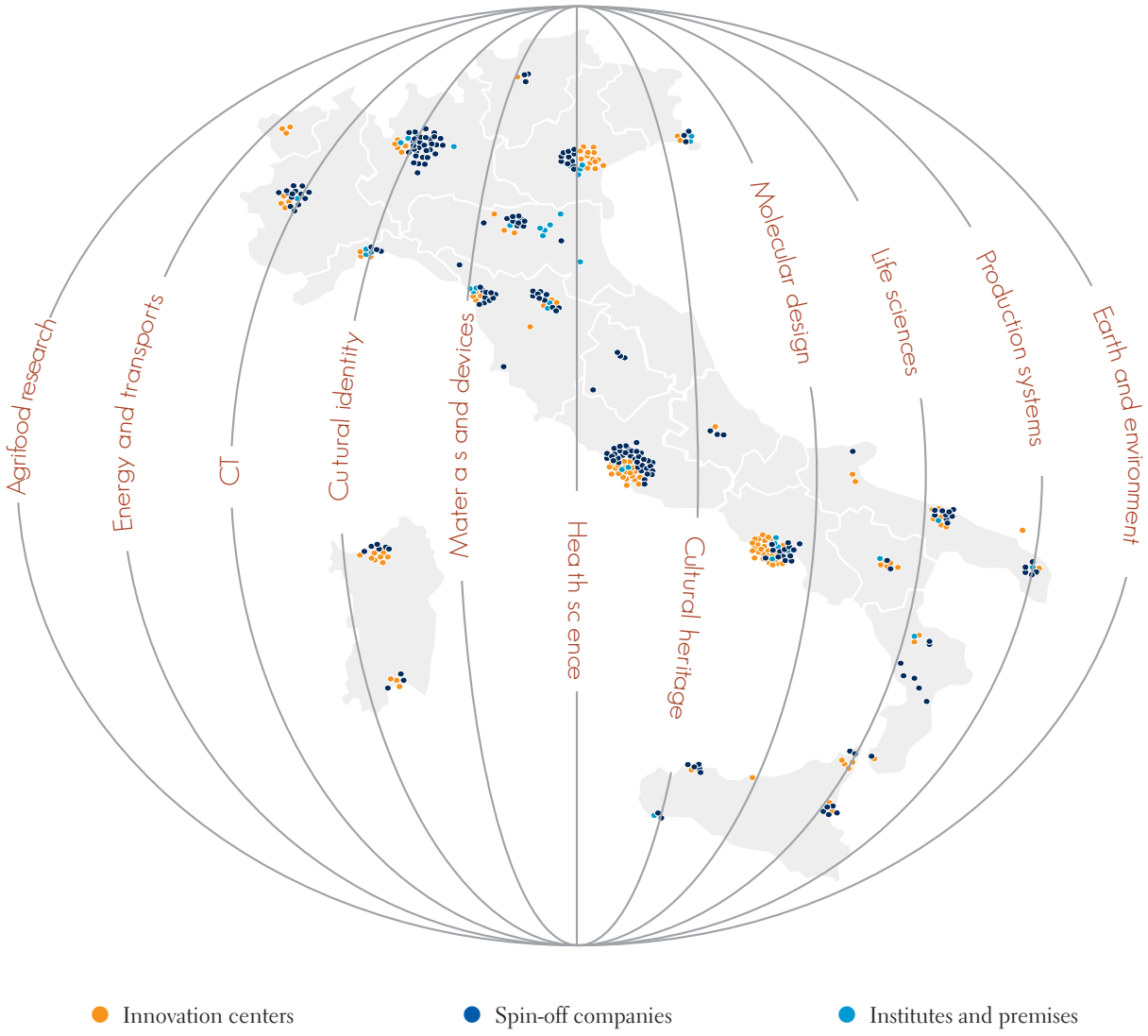
The epistemological relevance of the notion of epoch between organism and system in 19th Century

The notion of epoch gains a crucial role in the philosophy of history particularly since Modern Age, as it comes to embody the emergence of a qualitative characterization of historical time in terms of internal and organic coherence among its component parts. This intrinsic characterization is also methodologically crucial for establishing the ontological specificity of historical periods, and thus visualizing the distance between past and present. Philology and history since the late 18th Century took inspiration from biological models for the notion of epoch; first the notion of system as expressed in Linnean taxonomy, and later, particularly in the philosophy of history of Herder and Hegel, the notion of organism.
With the rise of German historicism, however, this holistic notion of epoch was challenged by the breakthrough of the idea of process; particularly Johan Gustav Droysen will stress that epochs are rather composed of different temporal layers, whose transformation in time is not necessarily synchronic. This outcome will be emphasized in the epistemology of history of the Annales school since Braudel, leaving however unanswered the methodological problem of a viable measure for transformation and discontinuity in history.
The paper offers a revision of the methodology of the history of concepts, as it enlarges its horizon to a wider comparative approach enclosing life- and human sciences. The temporalization of history, meant in the view of Reinhard Koselleck to detach human from natural history, results instead as an extension to human history of the contemporary temporalization of nature pushed forward since Buffon in the biological sciences.

S. Caianiello, "L'enjeu épistémologique de la notion d'époque entre organisme et système au XIX siècle". *Annales HSS*, (2009), n.1, pp. 111-139.

Activity Report

What is CNR?



The National Research Council (CNR) is the largest public research institution in Italy, the only one under the Research Ministry performing multidisciplinary activities. The mission of its Departments and Institutes (geographically located all over Italy) is to carry out, spread, transfer and improve research activities in the main sectors of knowledge growth and of its applications for the scientific, technological, economic and social development of the Country. Further, in order to promote innovation and competitiveness of the national system, CNR provides technologies and solutions to emerging public and private needs, and advices Government and other public bodies.

CNR's Departments are organizational units, structured by macro-areas of technological and scientific research, concerning the following sectors: Agrifood, Cultural Heritage and Identity, Earth and Environment, Energy and Transport, Information and Communication Technologies, Life sciences, Materials and Devices, Medicine, Molecular Design, Production Systems. The 109 Institutes grouping together different technical and scientific areas of expertise, propose programs and

implement the scheduled activities. Their geographical distribution throughout Italy, allows them to contribute significantly to regional innovation. CNR's financial capital comes from the Government, but also from the market: even 30% of CNR's balance sheet is the result of revenues coming from external job orders for studies and activities of technical advice as well as from agreements with firms, contracts with the European Union and with other international organizations. The main resource is the available knowledge which means people with their skills commitment and ideas. This capital comprises more than 8.000 employees, of whom more than half are researchers and technologists. These are complemented by more than 1.500 technicians. At the same time, some 4.000 young researchers are engaged in postgraduate studies and research training at CNR . A significant contribution also comes from research associates: researchers from Universities or private firms who take part in CNR's research activities.

The impact of CNR on the advancement of science

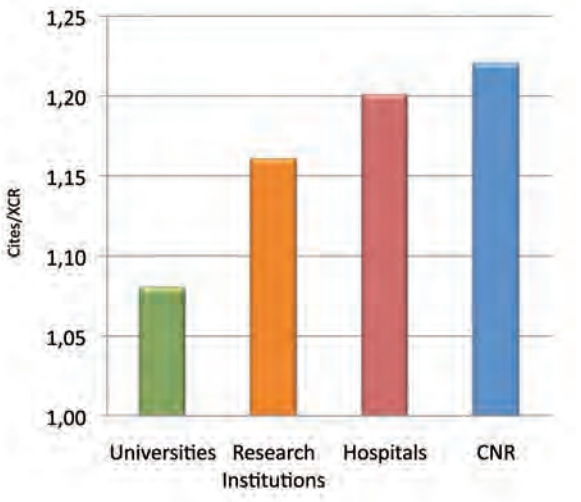
The National Research Council (CNR) is the main Italian public research institution. It ranks first in Italy, sixth in the EU, and 23rd in the world per number of publications (SCImago 2010). In 2010 it produced 6,898 publications and 6,986 in 2009, indexed in the Web of Science (WoS). While international comparisons of research productivity are not yet feasible, due to lack of data from foreign institutions, it has been possible to assess the average impact of the CNR's research activities and compare it to the world average. The average impact of overall Italian research is above the world average and the CNR's is above the Italian average. The outcome stems from an empirical study that analyzes all publications of research institutions located in Italy, indexed in the Science Citation Index of WoS, from 2001 to 2006. In total there were analyzed over 250,000 publications, authored by 78 universities, 75 research institutions and 192 hospitals and health care research organizations. Publications are classified in the WoS subject categories (164 in the hard sciences) for the journal of publication. Citations of each publication are standardized to the average number of citations received by all world publications listed by the WoS for the same year and field. Field-standardization removes the distortions due to the varying intensity of citations across fields, making it ideal for comparing average research impact of institutions with different research profiles. The length of the observation period and the time elapsed from date of publication, which is enough to allow for citations to accumulate and stabilize, make the findings accurate and robust.

Italian publications are on average cited 12% more than the world average, over the period of observation. In detail, those by universities 8% more; by research institutions 16% more; by hospitals and health care research organizations 20% more. The CNR, which produces 12,5% of overall Italian research output in the hard sciences, scores an impact of 22% above world average. 11,7% of its articles are published in the top 10% journals per impact factor, i.e. 17% more than expected. The CNR's performance can be considered even more outstanding if one carries out a time series analysis. The CNR average impact shows a conspicuous increase in the latest years. In 2006 CNR publications are on average cited 42% more than the world average, while overall Italian publications 30% more.

[1] SIR world report 2010, http://www.scimagoir.com/pdf/sir_2010_world_report_002.pdf

[2] Abramo G., D'Angelo C.A., Viel F., The field-standardized average impact of national research systems compared to world average: the case of Italy, Scientometrics, forthcoming.

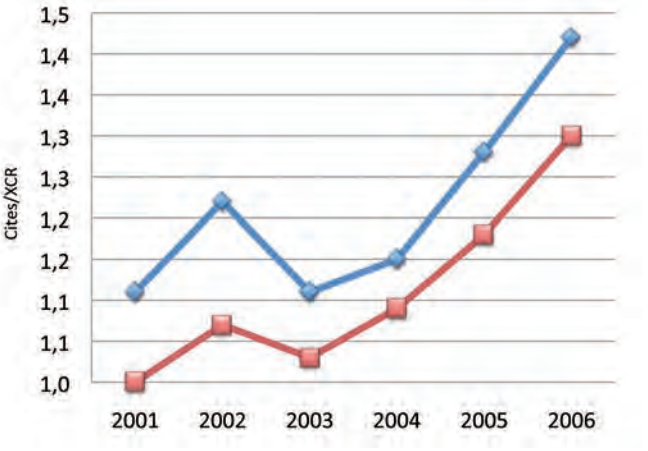
Standardized average impact of Italian publications



- Universities
- Research Institutions
- Hospitals
- CNR

XCR = average world citations

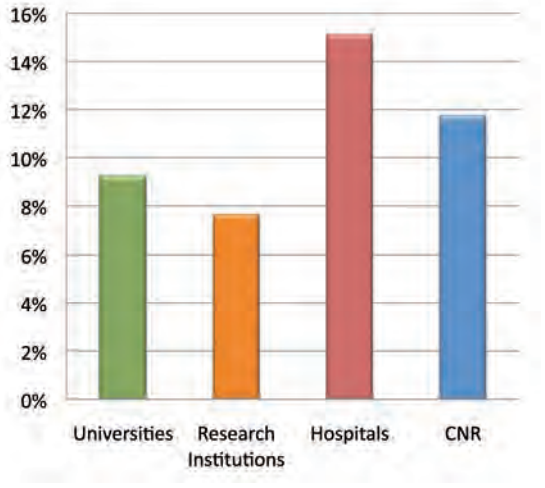
Time series of standardized average scientific impact for CNR and the Italian Research System



- CNR
- Italy

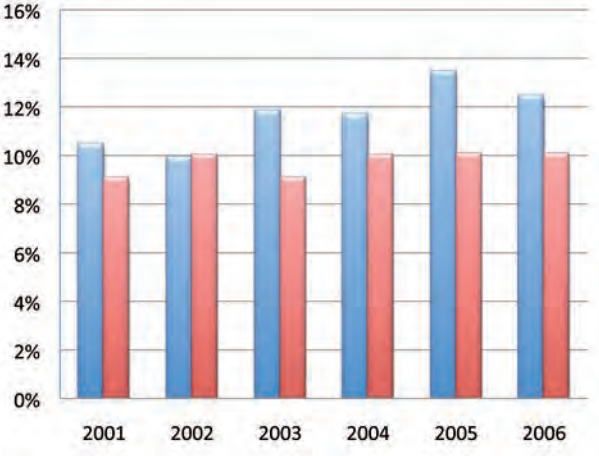
XCR = average world citations

Percentage of publications in top 10% journals



- Universities
- Research Institutions
- Hospitals
- CNR

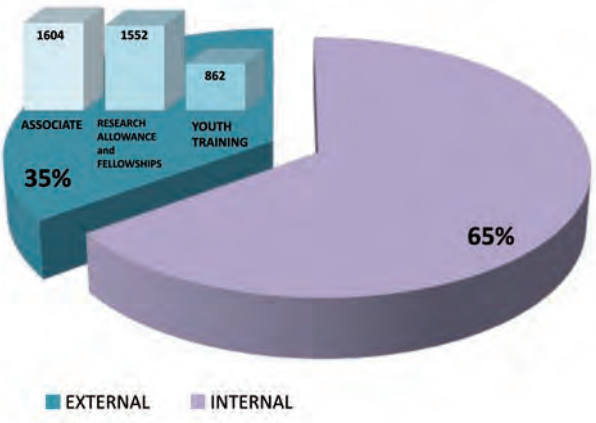
Time series of percentage of publications in top 10% journals for CNR and the Italian research system

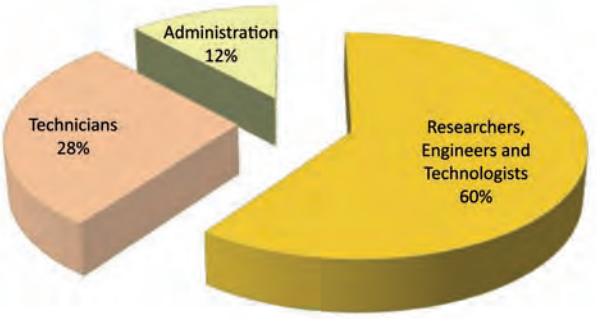


- CNR
- Italy

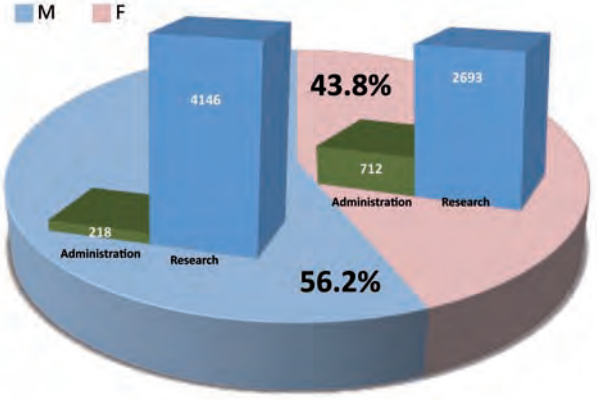
CNR People

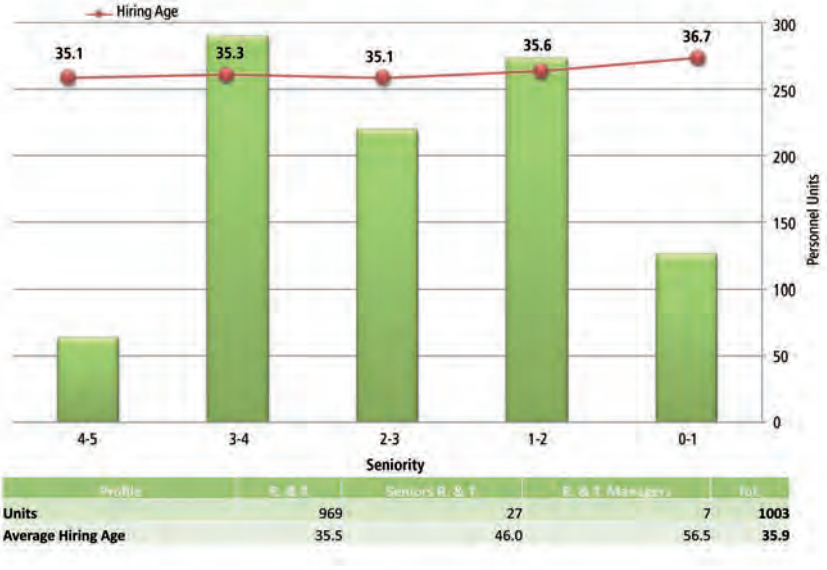
Professional profiles





Professional profiles and gender (march 2011)

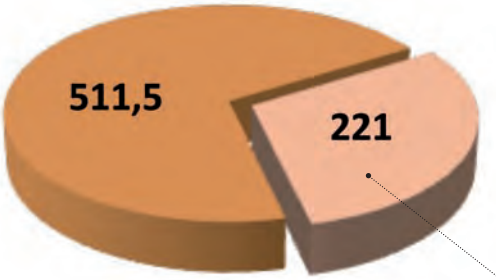




Profile	R. & T.	Seniors R. & T.	R. & T. Managers	Tot.
Units	969	27	7	1003
Average Hiring Age	35.5	46.0	56.5	35.9

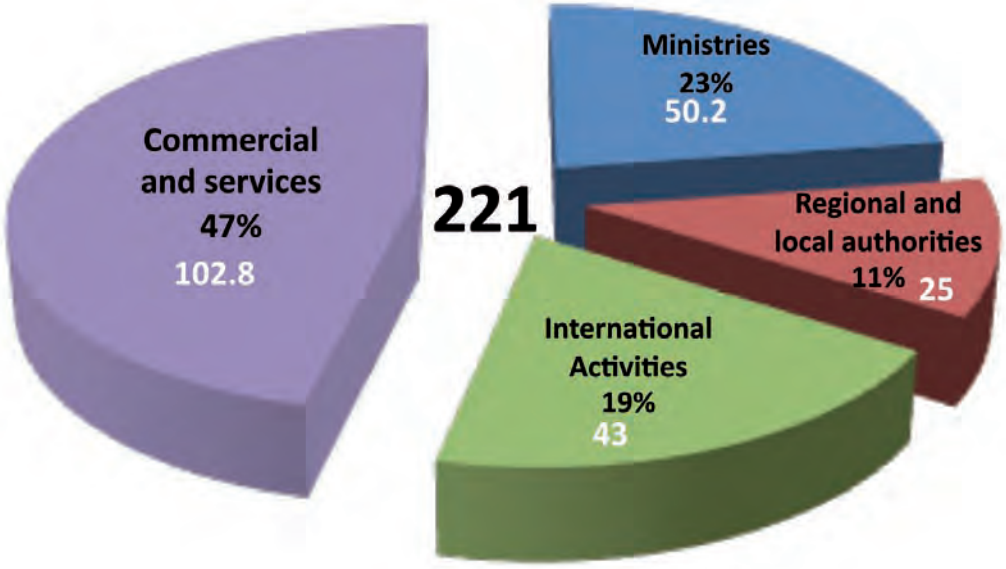
New entries in the last 5 years

Total funding 2010



- Internal resources in ME
- External resources in ME

External resources



Absolute values in ME

Fund Raising Index
1.43

CNR in the world

The data currently available on the presence of CNR in EU RTD activities and, in particular, in the 7th Framework Programme for RTD (2007-2013), confirms the previously positive trend both in numbers and financial terms, showing a significant interest of the scientific community for European research programmes and the competitiveness of CNR Institutes at European level, which are significantly strengthening the already excellent results achieved at the end of FP6. In the Interim Evaluation of FP7 (November 2010), CNR remains, compared to FP6, the fifth ranked among European research institutions recipients of EU funding (240 projects amounting to € 78.6 M) and the 12th amongst European public organisations.

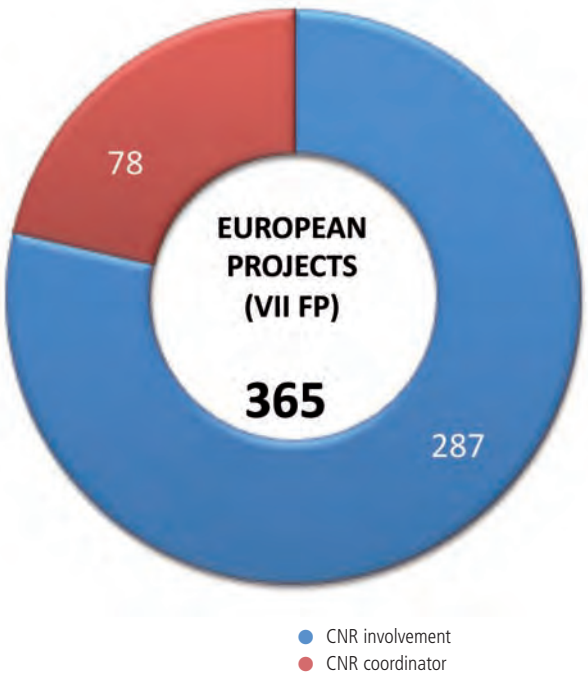
A more recent analysis shows an already increased CNR presence in the 7th Framework Programme with 365 projects, plus 44 others funded from other EU programmes. It is worth underlining that a number of project proposals are presently still under negotiation.

Further, CNR has a long standing tradition of bilateral agreements for the promotion of Scientific and Technological Cooperation with foreign research institutions throughout the world: in particular, such Agreements provide support for joint research projects, exchange of researchers, and the organisation of joint Workshops alternatively in one country and the other. Presently 31 agreements are in force, representing a strong and successful network of permanent international cooperation activities and an acknowledgement of the CNR central role as major research institution in Italy. Furthermore, currently 24 Memoranda of Understanding are in force with foreign research institutions and centres interested in establishing a cooperation, and often leading to stipulate Cooperation Agreements as such.

CNR covers the 20th position including universities and other enterprises

CNR is now 5th among European Research Institutes for grants.

As to major international scientific initiatives, CNR has been traditionally participating to activities and projects within a wide range of areas: from the Life Sciences, with the Human Frontier Science Program, to information technology and applied mathematics through the European Research Consortium of Informatics and Mathematics and becoming the European reference for the World Wide Web Consortium; from Earth Sciences (International Ocean Drilling Program) to Physics, with the participation in large-scale research infrastructures such as ISIS (UK), ILL and ESRF (France), and ELETTRA (Trieste), from VLBI to the heliographic telescope THEMIS, from the Arctic and Antarctic basis to the Pyramid on Mount Everest and the Virtual Museum of Baghdad. Furthermore CNR is a member and actively participates with its experts and representatives in the most important International Scientific Organisations so that its presence on the international scientific arena can clearly be acknowledged to be at 360 degrees, both in terms of scientific areas of research and of international relations with other countries in the world.



Facilities

CNR Oceanographic Infrastructures 2010

Personnel involved in research units

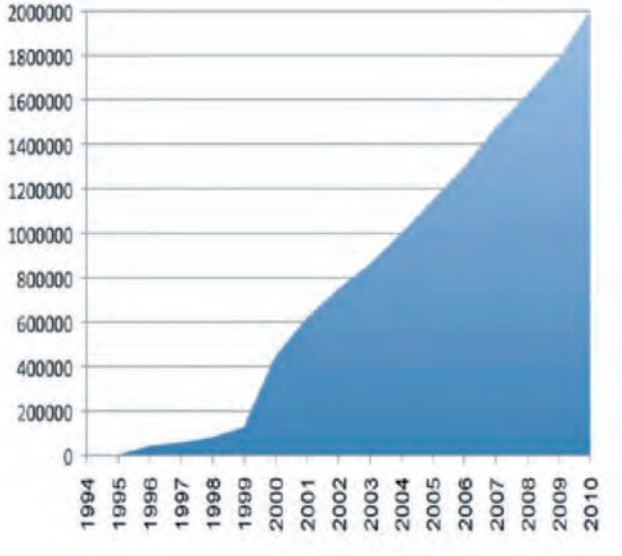
Urania
no. of cruises: 22
days: 354

Dallaporta
no. of cruises: 7
days: 228

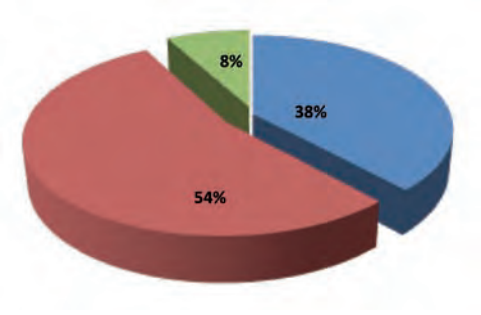
Maria Grazia
no. of cruises: 13
days: 277

Domini.it

Within 5 years the number of registered Italian domains is doubled
The ranking for the number of domains in Italy:
- Fifth place (ranking of European countries)
- Ninth place (world ranking)



Italian Arctic Station 2011



- Investment
  - Education
  - Dissemination
- Logistic & Infrastructures
  - Italian Airship Station
  - Climate Change Tower, Instrumental Platform
- Science & Technology
  - Atmosphere
  - Oceanography
  - Geology and Geophysics
  - Biology and Ecology
  - Astrophysics
  - International projects
  - International relationship

Ev-K2-CNR

ACTIVITIES

- SHARE project
  - WP1 Scientific Research
  - WP2 Technology Research
  - WP3 Information Systems
  - WP4 Capacity Building
- SEED project
- KARAKORUM TRUST II project
- EARTH SCIENCES research

Italian Antarctic Station 2011

SCIENTIFIC AREAS

- Technology
- Space & Atmosphere Sciences
- Life Sciences

Knowledge and Technology Transfer, Outreach

As the main Italian public research organisation, CNR contributes to the social, cultural and economical development of the Country, and is therefore strongly committed in the dissemination and exploitation of research results.
Being one of the largest research networks at European level, CNR can easily make available to industries and to the society at its whole the best competences in order to match and satisfy the industrial needs, and – on a higher level – to diffuse innovation in the Country.
To this aim the **NetwOrK O**utreach and **K**nowledge – supported by an intranet tool called **cnr@work**- has been organized, grouping over 200 experts and researchers operating inside the CNR Departments and Research Institutes collaborating to technology transfer to industries, helping colleagues to start-up new companies and promoting communication and outreach activities. This network is coordinated by the **KTT Office**, a *business development unit* established under the presidency of CNR to coordinate knowledge and technology transfer activities. KTT is supported by **Rete Ventures** (www.reteventures.com), the *in-house* company providing professional services and entrepreneurial skills to protect, exploit and license new technologies. Funding for new enterprises is available by **Quantica SGR** (36% shared by CNR), the first venture capital originated in the scientific environment in Italy.
For a better management of IPRs CNR has established a Task Force supporting research teams in patenting and planning exploitation of inventions, available to potential users by means of the newly launched **'CNR Patent Catalogue'** (https://brevetti.cnr.it/brevetti/Catalogo.do) which contains the CNR portfolio of over 600 patents grouped in 481 'families', CNR being the Italian research institution holding the largest number of patents.
Since setting up new companies seems to be the most effective way to exploit high technologies and skills on the market, the CNR launched in 2010 its first **'Start Cup'**, a high-tech business ideas competition held in collaboration with the main Italian economic newspaper Il Sole 24 ORE with the aim to exploit the 'high-tech potential' of the CNR scientific network. The contest generated 32 business ideas from all over Italy and in particular from Southern Italy, so confirming the strong and vivid high-tech potential of Italian research. Besides awarding the three best projects at the official ceremony held in Genova during the 2010 Science Festival (see box), nine business ideas were selected to participate in the national competition: the newCo Amolab from CNR-IFC based in Lecce, for the production of an innovative non-invasive labour-monitoring system, has been awarded the Italian Innovation Prize (PNI –Premio Nazionale Innovazione), and the Start-Cup CNR-Sole24Ore got the "Champions Cup".
Beyond witnessing the highest quality standard of the CNR research, these goals are a result of the KTT strategy strongly aimed at integrating the scientific competences of research and technical staff with managerial skills: a summer school is available every year for selected and moti-

Festival della Scienza

A Science Festival as a melting pot of disciplines, cultures, traditions and people. Science everywhere and accessible to everyone: this seems to be the magic lying in the 'formula' of the Genova Science Festival, since 2003 acknowledged as one of the most effective events to attract people, and in particular youngest generations, to science. With an average of 200,000 visits per edition and a huge programme of interactive laboratories and exhibitions, theatrical plays, science performances, conferences and cafes with outstanding scientists from Italy and abroad- the Festival has become an 'open laboratory' fostering a new 'science-attitude' and supporting the growth of innovative ideas and talents. CNR, founder and partner of the Associazione Festival della Scienza, supports every year the event organizing a wide range of activities involving its research groups and structures.

www.festivalscienza.it

The Start Cup CNR Il Sole 24 ORE

Aware of a large, unspoken 'high-tech potential' of its research structures, the CNR launched for the first time in 2010 -during the 'Emerging Companies' meeting- a business ideas competition open to CNR projects and research team authors of scientific results that could have an impact on the productive world. The contest was organized in collaboration with the most important Italian editorial group Il Sole 24 ORE, and participated by 41 research teams from all over Italy. On the final ceremony held during the 2010 Genova Science Festival, three projects were awarded –North Italy: Ceramized tissues (Istec-Cnr, Faenza); Central Italy: Quipu (Ifc-Cnr, Pisa); Southern Italy: Soft Materials and Technologies (In-Cnr)- while 9 business ideas were globally admitted to participate in the Italian Innovation Award (PNI Cube). On the final selection held in December 2010 in Palermo, the Cnr project Amolab (Ifc-Cnr Lecce) was awarded as the most innovative idea and CNR got the "Champions Cup" as start-cup organizer.

vated people called **'Come va… la ricerca?'**, and in 2010 a course on **'Research Design'** was organized together with Milan Technical University with the aim of enhancing prototypes design skills as a distinctive mark of the 'Made in Italy' also in new high-tech products.

Furthermore, as the exploitation of scientific results to the industrial world requires the sharing of a sensibility towards innovation in the whole Society, CNR pays a particular attention to dissemination and outreach, starting from the worldwide known **Genova Science Festival** (www.festivalscienza.it, the largest European event dedicated to science dissemination and public engagement, see box), **Matefitness, the math arena** (www.matefitness.it) and several travelling exhibitions and events. Besides having a positive effect on orienting young generations and students in particular towards science and technology, these kind of initiatives can also reveal a great impact on the productive world so far as they can effectively attract Italian SME's – whereas the national industrial context is quite fragmentary – to the research world and its actors.

Finally, dissemination is also supported by CNR as a Publisher of books, technical reports, research monographs and e-editions presenting the research results and know-how developed by the CNR scientific network.

CNR Departments

Agrifood

The Agrifood Department's (**DAA**) mission is to contribute to the progress of the scientific and technological knowledge useful for the development and improvement of a sustainable and innovative agro-food system. For this purpose the department promotes research projects through planning, coordination and control activities. The research projects managed by the Department are performed by 20 Institutes distributed all over Italy.

DAA Projects

1. Plant, animal and microbial genomics

Improvement of knowledge in molecular biology and plant genetics as well as in organisms (pathogens or symbiotic) that interact with them; use of scientific and technological knowledge for characterizing and improving production; introduction of new crop and resistance to biotic and abiotic stress; development of new analytical and diagnostic methods.

2. Sustainable agriculture

Improvement of knowledge and research results application for promoting sustainability in crop and animal production, including aquaculture and fisheries, through characterization, conservation and enhancement of biodiversity profiles of plants, animals and microorganisms; development of methods for low environmental impact farming; study and use of integrated and eco-friendly techniques; development of models, indicators and systems for agro-ecosystems monitoring and management

3. Food

Development of advanced diagnostic methods for traceability and analysis of quality, typical and geographical origin of food products; safety assessment and early diagnosis in food chain; development of integrated and multidisciplinary approach to identify new products or processes in food industry; advancement of knowledge in the relationship between diet and health; development of food regulations

Institutes of DAA

IBBA Institute of Biology and Agricultural Biotechnology, IBIMET Institute of Biometeorology, IGV Institute of Plant Genetic, IPP Institute of Plant Protection, ISA Institute of Food Sciences, ISPA Institute of Sciences of Food Production, ISPAAM Institute for Animal Production System in Mediterranean Environment, IVV Institute of Plant Virology, ISAFoM Institute for Mediterranean Agriculture and Forest Systems, IDAIC Institute of International and Comparative Agriculture Law.

Institutes participating in DAA activities

IAMC Institute for Coastal Marine Environment, IBP Institute of Protein Biochemistry, IBAF Institute of Agro-Environmental and Forest Biology, IC Institute of Crystallography, IGB Institute of Genetics and Biophysics "Adriano Buzzati Traverso", IMC Institute of Methodological Chemistry, ISMAR Institute of Marine Science, IVALSA Institute of Tree and Timber, ISE Institute of Ecosystem Study.

Main National and International collaborations

Italian Ministries, including: Education and Research; Productive Activities; Health; Labour; Infrastructures and Transport; Agricultural, Food and Forestry Policies; Foreign Affairs; Environment; Economy and Finance. Local Authorities, including: Region of Abruzzo, Sardegna, Basilicata, Campania, Emilia Romagna, Liguria, Lombardia, Piemonte, Puglia, Sicilia, Veneto; Toscana; Province of Nuoro, Firenze, Lecce, Livorno, Bari, Milano). Italian Research Public Bodies, including: CRA "Agricultural Research Council"; INRAN "National Research Institute of Food and Nutrition"; ENEA "Italian National agency for new technologies, Energy and sustainable economic development"; INGV "National Institute of Geophysics and Volcanology"; Naples Zoological Station "Anton Dohrn". Foreign Research Institutes, including: CNRS e INRA (France); MPI-Plant Physiology and Max-Planck (Germany); CSIC (Spain); INRS (Canada). USA and Canada Institutions: US DA and US NIH; NRC and AAFC (CA). Other Countries Institutions: Biotechnical Institute (Serbia and Montenegro); CAAS - Plant Protection Institute (China); ICARDA (Syria); IITA (Nigeria); Instituto Biologico San Paolo (Brazil); Malaysian Palm Oil Board – MPOB; Russian Research Institute on Agricultural Microbiology; ARO The Volcani Center (Israel); National Meteorology Directorates of Senegal, Burkina Faso, Mali, Niger, Mauritania,

Chad, Gambia, Guinea Bissau and Cape Verde; CSE - Centre for Ecological Monitoring of Senegal; Agrhymet (Niger). Collaborations with Universities: around 45 Italian Universities. Over 30 Universities in Europe and more than 20 Universities in USA and Canada, including: the Agricultural University of Norway (N); University College of London (UK); Glasgow University (UK); Karlsruhe University and Potsdam (D); University of Bern (CH); University of Uppsala (S); University of Cambridge (UK); Cornell University and University of California-Berkeley (US); Carleton University, University of Laval and University of Guelph (CA). International Bodies and Research Networks: UN-FAO; ESA; JRC; CGIAR, CIHEAM-IAM. Private Organizations, including: Vignaioli Piemontesi; Tecnoalimenti; Barilla Alimentare SpA; Bayer CropScience; Centro Sperimentale per il Vivaismo (CeSpeVi); COOP; Finmeccanica; Menarini S.r.l.; Metapontum Agrobios; ENI; Centro Ricerche sul riso; TELESPAZIO; Seminis, Nunhems, ISI8 Sementi; Consorzio Tutela Mozzarella Bufala CE, ICE NA.

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Cultural heritage

The activities of the Cultural Heritage Department (**DPC**) are addressed to improve knowledge and preservation of the Italian, European and Mediterranean heritage through the management of national and international research projects and the exploitation of its research results. Its aim is to increase the value of the heritage and to improve its governance. Strategy and strength of DPC is an innovative model of scientific network able to establish fruitful co-operations and synergies between human and engineering sciences and operative expertise and skills, both necessary and inseparable knowledge in the field of research for cultural heritage.

DPC Projects

1. Territory and settlements in Europe and the Mediterranean
2. Manufactured artefacts as historical and material evidence of cultural heritage
3. Diagnosis, intervention and conservation of cultural heritage
4. Creation of a need of cultural heritage
5. Fruition and valorisation of cultural heritage
6. Cultural landscape
7. Culture and Landscapes (Interdepartmental, lead by DPC)

In the near future, the established and operative assets of knowledge, skills and technologies will be set in three strategic lines that represent different aspects of a single policy:
- Methodologies and technologies for the monitoring and preventive maintenance of cultural heritage
- Holistic strategy for the integrated management and multi-user use of the cultural heritage of a territory
- Process for the enhancement and sustainable development of natural and anthropogenic cultural landscapes

Institutes of DPC

IBAM Institute of Archaeological Heritage, Monuments and Sites, ICEVO Institute for Aegean and Near Eastern Studies, ICVBC Institute for the conservation and promotion of cultural heritage, ITABC Institute for technologies applied to cultural heritage, ISCIMA Institute for the study on the italic and ancient Mediterranean civilizations.

Institutes participating in DPC activities

CERIS Institute of research on firm and development, IAC Institute for applied mathematics "Mauro Picone", IBIMET Institute for biometeorology, ICAR Institute of high performance computing and networking, ICIB Institute of cybernetics, ICIS Institute of inorganic chemistry and surfaces, ICCOM Institute of chemistry of organometallic compounds, IDPA Institute for the dynamics of environmental processes, IFAC Institute of applied physics "Nello Carrara", IFN Institute for photonics and nanotechnologies, IGAG Institute of environmental geology and geo-

engineering, IGG Institute of geosciences and earth resources, IIA Institute for atmospheric pollution, ILC Institute of computational linguistics, IM Istituto motori, IMAA Institute of methodologies for environmental analysis, IMATI Institute for applied mathematics and information technologies, IMC Methodological chemistry institute, IPP Plant Protection Institute, IRAT Institute for service industry research, IRPPS Institute for research on population and social policies.
ISAC Institute of atmospheric sciences and climate, ISC Institute for complex system, ISEM Institute of Mediterranean Europe history, ISM Institute of structure of matter, ISMAR Institute for marine science, ISOF Institute for organic syntheses and photo-reactivity, ISSIA Institute of intelligent system of automation, ISSM Institute of studies on Mediterranean societies, ISTC Institute of cognitive sciences and technologies, ISTI Institute of information science and technology "Alessandro Faedo", ITC Institute for construction technologies, IVALSA Trees and timber institute.

Main National and International collaborations

The DPC collaborates with national and international partners in order to make the models of the theoretical and methodological analysis operative and shared and to realize the common objective of sustainable development.
The extension of the research network has been built thanks to corporate partnership agreements (Consorzio Civita, Cultura e Innovazione, INNOVA, Venice International University), involvement in technology platforms (DARIAH, DC-NET, EACH, IRICH, JPI - Cultural Heritage and Global Change, NET-HERITAGE, SERIT), partnerships with the Ministry of Cultural Activities and Heritage (MiBAC), ENEA, Universities (e.g. University of Ferrara), local authorities (e.g. the province of Crotone, regions of Basilicata and Valle d'Aosta), private and public corporations (Associazione Città e Siti Italiani Patrimonio Mondiale UNESCO, Confindustria, COTEC Fondazione per l'innovazione tecnologica, Fondazione Cardinale Cusano onlus, ICOMOS Italia, Società Geografica) and SMEs (Officina Rambaldi, Novamusa, Syremont).
Within the European project 'CINEMA - Central Italy Network to Enhance coMpetitive business Activities' (FP7 - CIP), the DPC is partner of the Enterprise Europe Network (EEN), the widest European network devoted to the support of innovation and international cooperation.

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Cultural Identity

The Department of Cultural Identity (**DIC**) consists of 15 research Institutes which deal with a highly diverse range of subjects including linguistics, juridical and socio-economic studies, the history of thought, Mediterranean cultures, cognitive sciences and technological studies in the field of humanities.

DIC Projects

1. History of ideas and culture

This project researches European and Mediterranean cultural traditions, from antiquity to the present day through a thorough analysis of languages and the history of ideas. It investigates the origins of Greek, Latin and Arab civilizations and examines the evolution of scientific and philosophical language and thought.

2. Italian language

Structures, patterns, archives material. This project investigates the Italian language and its history, development and use, using innovative methods of lexicographical analysis and close examination of phonetics, morphology, syntax and dialects. The research combines linguistics and cognitive sciences; moreover, new research topics such as computational philology on digital files have been introduced thanks to use of information technology in the field of humanities.

3. Innovation in educational systems and research

The study of the relationship between cognitive processes and our social and physical environment throughout our lives, and of technological innovations aimed at improving the quality of all aspects of educational systems and scientific research: cognitive, educational organizational and economic.

4. European and Mediterranean culture

This study looks at migration flows in the Mediterranean area, investigating the relationship between cultures from the Middle Ages to the present day, with specific focus on the latter. It examines a broad spectrum of related issues: reciprocity and interdependence; mobility, Diaspora and languages; the construction of identity, cultural practices, social relationships, new communication systems, transnational perspectives and localism.

5. Italian innovation and development in the post industrial global economy

It is the aim of this research to compare the Italian economic system with other international economies, looking at the evolution of the main features of our economy and analyzing the development of localized economic systems. The role of services, Industrial Districts, and the national manufacturing system are investigated as well as the problem of financial intermediaries and their effects on Italian economic development.

6. Law, technological innovation, juridical heritage

This research considers the entire Italian juridical heritage not just as a collection of norms but also as a complex of values and fundamental rights. The aim of the project is to apply new communication technologies to the juridical system as a whole, from the lexicon to archives and the teaching of law, and not least to foster and improve the diffusion of juridical information.

7. Development, regionalism, federalism and self government

The aim of the project is to make the Italian juridical system more widely known internationally, highlighting its basis in Roman law and looking at models and tools of international law as well as at the process of globalization of law or at new technologies and private law. The objective is to contribute to the development of an international legal system in order to participate in the evolution of European unity.

8. Social and institutional transformation of governances

This research area includes different projects concerning different aspects of the multilevel Governance at European level: federalism, regionalism and institutional policies and procedures. It also investigates Governance of judicial systems on comparative analyses of: judicial governance institutions, judicial and prosecutorial roles and extra-judicial activities of judges and public prosecutors.

9. Migration

This study looks at migration phenomena as a displacement of knowledge and cultural experiences; books authors, translations. It analyzes migration with an interdisciplinary perspective examining different related issues: history, philosophy, linguistics, demography, legal studies and education science.

Institutes of DIC

CERIS Institute for economic research on firms and growth, ILC Institute of computational linguistics "Antonio Zampolli", ILIESI Institute of european intellectual lexicon and history of ideas, IRAT Institute for services industry research, IRPPS Institute of research on population and social policies, IRSIG Institute of research on juridical system, ISEM Institute of history of mediterranean Europe, ISGI Institute for international legal studies financial intermediaries and their effects on Italian economic development, ISPF Institute for the history of philosophical and scientific thought in modern age, ISSIRFA Institute for the study of regionalism federalism and self governance, ISSM Institute of studies on mediterranean societies, ISTC Institute of cognitive sciences and technologies, ITC Institute for educational technology, ITTIG Institute of legal information theory and technique, OVI The Italian dictionary.

Institutes participating in DIC activities

IREA Institute for Electromagnetic Sensing of The Environment, ISAC Institute of Atmospheric Sciences and Climate, ISTI Institute of Information Science and Technologies.

Main National and International projects and collaborations

Public and Private Universities, Ministry of Education, University and Research, Ministry for the Cultural Heritage and Activities, Ministry of Foreign Affairs, Ministry of Economy and Finance, Local Authorities, Foundations, Istat- National Institute of Statistics, Iss- Italian National Institute of Health, Crusca Academy, National Council of Italian Notaries, European and International Universities, European Science Foundation, CUPL - China University of Political Sciences and Law – Beijing, Eurocores: The Evolution of Cooperation & Trading (Tect), Eurocores: Consciousness in Natural and Cultural Context (Cncc), LGA - Language Grid Association, Bernard Van Leer Foundation of Bruxelles, CSIC - Spanish National Research Council, CNRS: Leibniz Laboratory – Grenoble, Centro Para el Desarrollo Tecnologico y Industrial, ASSER - Institute Of International Law.

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Earth and Environment

The research activities of the Earth and Environment Department (**DTA**) are focused on increasing the knowledge of:

1. the structure of the Planet, defining the temporal and spatial changes of the structure and composition of the different features constituting the Earth system, from the mantle to the atmosphere;
2. the dynamics of the Planet, studying the energetic exchanges among the several components of the Earth and the effects on its dynamics;
3. the ecology and metabolism of the Planet, contributing to the understanding of terrestrial and marine ecosystems, their evolution, their interactions and the exchanges of the biosphere with the other components of the Earth system.
4. polar research: in the Arctic region, DTA manages the station "Dirigibile Italia", giving support to field surveys of different research groups and being strongly involved in SIOS, and ESFRI initiatives focused on the Svalbard Islands; in the Antarctic region, CNR-DTA coordinates the scientific activities of the Italian National Antarctic Research Programme (PNRA), and is responsible for the management of the research projects and of the reporting activities to the Italian Ministry of Research (MIUR).

DTA Projects

1. Earth system

Interactions among solid Earth, Sea, internal Waters, Atmosphere and Biosphere; Improvement of our understanding of processes that regulate the Earth system and the interactions between its components, aimed at predicting the main evolutionary trends.

2. Global change

Evaluation of ancient and recent climatic changes in the Earth system as a result of natural and anthropogenic causes, using models and experimental measurements; prediction of the ecological responses of species and communities.

3. Quality of environmental systems

Improvement of the evaluation of environmental system quality; support to local and national policies devoted to the safeguard and recovery of land and marine ecosystems.

4. Sustainability of land and water systems

Definition of the level of functionality of environmental systems and their response to human impact; development of methods and standards to support sustainable management.

5. Natural and anthropogenic risks

Improvement of the knowledge of the causes of natural and human induced risk in both inland and off-shore areas; development of efficient prevention and now-casting strategies; cooperation with Civil Protection.

6. Earth observation

Development of technologies to observe the Earth by ground-based, airborne and satellite instruments; participation into Euro-Mediterranean infrastructure systems focused on global monitoring and security.

7. Pollution control and ecological restoration

Development of technologies and methods to reduce environmental pollution and to support ecological restoration, also providing new inputs to industrial technological development.

8. Health and environment (Interdepartmental, lead by DTA)

Improvement of the knowledge of environmental factors which can potentially affect health.

9. GIIDA, integrated and interoperational Management of Environmental Data (Interdepartmental, lead by DTA)

Development of a multi-purpose infrastructure system for the management, elaboration and valuation of environmental data.

Institutes of DTA

IAMC Inst. for Coastal Marine Environment, IBAF Inst. of Agro-Envinronmental and Forest Biology, IDPA Inst. for the Dynamics of Environmental Processes, IGAG Inst. of Environmental Geology and Geoengineering, IGG Inst. of Geosciences and Earth Resources, IIA Inst. for Atmospheric Pollution, IMAA Inst. of Methodologies for Environmental Analysis, IRPI Research Institute for Geo-Hydrological Protection, IRSA Water Research Institute, ISAC Inst. of Atmospheric Sciences and Climate, ISE Inst. of Ecosystem Study, ISMAR Marine Science Institute, IVALSA Tree and Timber Institute.

Institutes participating in DTA activities

CERIS Inst. of Research on Firm and Development, IA Inst. of Acoustics "O.M. Corbino", IAC Inst. for Applied Mathematics "Mauro Picone", IBF Inst. of Biophysics, IBIMET Inst. for Biometeorology, IBIM Inst. of Biomedicine and Molecular Immunology "Alberto Monroy", IBP Inst. of Protein Biochemistry, ICIS Inst. of Inorganic Chemistry and Surfaces, ICRM Inst. of Chemistry of Molecular Recognition, IFAC Inst. of Applied Physics "Nello Carrara", IGV Inst. of Plant Genetics, IMATI Inst. for Applied Mathematics and Information Technologies, IMC Methodological Chemistry Institute, IPP - Plant Protection Institute, IREA Inst. for Electromagnetic Sensing of the Environment, ISAFoM Inst. for Mediterranean Agriculture and Forest Systems, ISSIA Inst. of Intelligent Systems for Automation.

Main National and International collaborations

The research activity is carried out in collaborations with the main national research performing institutions (e.g. ENEA - Department for new technologies, energy and the environment, OGS - National Institute for Experimental Oceanography and Geophysics, ISPRA - Superior Institute for Environmental Protection and Research, INGV - National Institute of Geophysics and Volcanology) in activities financed both by Italian ministries (Ministry of the Environment, Land and Sea, DPC - Civil Protection Department), and by other national and international funding initiatives, as the 7th Framework Program of the European Commission.
The following list is an example of the main projects of Earth and Environment area in which the Institutes of CNR are involved: COPAL (COmmunity heavy-PAyload Long endurance Instrumented Aircraft for Tropospheric Research in Environmental and Geo-Sciences); EGIDA (Coordinating earth and environmental cross-disciplinary projects to promote GEOSS); ERA-EnvHealth (ERANET for coordination of national environment and health research programmes Environment and Health); JERICO (Joint European Research Infrastructure network for Coastal Observatories); SEAS-ERA (Towards Integrated Marine Research Strategy and Programmes); SIOS (Svalbard Integrated Arctic Earth Observing System); VIGOR (Valutazione del potenzIale geotermico delle Regioni della convergenza); SHARE (Stations at Hght Altitude for Research on the Environment); RITMARE (La Ricerca ITaliana per il MARE); EUROFLEETS (Towards an alliance of European Research Fleets).

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Energy and Transport

The objectives of the Department of Energy and Transport (**DET**) mainly focus on: energy source diversification; efficiency improvement and emission control; technology for renewable energy; waste recovery and exploitation; optimization and safety of energy production systems; energy trigeneration and smart grids; more sustainable road transport; development of new and advanced materials for energy applications. The Department is carrying out external activities aiming at strengthening its role of "hub" for R&D on energy and transport. The Department is taking care of international relations and is coordinating the participation in the 7th Framework Program and in the Joint Programs of the European Energy Research Alliance (EERA), according to the goals of the Strategic Energy Technology Plan (SET Plan).

DET Projects

1. Clean energy generation by fossil fuels

- New processes and technologies for fossil fuels combustion/gasification
- High efficiency & low environmental impact

2. Rational use of energy in transport

- Innovative engines and alternative fuel applications
- Advanced projects for higher performances, lower pollution and fuel consumption

3. Distributed energy generation
- Renewable energy integration in the energy production system
- Fuel cells, heat pumps, biomass, waste recycling and storage systems smart grids;

4. Participation in national and international programmes on nuclear fusion
- Tests on a magnetically confined plasma in RFX
- Development of RF systems and neutral beam Injector for ITER Project

5. Nanotechnologies and physical metallurgy for energy and transport components
- Development of new manufacturing materials and methods
- Energy Efficiency Improvement of energy/transport actuators and devices

6. Sustainable mobility (Interdepartmental, lead by DET)
- Best practices identification in the urban context
- Methods and Model definition for system evaluation.

Institutes of DET

IENI Institute for Energetics and Interphases, IFP Institute for Plasma Physics "Piero Caldirola", IGI Institute on ionized gas, IM Institute on engine research, INSEAN National Institute for Studies and Experiences of Naval Architecture, IRC Institute on combustion research, ITAE Institute for advanced energy technologies "Nicola Giordano", ISTEC Institute of science and technology for ceramics, Research Unit at the University of Cagliari, Research Unit at the University of Napoli "Federico II".

Main National and International collaborations

The Department manages a significant number of projects and national and international collaborations with universities and public and private institutions. International collaborations: EARPA (European association that brings together all the independent research centers in the automotive sector), EURATOM, ESA, IEA (Italian representative in Heat Pump Programme of IEA) European JTI on Hydrogen and Fuel Cell Joint Technology Initiative, Institut Français du Petrol, Max-Plank Institut, Universities of Osaka, Cambridge, Leeds, the major foreign companies such as Daimler Chrysler, Bosch, De Nora, ST Microelectronics, General Motors in the areas of sustainable transport and advanced components. At national level: ENEA, RSE and INFN, almost all the Italian universities, ENEL, CRF, Elasis, Ansaldo, ENI, Fiat Powertrain, Ferrari Motori, Dell'Orto, ENI Tecnologie, Fincantieri, Rodriguez, Rina, Tozzi, Tre, Pirelli Labs, Nuvera, Sudchemie, SORIN, Galileo Avionica, Riello, Alenia Spazio, Snam Progetti, Ecotec, EFDA-ITER (Garching–GE), Consorzio RFX, Consorzio Metrologico Gas, Consorzio Ricerche Innovative per il Sud. DET also collaborates with the Ministry of Economic Development (to manage a R&D program on the national electrical system), the Ministry of Environment and the Ministry of Education and with Regional administrations (e.g. Campania, Tuscany, Sicily, Veneto). Agreements with: International Centre for Technology Transfer on Renewable Energies in Tuscany, Technical Center on Energy and Transport (aeronautics included) in Naples, Technological District on Transport in Sicily.

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Information and Communication Technologies

All the strategic lines of the ICT Department (**DICT**) are mainly accomplished through its role of hub in accordance with CNR's general strategy. The Department collects its resources both from public and private entities, interested in boosting the research activity within the ICT field. Good examples of the ICT activity developed between 2006 - 2008, are represented by several initiatives: MERIT, approved and financed by the Ministry for University and Research and by the Ministry for Innovation with 24 million Euro; TERIT, elaborated in close collaboration with the National Inter-University Consortium for Telecommunications (CNIT) and the main national industrial actors in the sector; RITMARE developed in collaboration with the whole maritime-shipyard sector lead by the RINA, with the Department Earth and Environment of the CNR, the OGS, the INSEAN and the principal Inter-University Consortia of reference; SERIT, under construction, in collaboration with FINMECCANICA.

DICT Projects

1. Devices and technologies for telematic networks
This project constitutes a pool of expertise at national level from which they can draw on to participate in research projects and programs, both nationally and internationally.

2. Data mining, ontologies and semantic web
This project contributes to the creation of a Platform of Knowledge for the Knowledge Society in Italy.

3. GRID and High Performance Computing (HPC)
The HPC and Grid projects aim at enhancing and coordinating cooperation between CNR research groups.

4. Multimodal and multidimensional content and media
The research in this project is targeted at improving the representation and use of multi-dimensional media.

5. Modelling and simulation of complex systems
The research activities conducted under this project aim at developing models and methods for representation, simulation, management and control systems and processes.

6. Security (Interdepartmental, lead by DICT)
The project intends to address both meanings of "security" and "safety".

7. Bioinformatics (Interdepartmental, lead by DICT)
This project allows a constant updating of knowledge in a highly innovative sector such as Bioinformatics applied to Genomics and Proteomics.

Institutes of DICT

IASI Institute for System Analysis and Computer Science "Antonio Ruberti", ICAR Institute for High Performance Computing and Networking, IEIIT Institute of Electronics, Computer and Telecommunication Engineering, IIT Institute for Informatics and Telematics, IMATI Institute for Applied Mathematics and Information Technologies, IREA Institute for Electromagnetic Sensing of the Environment, ISTI Institute of Information Science and Technology "Alessandro Faedo".

Institutes participating in DICT activities

CERIS Institute of Research on Firm and Development, IAC Institute for Applied Mathematics "Mauro Picone", ICIB Institute of Cybernetics "Edoardo Caianiello", ICRM Institute of Chemistry of Molecular Recognition, IDPA Institute for the Dynamics of Environmental Processes, IFAC Institute of Applied Physics "Nello Carrara", ILC Institute of Computational Linguistics, IMAA Institute of Methodologies for Environmental Analysis, IPCF Institute for Chemical and Physical Processes, IRPPS Institute for Research on Population and Social Policies, ISIB Institute of Biomedical Engineering, ISN Institute of Neurological Sciences, ISSIA Institute of Intelligent Systems for Automation, ISTC Institute of Cognitive Sciences and Technologies, ISTM Institute of Molecular Science and Technologies, ITTIG Institute of Legal Information Theory and Technology.

Main National and International projects and collaborations

Minister of University and Research (MUR), Tuscany Region, Civil Protection, Telespazio, Insean, INAF-IRA, INGV, ASI, CNIPA, ISTAT, Istituto Superiore Mario Boella Turin, Astronomical Observatory of Arcetri, National Institute for Studies and Experiences of Naval Architecture, IASF, ICEmB, CNIT.
Seventh Framework Programme (FP7) - Theme for research and development under the specific programme "Cooperation"; Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions European Information Society 2010; Information Technology Union – 2008; Report on the World summit on the Information Society Stocktaking United Nations - Development-oriented policies for socio-economic inclusive information society - Kuala Lumpur ICT Policy Support Program CCLRC (UK), ERCIM EurID register ccTLD.eu, INRIA, ESA, the European Southern Observatory (ESO). Los Alamos National Labs, San Diego Supercomputing Center, Edinburgh Parallel Computing Centre, CNRS, Institut FOKUS, MIT Media Lab, Marie Curie Research, Europe Labs, CNES, ONERA, Fraunhofer-Gesellschaft, ENST, UCAR / NCAR, Max-Planck - Institut, ESA, Russian Academy of Sciences Getronics, Intel (UK), IBM Research, Thomson, CSP, CREATE-NET VPtech, BiometriKa, Microsoft, Vodafone, Motorola, ZGDV, British Telecommunications, Hewlett Packard, NEC Europe, Microsoft Innovations, Jujitsu, IBM, Oracle, SUN, Toyota Technological Institute, Konica, Minolta.
Universities: EPFL, Loughborough, Portsmouth, Cambridge, Di Vigo, Barcelona, Ulm, Goteborg, Thessaloniki Aristotle, Bradford, Graz, Carlos III de Madrid, Surrey, Toulouse, Twente, Cork, Linz, Uppsala, Vrije Universiteit, University Catholique de Louvain, LIB Université de France, Université de Luminy, Melbourne; Portsmouth, Universidad Complutense de Madrid, Iowa University, University of Paris South, University of York, Glasgow, Grenoble, Istanbul, Granada, Bristol, Colorado University, Dallas, Louisiana, Tel Aviv, Grenoble, Cologne, Heidelberg, Polytechnic of Catalo-

nia, Georgia Institute of Technology. European registry for internet domains VZW/ASBL, CWI (Olanda), ZIB (Germania), ERCIM (Francia) Groupment europeen d'internet economique, ISRO (India), IMCCE (Francia), WPI (Austria), FORTH (Grecia), LLNL (USA).

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Life sciences

The Department of Life Sciences (**DSV**) embraces a range of research on the fundamental mechanisms governing living organisms. DSV supports research on the human and model genomes and on all aspects of genetics, basic biochemistry and cell biology related to health and disease, including the translation of knowledge into health policy and practice, and the societal implications of genetic discoveries. Its overall objective is to advance science and technology to better understand complex biological systems and their relationship with human health and the environment. DSV researchers have significant expertise and special facilities in Mammalian Genetics and Genomics, Computational Biology, Biophysics and Biomedical Technologies, and Toxicology and Risk Analysis.

DSV Projects

1. Function, regulation, and evolution of eukaryotic genomes

Define the molecular mechanisms which regulate the expression of genes involved in the control of fundamental biological processes, identify and characterize the function of new genes of biomedical and biotecnological interests. Study the genetic (mutation and recombination) and epigenetic mechanisms involved in genetic variability, genetic alterations and genome plasticity.

2. Structure, function and design of proteins, nucleic acids and their supramolecular complexes

Study relationships among three-dimensional structure, dynamics, protein and nucleic acids functions and macromolecules recognition processes; Design proteins and nucleic acids with new functions. Expand the structural/functional knowledge of supramolecular structure components with particular attention to nucleic acid-protein complexes and to the ones involved in cellular respiration.

3. Molecular mechanisms and signaling in the control of cell proliferation, differentiation and death

Develop the understanding of the molecular mechanisms which determine cell diversity and regulate differentiation, omeostasis, oncogenic transformation and cell death; analyses of potential apllication for diagnosis and therapy of human diseases. Study the mechanisms through which extracellular signals are converted in intracellular ones, integrated and involved in tissues and organs metabolic activities. Pharmacological modulation of signals with selected molecules.

4. Animal models in physiopathology and behaviour

Model organisms to understand the function of specifc genes involved in the regulation of physiological processes in complex organisms and studies on human diseases in which such functions are altered. Biological evolution, behavioural and cognitive studies in human and not human primates, also through genetic and molecular approaches; development of basic knowledge and its applications in behavioural neuroscience.

5. Biodiversity and mechanisms of adaptation to stress

Study the adaptation mechanisms of extremophile organisms to adverse environmental conditions (temperature, pH, salinity) and those underlying the response to exogenous stress factors in model organisms. Develop ad hoc methods for the identification, classification and cataloguing of animal and plant species through bioinformatic analysis of genomic sequences also to contribute to safeguarding biodiversity.

6. Bioinformatics and Computational Biology

Develop and set up informatic technologies for the organization and management of gene and protein sequences; Structure protein prediction based on well known three-dimensional protein family structure analyses. Analyses of isolated populations in their environmental context through

multidisciplinary approaches in order to identify genomic regions associated with complex diseases and risk factors for common diseases.

7. Biodiversity molecular (Interdepartmental, lead by DSV)
Biodiversity Molecular users located in many different fields ranging from basic biology to applied research.
The general objectives of the project are:
- Enhance the study of biodiversity at the molecular level in various fields from the activities currently performed in laboratories of the CNR in the Departments of: Life Sciences, Medicine, Agrifood, Earth and Environment, Information and Communication Technology, and possibly others.
- Expand and establish links between research in the field and the possible fallout in the world of production, labor and education.

8. FaReBio of quality (Interdepartmental, lead by DSV)
Identification and characterization of new molecular targets; development of innovative medicines for tumors medicines-resistant and without treatments, rare and autoimmune diseases; development of new nutritional products for health.

Institutes of DSV

IBP Institute of Protein Biochemistry, IBPM Institute of Molecular Biology and Pathology, IBBE Institute of Biomembrane and Bioenergetics, IBCN Institute of Cellular Biology and Neurobiology, IEOS Institute Experimental Endocrinology and Oncology "Gaetano Salvatore", IGB Institute of Genetics and Biophysics "Adriano Buzzati Traverso", IGP Institute of Population Genetics. Institutes participating in DSV Activities, IAC Institute for Applied Mathematics "Mauro Picone", IBIM Institute of Biomedicine and Molecular Immunology "Alberto Monroy", IGM Institute of Molecular Genetics, ISMAC Institute for Macromolecular Studies, ISTC Institute of Cognitive Sciences and Technologies, ITB Institute of Biomedical Technologies.

Main National and International projects and collaborations

Italian Ministry of Health, Italian Ministry of University and Research, ISS - National Institute of Health, IPI – Institute for Industrial Promotion (Italian Ministry Economic Development, TELETHON, AIRC, IRCCS Specialized Hospitals for Research and Cure (Italian Ministry of Health), The main important private and public research bodies, CNR Interdepartmental project "FaReBio di Qualità", Stazione Zoologica "A. Dohrn", Local and Regional authorities, The main important Italian Universities, Memorandum of Understanding between Genome Canada and CNR. Projects: LIFEWATCH -European infrastructure developed to support all aspects of research on the protection, management and sustainable use of biodiversity, NATIONAL FLAG PROJECT "EPIGENOMICS" - for academic and industrial research about epinetics with strong emphasis on "omics", IMI – Innovative Medicine Initiative, INSERM – Institut National de la Santé et de la Recherche Médical (France), ITALY-TAIWAN Seminars Programme, JPI "A healthy diet for a healthy life", ELIXIR - European Life Sciences Infrastructure for Biological Information, ERA INSTRUMENTS - Infrastructure funding in the Life Sciences, EURO BIO IMAGING, EUROCORES: EUROMEMBRANE, Membrane Architecture and Dynamics.

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Materials and Devices

The overall goals of the Materials and Devices Department (**DMD**) include both the development of scientific topics at the frontier of knowledge and technological applications with significant outcomes. The Department has a leading role at national and international level in the field of fundamental and applied physics, from atomic physics to condensed matter, materials science, optics, plasma physics, physical chemistry, complex systems and soft matter.
Frontiers such as those of quantum science and technology, atom based nanotechnologies, lasers, laser-matter interaction and matter superfluidity are explored and made available for innovative applications. Some of the topics include: Functionalities, processes and properties referring to atomic and molecular condensed states; Development of the fundamental knowledge and of the technological use of matter; Sensors; Synergy of different disciplines such as physics, chemistry, biology, ICT, cultural heritage and engineering in the areas of photonics, micro and nanosciences. DMD research, mostly performed in well established CNR Institutes, benefits also from the interaction with national and international facilities spread all over

the national territory. Moreover, thanks to the dynamism of the DMD groups performing top level research, more than 10 young researchers in the past three calls of the programme won the ERC starting grants, a prestigious acknowledgment of excellent investigator-driven frontier research carried out in different fields of activities within the Department.
At present, there are more than 140 projects financed by the 7th Framework Programme and many others are running within existing collaborations with national and international Institutions, indicating that the DMD scientists have considerable capability of being competitive as well as of attracting external funds.

Institutes of DMD

IAC "M. Picone" Institute for Computational Applications, IBF Institute of Biophysics, ICIB "E. Caianiello" Institute of Cybernetics, IFAC "Nello Carrara" Institute of Applied Physics, IFN Institute of Photonics and Nanotechnologies, INO National Institute of Optics, IMIP Institute of Inorganic Methodologies and Plasmas, IMM Institute for Microelectronics and Microsystems, IOM Institute of Materials, IPCF Institute of Chemical and Physical Processes, ISC Institute of Complex Systems, ISM Institute of Structure of Matter, NANO Institute of Nanoscience, SPIN Institute for superconductors, oxides and other innovative materials and devices.

Institutes participating in DMD activities

IMEM Institute of Materials for Electronics and Magnetism, ISTI "A. Faedo" Institute of Information Science and Technologies, ISAC Institute of Atmosphere Sciences and Climate, IDASC Institute of Acoustics and Sensors "Orso Mario Corbino", ICCOM Institute of chemistry of organometallic compounds.

DMD Projects

1. Biophysics and soft matter

Study and identification of possible applications of the so called "soft" matter, the state of matter mainly characterised by processes which are self-aggregated in mesoscopic complex structures having extraordinary resistance and/or adaptation properties. Study of the structures and mechanisms ruling the organization and dynamics of biological systems from the molecular to supra-molecular, up to the systemic level.

2. Complex materials and systems

Interdisciplinary applications of complex systems; models and theoretical methods; study of disordered, vitreous and composite materials; many-body systems and high-Tc superconductivity; development and applications of experimental methods for complex systems. Analysis by light and neutron spectroscopy and X-rays of complex, disordered, vitreous, porous and granular systems as well of heterogeneous catalysts and new superconductors.

3. Optics, photonics and plasmas

New materials for photonic and optical devices; ultrashort pulse sources and intense-fields physics; new optical devices for photons manipulation; innovative coherent sources and advanced spectroscopic techniques in less explored spectral regions; new imaging methods and techniques; theoretical and experimental study of new non classical field states and of quantum correlations; ultra-cold atomic physics; study of atomic and molecular systems, including those relevant in the chemistry and physics of plasmas; collisional plasmas.

4. Magnetic and superconductor materials and devices

Magnetic, superconductors and complex functional materials based on strong electronic correlations; advanced devices for applications in magnetic memories, electronic devices and magnetic and superconducting sensors. Focus on three main macro areas: a) Magnetization processes and transport mechanisms in magnetic and superconducting materials; b) Spintronics and oxides electronics; c) Magnetic, magnetoelectronic and superconducting devices.

5. Microelectronics and microsystems

Materials and processes for miniaturising CMOS technology; silicon integrated optoelectronics; power and hyperfrequency devices; materials and processes for sensors and actuators; microsystems technologies and micro-components development; microsystems for environment, food, biomedicine and space applications.

6. Nanosciences and nanotechnologies

Interdisciplinary activity combining fundamental research, search for new materials and innovative methodologies and devices with major applications in electronics and telecommunications, pharmaceutics, genomics and biomedicine.

7. Photonics 2015

(Interdepartmental project, lead by DMD). Promotion of research activities in the field of photonics with particular attention to the young researchers.

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Medicine

The Department of Medicine (**DM**) performs research and training in Biology, Medicine and Public Health providing technologies and services to the National Health System and to the public and private industrial sectors.
The mission of the Department of Medicine is to promote knowledge in health-related fields by studying the mechanisms of various diseases and by exploring new therapeutic opportunities with the aim of transferring results to the amelioration of the health of mankind.

DM Projects

1. Cardiovascular and pulmonary diseases
Imaging; Genetics of monogenic and complex diseases; ICT; Drug development

2. Neuroscience: molecular bases and clinical application
Neuroimaging; Behavioral sciences; Genetics of chronic degenerative diseases

3. Oncology
Tumor transcriptome and genomics of molecular targets; Development of immuno-therapy and new radiant therapies

4. Immunology and infective diseases
Identification and development of immune system antibiotic-resistant strains; Development of new antibiotic and anti-viral drugs

5. Human molecular medicine
Genetic and molecular determinants of illnesses; Development of animal models; Design of vectors for gene therapy; Application of stem cells for disease therapy

6. Biomedical technologies
Development and validation of ICT technologies applicable to medicine, imaging, surgery, biotechnology, bio-engineering, biomaterials and medical devices

7. Epidemiology and health care research
Identification and quantification of genetic and environmental risk factors; Development of informatics systems for the organization and management of health care and services

Institutes of DM

ITB Institute of Biomedical Technologies, IFT Institute of Translational Pharmacology, IN Institute of Neuroscience, ISN Institute of Neurological Science, IGM Institute of Molecular Genetics, IBFM Institute of Molecular Bioimaging and Physiology, IFC Institute of Clinical Physiology, ISIB Institute of Biomedical Engineering, IRGB Institute of Genetic and Biomedical Research, IBIM Institute of Biomedicine and Molecular Immunology.

Institutes participating in DM activities

IBCN Institute of Cell. Biology and Neurobiology, IBB Institute of Biostructures and Bioimages, IASI Institute Analysis of Informatics Systems, IAC Institute "Mauro Picone" Calculus Applications, IMATI Institute Applied Mathematics and Informatics for Technologies, IRPPS Institute Research on Population and Social Problems, ISTC Institute Science and Technology of Knowledge, ISTEC Institute. Science and Technology of Ceramic Materials.

Main National and International collaborations

Italian Ministry of University and Research, Italian Ministry of Health, Italian Ministry Reform and Innovation in the Public Administration / Dept. for Innovation and Technologies, Italian Ministry Economic Development, Italian Ministry of Environment and of the Protection of the Territory and Sea, ISS National Institute of Health, ASL Regional Health Organization, Local and Regional Authorities, IRCCS Specialized Hospitals for Research and Cure (Ministry of Health), Universities, Consortia, Private and public research bodies, Pharmaceutical, biomedical and biotechnological companies, Joint Spin-offs, EMMA (European Mouse Mutant Archive and Data Base) Project – EU (finalized to set up a bio-depository for mouse strains mimicking human, diseases at the Institute of Cell. Biology and Neurological, Monterotondo -RM), National Institutes of Health (NIH), USA (The NIH's Institute of Aging sponsors a project of community genotyping aimed at finding haplotypes of common diseases), INSERM (Institut Nationale de la Santé et de la Recherche Médicale), IMI Innovative Medicine Initiative.

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Molecular Design

The general goal of the Department of Molecular Design (**DPM**) is the development, through the "chemical manufacturing", of innovative functionalities in molecular, macromolecular and solid systems with different level of structural organization. The purpose is to contribute to the innovation in some specific fields such as the development of new molecules with bio-pharmaceutical properties, products and industrial processes with low environmental impact, materials built-up from innovative nanostructures. The Department strategy is focused in three main areas of interest: 1) Health; 2) Sustainability; 3) Convergent technologies.

DPM Projects

1. Design of new molecules with biochemical properties

The general objective of the project, involves the design, realization, characterization and pre-competitive development of new molecules with predetermined biochemical properties, as well as innovative processes within the industrial, medical and pharmaceutical biotechnology.

2. Nano-structured polymeric systems and membranes

Objectives of the project are the development, the advanced characterization and the engineering of macromolecular systems with different levels of structural organization with the aim of developing multi-functional structures designed for sectorial and cross-sectorial applications. The integration of pre-existing competences in the field of synthesis and chemical modification (bulk and surfaces), advanced characterization, design techniques, engineering and processes will be focused to the development of added value materials and the related processes and technologies.

3. Innovative products and processes for sustainable chemistry

The Project is aimed at the intensification of CNR research towards sustainable chemistry, in particular the minimization of waste and the replacement of harmful chemicals, steering the production of environmentally compatible products from renewable resources. Advancement in catalysis is the mandatory tool to reach these goals by enabling processes with low energy demand and low environmental impact improving at the same time their efficiency and selectivity.

4. Nano-organized systems with electronic, photonic and magnetic properties

Integration of the molecular design of nanostructured multifunctional materials together with multiscale fabrication of innovative architectures of novel optoelectronic and photonic devices for next manufacturing and biodiagnostic is the general aim of the Project.

5. Molecular design of thin films and surfaces

The project is related to the strategic field of molecular manipulation aimed at the fabrication of thin films and multifunctional surfaces. The project is focused on the design and synthesis of inorganic and hybrid organic-inorganic multifunctional systems and on the widespread characterization of their composition, morphology and structure up to the testing of their functional performances.

6. Enabling technologies for drug discovery

This Project is in a close and contiguous position with respect to Life Sciences and Materials Science, targeting its achievements into the field of Medical Sciences. The three objectives are:

- Drug Design, Development and Delivery
- Discovery of Targets and Biomarkers
- Study of Systems and Modeling

7. Computational modelling

The most significant motivations are related to the increasingly central position of molecular modelling and computer simulations in connection with:

- the rationalization at the molecular level of material properties;
- the targeted synthesis of innovative products and materials, by means of molecular design;
- the design and optimization of nano-systems for a wide range of applications, ranging from electronics, to catalysis, to the development of (bio)materials endowed with sophisticated features.

Institutes of DPM

IBB Institute of Biostructure and Bioimaging, ICB Institute of Biomolecular Chemistry, ICCOM Institute of Chemistry of Organometallic Compounds, ICRM Institute of Chemistry of Molecular Recognition, ICTP Institute of Chemistry and Technology of Polymers, IC Institute of Crystallography, ICIS Institute of Inorganic Chemistry and Surfaces, IMCB Institute for Composite and Biomedical Materials, IMC Method-

ological Chemistry Institute, ISTM Institute of Molecular Science and Technologies, ISOF Institute for Organic Syntheses and Photoreactivity, ISMN Institute of Nanostructured Materials, ISMAC Institute for Macromolecular Studies, ITM Institute on Membrane Technology.

Institutes participating in DPM activities

ITB Institute of Biomedical Technologies, IBP Institute of Protein Biochemistry, IBIM Institute of Biomedicine and Molecular Immunology "Alberto Monroy", IGB Institute of Genetics and Biophysics "Adriano Buzzati Traverso", IGM Institute of Molecular Genetics, IPCF Institute for Chemical and Physical Processes.

Main National and International collaborations

Ministry of University and Research, Ministry of Economic Development, ISS National Institute of Health, Center for Biomolecular Interdisciplinary Studies and Industrial Applications, Italian Interuniversity Consortium on Materials Science and Technology, Italian Interuniversity Consortium for Colloid and Surface Science, Technological District on Polymeric and Composite Materials Engineering and Structures, FEDERCHIMICA, FINMECCANICA, Local and Regional Authorities, Major Italian Enterprises, all major international & national research centers, universities and companies through the following projects:

NOVELQ (Novel Processing Methods for the Production and Distribution of High-Quality and Safe Foods. Innovative, integrated physical processing and preservation methods through solutions of development problems and performances of relevant strategic basic research); DISC REGENERATION (Novel Biofunctional highly porous polymer scaffolds and techniques controlling angiogenesis for the regeneration and repair of the degenerated intervertebral disc); NANOGLOWA (Nanostructured membranes against global warming; IDECAT (Integrated Design of Catalytic Nanomaterials for a Sustainable Production; NANO-HOST (Homogeneous Supported Catalyst Technologies: the sustainable approach to highly-selective, fine chemicals production; AQUACHEM (Transition Metal Chemistry and Catalysis in Aqueous Media; OLLA (Organic Led for Lighting Applications; OLAS (Organic electrically pumped LASer by engineering of heterostructures in field-effect devices); OFSPIN (Organic-Ferromagnetic Hybrid Interfaces for Spintronic Applications); MAGISTER (Highly porous bioactive scaffolds favouring angiogenesis for tissue engineering); BIMORE (Bio-Inspired Molecular Opto-Electronics; MAGMANET (Molecular Approach to Nanomagnets and Multifunctional Materials); NAIMO (Nanoscale Integrated Processing of Self Organizing Multifunctional Organic Materials); MOLSPINQIP (Molecular Spin Clusters for Quantum Information Processing); EUROGLYCANET (Congenital disorders of Glycosilation: a European network for the advancement of a growing group of rare disorders; NANOSPAD (Protein microarray for enhanced diagnostics at low cost by integration of new technological developments); BACABS (Assessment of Structural Requirements in Complement; MEDIATED BACTERICIDAL EVENTS (Towards a Global Approach to the Selection of New Vaccine Candidates; INSTRUCT (Infrastructure for Structural Biology); PROMET (Developing new analytical techniques and materials for monitoring and protecting metal artefacts from Mediterranean region; EU-VILLAGE (EUropean Virtual Integrated Laboratory for Large-scale Applications in a Geographically-distributed Environment; THETIS (Theoretical Tools for In-silico Spectroscopy); ESF - EUROCORES: Sons 2.

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Production Systems

The Department Production Systems (**DSP**) is the unique scientific initiative generated by CNR that focuses the coordinated efforts of a meaningful number of researchers, belonging to different disciplinary sectors, on the research thematics in the field of industrial process and product.

DSP Projects

1. Processes, industrial production systems, Hi-tech products and advanced materials

The project studied processes that, in the relationship that unites the vertical chains of production, characterize the life cycle of the factory in its main macro levels (machine, cell/system and enterprise) and identify the most important processes (planning, management, reconfiguration) in order to achieve a real, knowledge-based, competitive advantage.

2. Microsystems and embedded devices

The overall objective is to design, build, study and application of innovative materials and systems of interest to the system of national production. Among the topics under development include: high-performance monitoring systems (gas detectors, high-energy radiation, chemical sensors, actuators and transducers, etc.); for applications in mechanical engineering, automation and manufacturing systems, advanced materials for generation and power transmission.

3. Robotics, production and handling systems in weakly structured environment

The project integrates skills related to mechatronics, robotics and automation, and has effects on companies operating in different business sectors with medium-high technologies. The design and development of integrated production systems, machine tools, robots, automation and high tech systems and components for different applications in unstructured environment, for mobile and standing machines. Activities cover the integrated development, material selection, simulation, prototyping, patenting, industrialization and the adaptation to relevant standards of production systems and processes.

4. Tools and methods for management and innovation in technology, energy management and environmental sustainability for construction

The project confronts the realities inherent in the construction industry technologies, systems and materials, both conventional and newly developed, primarily aimed at improving the level of performance and safety of buildings, as well as the optimization of the final uses of energy. One of the most significant cross-cutting objectives concerning the definition of methods and tools for improving the environmental sustainability of energy in buildings.

5. Monitoring systems, safety control in production and user environment; meterials and sensors

Autonomous intelligent systems for monitoring, control and safety applications in specific contexts with the development of design methodologies as alternatives to those currently to meet the needs of innovative application contexts involved.

6. Tourism: open production system

The project addresses the Tourism issue with approach, methodologies, tools and strategies for their scientific research and its technological applications, in order to provide guidance to operators for the unitary and attractive presentation of the tourist Italy.
The innovative approach to tourism is to represent all the components of tourism as a system, highlighting all the entities involved in an organic characterization in terms of product and interconnections and interrelationships, identifying strengths and weaknesses of Tourism. The originality of the approach lies in having taken the production systems of quality as a benchmark for an integrated intervention methodologies for planning, design, management and control of tourist products and processes involved.

Institutes of DSP

IDASC Institute of acoustics "Orso Mario Corbino", IMAMOTER Institute for agricultural and earthmoving machines, IMEM Institute of materials for electronics and magnetism, ISSIA Institute of intelligent systems for automation, ISTEC Institute of science and technology for ceramics, ITC Institute of construction technologies, ITIA Institute of industrial technologies and automation.

Institutes participating in DSP activities

IAC Institute for applied mathematics "Mauro Picone", IMATI Institute for applied mathematics and information technologies, IMCB Institute for composite and biomedical materials, IFAC Institute of applied physics "Nello Carrara", ISTC Institute of cognitive sciences and technologies, ITM Institute on membrane technology, ISMAC Institute for macromolecular studies, IVALSA Institute for tree and timber.

Main National and International projects and collaborations

Universities and Polytechnic Schools, Ministry of Interior, Ministry of University and Research, Ministry Economic Development, Ministry of Cultural Heritage and Activities, Local and regional authorities, CESI - Italian Electrical Experimental Centre, ASI (Italian Space Agency), ENEA (Italian National Agency for New Technologies, Energy and the Environment), INGV - National Institute of Geophysics and Volcanology, UNI – Italian Organization for Standardization, CEI - Italian Electrotechnical Committee, ARPA - Regional Agency for Wastes and Waters, CONFARTIGIANATO

- Italian Federation of Handicrafts, Italian Associations of Category, ENEL - Italian Energy Provider, EDISON s.p.a. - Italian company of gas and energy, Major Italian Enterprises, Definition and realization of hardware/software interfaces for inter-communication between industrial PLC based control systems and PC based simulation systems for the assisted design of control algorithms (project EU VI PQ RIMACS). Design and development of configuration environments of industrial PC based control systems which are based on IEC 61499 standard (project EU VI PQ CEC Shoe). European project "ROM – Network of optics in Mediterranean Countries" (EU INTERREG MEDOCC).

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CNR Institutes

CERIS

Institute for Economic Research on Firms and Growth

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SECTIONS Roma, Milano

Ceris (Institute for Economic Research on Firms and Growth) specializes in applied industrial and managerial economics with focus on industry, innovation and local development. Ceris research staff has strong interdisciplinary competencies and long standing relationships with universities, government departments, public agencies and authorities, regional institutions, chambers of commerce, bank foundations, entrepreneurial associations and firms. Recently Ceris enlarged its research competencies towards the environmental issues and the science policies and new research lines have been successfully activated concerning the evaluation of public policies, the labor market, the agri-food *filière*, the impact of art and culture on the local development. In recent years Ceris has intensified its international liasons by joining European Community programmes (Erawatch, Imera, Equal, Tempus Meda, Ape, True) and European networks (PRIME, ESTO, Gate 2 Growth). Moreover the Institute is involved in several collaborative international projects with foreign universities and research groups.

IAC

Institute for Applied Mathematics “Mauro Picone”

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The IAC, founded in 1927, is the oldest research centre in the world completely dedicated to applied mathematics and the largest one in Italy. Its mission is the development of new models and advanced mathematical, statistical and computational methods, all key tools for innovation in a technology-based society. Significant know-how is present in the fields of differential modelling, fluid mechanics, control theory, statistics, probability theory, computational mathematics and computer science. Important research areas concern image processing (biomedical imaging, remote sensing, cultural heritage), mathematical modelling in biomedical applications (simulation of the immune response to a virus or tumour, data analysis in genetics, models for stem cells, simulation of blood flow), finance (emission of treasury stocks), traffic modelling and complex fluids. IAC collaborates, among others, with the Italian Treasury, the Istituto Superiore per la Conservazione ed il Restauro in Rome, a great amount of Italian and foreign universities and research centers, and the private companies Selex Sistemi Integrati e Octo Telematics.

IAMC
Institute for Marine and Coastal Environment

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SECTIONS Oristano, Taranto, Messina, Mazara del Vallo (TP) e Capo Granitola (TP)

The IAMC deals with issues concerning the marine environment, paying particular attention to the geological, chemical, physical and biological aspects. The areas of interest include the study of marine geology and geophysics, biodiversity of marine ecosystems and biogeochemical cycles, coastal areas and tolerance analysis of marine system to natural and anthropogenic disturbances, biological resources; pre-operational oceanography and ecology and sensory systems of the future conditions of the marine ecosystem, the ecology of coastal ecosystems. Research activities are also carried out within several laboratories and other vessels, modernly equipped with advanced instrumentation for research at sea. The IAMC also analyzes documents on major catastrophic events in historic times, it is engaged in strategic mapping of the seabed in critical coastal areas (port areas, marine parks) and it is involved in projects financed by ministries and public bodies, using modern technology and marine banks data.

IASI
Institute for Systems Analysis and Informatics "A. Ruberti"

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The Institute for Systems Analysis and Informatics "A. Ruberti" (IASI) has the goal of representing, with a logical-mathematical language, behaviour and functions of complex systems, in biology, physics, medicine, economics or engineering. Systems are simulated and optimized by algorithms and computational procedures, allowing forecasting and assessment of strategies. In biomedicine this approach is embodied in translational research, for instance in studies on the pathophysiology of the acutely ill patient and models of the effects of tumour therapy. Another leitmotif topic is the investigation of methods and technologies for knowledge management in information systems of public organizations or private enterprises, in synergy with new Internet technologies (Future Internet). Lastly, IASI has been traditionally involved in transportation problems: it has developed a system for controlling urban traffic through advanced logical programming techniques. More recently IASI is studying models and algorithms for genomics and proteomics. IASI counts collaborations with many prestigious organizations, among which are Università Cattolica del Sacro Cuore, EBRI, the National Institute for Occupational Safety and Health (USA), IEO, ISS, Finmeccanica, TXT e- solutions, IBM Italy, Telecom Italia, FIAT, Agip Petroli.

IBAF

Institute of Agro-environmental and Forest Biology

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IBAF carries out researches on the responses of plant, agricultural and forest ecosystems to environmental constraints with attention to abiotic stresses and global change. Scientific approaches range from molecular genetics, biochemistry, physiology, physiological ecology, agriculture and forestry sciences, adopting an integrated approach for the improvement of the environment by means of sustainable and "green" technologies, and useful plants and organisms such as fungi. IBAF research activity involves the study of abiotic stress, global changes, reduction of pollution and environmental degradation, photosynthesis, microbiology, soil science, biochemistry of pesticides, weed science, tree evolutionary genetic, stable isotopes in plants and the environment, biomass production and bio refinery, food quality improvement and traceability, mitigation of global changes, biodiversity conservation and phytoremediation.
IBAF has long-term collaborations in research projects with Governmental Organisations, (Ministries of Environment, of Forestry Food and Agricultural Politics, of University and Scientific Research, Ministry of Economic Development) Regions, Local Enterprises, Industries, Universities and Research Centres in countries from Europe, America and Australia, but also Asia and Africa. There are also several collaborations with International Agencies (e.g., FAO, IPGRI, IAEA).

IBAM

Institute for Archaeological and Monumental Heritage

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The Institute is involved in research, development, technology transfer and training in the fields of innovative methodologies for the knowledge of ancient landscapes, integrated multidisciplinary approaches for the analysis of the archaeological artifacts, integrated innovative methodologies for the diagnostic focused on the preservation of the architectural and archaeological heritage in the Mediterranean basin, methods and technologies for knowledge and management of the archaeological, monumental and environmental heritage, territory protection and cultural heritage preservation, in relation to landscape evolution and geomorphologic risk factors, multidisciplinary studies on the foundation and the development of ancient Greek town and, finally, archaeology and enhancement of ancient and post ancient landscapes. The scientific staff of IBAM comprehends archaeologists, architects, geologists, computer scientists, engineers and technicians. Some of the major collaborations are with: Italian Ministry of Foreign Affairs; Italian Superintendence for the Archaeological Heritage, Centre for Cretan Archaeology of the University of Catania, Centro de Estudios Arqueológicos Precolombinos-Nasca (Peru), University of Basilicata – post graduate School of Archaeology, Society for the Study of the Crusades and the Latin East of London, Universidade do Porto (Portugal), Ministry of Culture and Tourism of Turkey; Foundation of the Hellenic World of Greece, University of Picardie Jules Verne (France); CISIC-IGE Madrid; Scottish University, Environmental Research Centre of Glasgow, Swedish Institute of Classical Studies.

IBB
Institute of Biostructure and Bioimaging

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The Institute of Biostructure and Bioimaging (IBB), has research expertise both in the development of diagnostic and therapeutic agents, and in diagnostic imaging. IBB has a staff of more than 60 researchers with different expertise such as medicine, biology, chemistry, physics and computer science. The combination of such broad fields of competence produces the interdisciplinary basis to carry out truly innovative research in the field of molecular imaging with great potential for applications in both pre-clinical and clinical settings. Research activities fall within the projects of the Departments of Medicine and of Molecular Design of CNR, and are involved in the project "Bioinformatics" of the ICT Department. Research interests of IBB are placed at the interface between Medicine, Biotechnologies, Chemistry and Imaging Technologies, for which the Institute has developed multidisciplinary competences for transactional research purposes. IBB is focused principally on the innovation of morphofunctional and molecular imaging, which beside having immediate effects on health, is a fundamental tool in medical research to characterize many human diseases, to monitor the effect of drugs and to study animal models of human diseases. In parallel and in synergy, the IBB designs new lead compounds for use in diagnostics and pharmaceutics, with potential effects on health and on quality of life.

IBBA
Institute of Agricultural Biology and Biotechnology

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The main activities carried out at IBBA (Institute of Agricultural Biology and Biotechnology) are in the field of post-genomics dealing with the isolation and the characterization of numerous genes from plants, animals and microorganisms. Genes are studied for their functional role within the cells and are used, when appropriated, for biotechnology. Historical major fields of investigations are those concerning gene expression, protein synthesis and assembly, intracellular trafficking, biodiversity, cell cytoskeleton and plant morphogenesis, citogenetics, and plant transformation. Since few years up to now, IBBA-CNR has developed great interest in the fields of bio-farming, nanotechnology and bioenergy.
The Institute, with headquarters in Milan and branches in Lodi, Pisa and Rome, has numerous partnerships, among them those with Agricultural Research Council, Indian Council of Scientific and Industrial Research, Ciencias Genomicas Center, Universidad Nacional Autonoma De Mexico, University of Postdam in Germany, the Republican Scientific Production Center for Decorative Gardening And Forestry in Uzbekistan and many other foreign universities (Heidelberg, Leeds, California, Glasgow, Copenhagen). Numerous are also the universities and research centers in Italy (Milan, Bologna, Florence, Pisa, Lodi).

IBBE

Institute of Biomembranes and Bioenergetics

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The IBBE is one of the major research centers in the field of Bioenergetics and Biomembranes at national and international level. The main research activities concern the structural and functional characterization of known or newly identified genes and proteins, involved in mitochondrial biogenesis and energy metabolism, particularly the respiratory chain complexes and mitochondrial carriers, the cellular regulation of these systems and their role in cellular homeostasis, the role of mitochondria in cell differentiation and apoptosis and mitochondrial alterations in both hereditary and degenerative aging. More recently, the IBBE research has expanded to issues concerning the "omics" scale, particularly in the fields of Comparative genomics and Transcriptomics by using data generated from new generation sequencing platforms, Bioinformatics and Molecular Biodiversity. Many collaborations have been established with other CNR Institutes and various Italian (Bari, Naples, Calabria, Molise, Milan) and foreign Universities (Barcelona, Manchester, Graz, Rochester), with other research institutions (CNRS) and pharmaceutical companies (Genzyme, Sanofi Aventis).

IBCN

Cellular Biology and Neurobiology Institute

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The Cellular Biology and Neurobiology Institute (IBCN) was created on December 2010 to carry out scientific investigations within the CNR Life Science Department, in particular along the following main themes: first of all genotype-phenotype correlations including behavioral studies, mouse genetics and animal modeling to study mechanisms inducing neurodegenerative, muscular, metabolic, inflammatory and cancerous pathologies. Secondly, the study of molecular and cell mechanisms involved in biological process regulations, like neural and muscular development and differentiation, cell cycle, cell proliferation and neoplastic transformation. Thirdly, production, storage, dissemination and primary phenotyping of murine mutants, models of human diseases (INFRAFRONTIER).
The activities of the Institute, committed to basic research in biological and medical science, include neurobiology, behavioral studies, immunology, genetics, oncology, mainly devoted to explore the molecular and cellular mechanisms of cell functions like the fundamental processes of cell proliferation, cell differentiation and cell death. Particular attention is dedicated to cell growth factors, their relations with membrane receptors and the biological signal transduction pathways with researches carried out on the pathologies of development and differentiation of the nervous and muscular systems.
The Institute hosts the Italian quarter of the European Infrastructure EMMA for the production, functional characterization, preservation, and international distribution of mutant strains such as models of human neurodegenerative diseases.

IBF
Biophysics Institute

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The aim of the Biophysics Institute's research is to understand deeply the structure and functional mechanisms of biological systems in the areas of molecular biology, bioenergetics, biochemistry, genetics, physiology and bioinformatics.
IBF's research explores complementary subjects (proteins, nucleic acids and supramolecular structures in microorganisms, animal and plant cells) using innovative biophysical approaches that go beyond a mere description of biological processes. The Institute also produces applied results such as bio devices and biosensors, and develops innovative processes for biocompatibility tests, pharmacological screening, biomedical signal acquisition and assessment of the environmental impact of biological factors.
IBF has well-established relationships with research institutions at national and international level. The institute collaborates with numerous Italian and foreign Universities such as Strasburg, Zürich, Lausanne, Havana, Sheffield, Berkeley, Yale, Pittsburgh, Sendai and Buenos Aires. It also works with leading research centres such as Istituto Giannina Gaslini, Istituto Agrario S. Michele all'Adige, Institute des Sciences du vegetal in Paris, Instituto de biotecnologia in Cuernavaca, National Institute for Medical Research in London, Russian Academy of Sciences, ESRF in France, Neuroscience Center of Excellence in New Orleans, Centre de Recherche sur l'énergie nucléaire – CEA. IBF also has important industrial partners such as STMicroelectronics, Bionat Italia SrL, Medtronic Italia, Industriale UNIMI.

IBFM
Institute of Molecular Bioimaging and Physiology

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The Institute of Molecular Bioimaging and Physiology (IBFM) exploits a widespread and many-level bio-medical activity research, involving imaging and molecular diagnostic techniques, and spanning from the microscopical aspects up to the full organism. In addition, it provides side approaches to computationally directed strategies. Namely, on this strongly interdisciplinary background, a wide array of techniques is deployed at all levels, bridging molecular diagnostics in neurology and oncology, to cellular and systemic physiology and physiopathology, muscle metabolism and neurodynamics both at experimental and clinical level, granting for a full-blown translational approach from pre-clinical to clinical research and viceversa. IBFM is part of the public-private laboratory LATO (Laboratorio di Tecnologie Oncologiche HSR-Giglio S.C.R.L.)

IBIM

Institute of Biomedicine and Molecular Immunology "A. Monroy"

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Activities: molecular, cellular and morphological studies on embryonic development and mechanisms for differentiation and degenerative processes of eukariotic cells; molecular biotechnologies for characterization of innovative drugs (e.g. anti-allergic) and yeasts for wine making; molecular strategies for adaptation/defence to environmental, chemical, physical, and biological factors of cellular stress (in particular, marine organisms); processes of aggregation, protein misfolding and neuropathologies (e.g. Alzheimer's disease); epidemiology of broncho-pulmonary (and other chronic noncommunicable) diseases and environment; functional diagnostic and clinic of cardio-respiratory alterations during sleep; biology, immunopathology and clinic in lung diseases, especially obstructive; genetics and enzimology of metabolic diseases; mechanisms of neurodegeneration and neuroprotection (e.g. retinopathies and rare neurodegenerative diseases); epidemiology, physiopathology and clinic of renal insufficiency and arterial hypertension. National and international collaborations: Universities (PA, Rome, NA, MI, PI), hospitals (Villa Sofia-Cervello, PA; San Raffaele, MI), specialized institutes (ISMETT and RiMED, PA; Mario Negri, MI), INSERM (Montpellier), CNRS (Bordeaux), King's College of London, University of Southampton, Japan Society for Promotion of Science, EU Cost Action on Sleep Medicine.

IBIMET

Institute of Biometeorology

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Since its establishment in 2000 IBIMET (Institute of Biometeorology) has been active in agriculture and forest research developing its own methodologies and technical means for environmental and socio-economic analyses. IBIMET took origin from the fusion of three Institutes, that for two decades had been working on crop growth modeling, on applied meteorology and climatology, on the development and application of remote sensing and GIS techniques, on plant and crop environmental physiology, on biochemistry and food quality, on forest fires risk and forecasting. In more recent years IBIMET has developed researches on greenhouse gases balance, on climate changes and related adaptation and mitigation strategies, on rural development both in European and in developing countries, on meteo-climatic risks, on sustainable management of agricultural and forest systems, and on multifunctionality both at farm and district level. A recently introduced work field is dynamic climatology for seasonal weather forecast; IBIMET is analyzing, in particular, its possible applications to food security planning, civil protection and crop yield forecast, focusing also on developing countries characterized by arid climates. Since its origin, IBIMET worked in cooperation with National and International Institutions, gaining a position in the International research scene, and promoting the creation of other strictly connected research centers, such as LAMMA for meteorology and environmental modeling, CESIA for informatics application in Agriculture, CiBIC for bioclimatology, COMMA-Med for marine meteorology, CRES for soil erosion studies, PIAN.TE for territorial planning, FCS – Foundation for Climate and Sustainability, and more recently OMA, Observatory for Art and Craftsmanship.

IBP
Institute of Protein Biochemistry

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The Institute of Protein Biochemistry (IBP) started as a centre of excellence in the area of protein structure, function and biocatalysis with a focus on the mechanisms of protein adaptation to extreme temperatures (in thermophilic and polar organisms). This focus has now been extended to research in cell biology and pharmacology, bioimaging and biosensing, with the aim of promoting links between the basic knowledge of protein biochemistry with biomedicine and biotechnology. Collaboration with industrial partners is an essential aspect of the IBP activity. Currently, the IBP organises its research into three main Programmes ("Cellular and molecular pharmacology", "Protein structure, function and biocatalysis", "Evolution and biodiversity in the polar environments") to facilitate interactions among researchers for debating scientific issues, seeking synergies, and planning common scientific and financial strategies. Biotechnological applications in the fields of environmental and agro-food science, biosensing and biomedicine are among the expected outcomes of the programmes. In addition, the IBP runs a training programme for students and predocs (with local Universities) and postdocs. Funds are raised through competitive applications at the national and international level. Numerous collaborative projects are ongoing with national and international partners.

IBPM
Institute of Molecular Biology and Pathology

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The research activities of the Institute of Molecular Biology and Pathology (IBPM) refer to several areas in the life sciences, and use complementary approaches and methodologies. Structural biology studies provide fundamental information on processes like functional control and dynamic properties of proteins, regulation of transcription, degradation and turn-over of biomolecules, signal transduction. On the other hand, genetic-molecular studies allow to define the overall frame of the interactions on the basis of complex biological processes like cell division, differentiation and death, development. The Institute obtained important results in the fields of structure and function of nucleic acids and proteins, protein dynamics and recognition, mechanisms of gene regulation, control of cell differentiation and division. The location of the Institute in the University of Rome Sapienza is strategic, and collaborations between the two Institutions are very active. There are also many joint projects with national (University of Bologna, University of Torino, University of Milano, University of Pavia, University of Parma) and international (Georgia Tech Institute of Technology, National Institutes of Health, Stanford University, Oxford University, Cambridge University, Rockefeller University, International Agency for Research on Cancer, Centro de Investigaciones Biologicas) research centers and universities.

IC
Institute of Crystallography

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The Institute of Crystallography (IC-CNR) merges two souls of Crystallography: the methodological and the experimental ones. Its research activity regards fundamental and applied studies: the development of original crystallographic methodologies and automatic computing strategies to powder, single crystal and macromolecular X-ray diffraction implemented in software useful for molecules of industrial and biopharmaceutical interest, as well as chemistry and structural biology. Furthermore, the IC deals with applied diffraction physics; structural chemistry-based interdisciplinary studies, such as biopharmacology oriented molecular modeling; development of novel biological and pharmacological compounds (antimicrobials, antitumor drugs, etc); characterization of materials of technological interest such as nanocrystals, quasicrystals; instrumentation development by introducing innovative scientific instrumentation in the international market; biosensor fabrication based on photosynthetic proteins, suitable for numerous environment, food and medical applications.
Main IC national and international collaborations, both public and private are Sincrotrone Trieste S.C.P.A., ESR, NIH, ASI, NASA, NIH, Los Alamos National Labs, MPI-Biochemie, Paul Scherrer Institute, University of Leicester, University of Halle, IIT, EBRI, ICGEB, SISSA, Rigaku, Menarini, Biosint, ACRAF Spa, Biosensor.

ICAR
Institute for High Performance Computing and Networking

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The ICAR main goal is to study and design innovative solutions in the research areas of high performance computing systems (computational and knowledge grids, parallel and distributed computing architectures, cloud computing, scientific computing, technologies and tools for future Internet) and intelligent complex systems (large-scale data management, data stream analysis, knowledge representation and discovery, perceptive systems for robotics, intelligent multi-agent systems, multimedia systems, and pervasive e-health).
The scientific contribution of the Institute encompasses very significant research areas for the advancement of society. Indeed, the implementation of models, architectures, and software for distributed and high performance systems based on data and knowledge processing are crucial for reaching the main objectives of advanced and modern societies and show the importance of the scientific mission of ICAR.
The ICAR activities are carried out through the cooperation of the personnel of the main site of Rende and the personnel of the two scientific operative units of Naples and Palermo that run projects and research activities also together with other CNR Institutes and Italian and foreign Universities and research centers such as INRIA, the University of California at Los Angeles, the Politechnic of Vienna, the Cardiff University, the University of Pisa, and the Politechnic of Torino.

ICB
Institute of Biomolecular Chemistry

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The Institute of Biomolecular Chemistry (ICB) is characterized by high uniformity from scientific and cultural points of view and by wide distribution in different branches spread over the national territory. The main branch is located in Pozzuoli (Naples) and other branches are in Catania, Sassari, Roma and Padova for a total of 118 permanent staff. The ICB is involved both in fundamental and in oriented researches in the chemical field. In particular the research fields are: isolation, chemical synthesis, molecular characterization, structure-activity relationship and molecular design of biologically active molecules; innovative chemical methods in synthesis, biosynthesis, purification, and characterization of biologically active molecules; chemistry, biochemistry, and microbiology in application and development of biomasses and compounds of interest in biotechnology and ecology; identification of molecular targets and characterization of markers of biological interest. The researches in the chemical synthesis are devoted to obtaining new molecules of biological interest in different fields, from pharmaceutical, agro-food, cosmetic to sustainable chemistry, etc. The ICB has an important position in national and international research projects concerning chemical biology, molecular design and drug discovery. Moreover the ICB is appealing for foreign students and postdoctoral scholars and, generally speaking, national and foreign visitors.

ICCOM
Institute of Chemistry of Organometallic Compounds

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SECTIONS Pisa, Bari
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The ICCOM (Institute of Chemistry of Organometallic Compounds) carries out its main activity in the field of the energy production coming from renewable sources and fuel cells, polymeric membranes electrolyzers, photovoltaic cells, sustainable catalytic processes for the synthesis of fine chemicals, and polymeric materials and nanocomposites with functional property. ICCOM has an important role within the European Research Institute of Catalysis (ERIC a.i.s.b.l.) seated at the Tuscany Region's premises in Brussels. Furthermore, the Institute carries on the HYDROLAB laboratory's activity for the production and the hydrogen storage, and it keeps continuous relations with the Tuscany and Puglia Regions.
Within the 2011, the Tuscany Region will fund two innovative projects of which, the first one will concern the development and the synthesis of new organic sensitizers for the production of non conventional photovoltaic cells and the other one will be related to the study and the definition of procedures of Micrometrologia for Field Emission Electric Propulsion (MI.ME.FEEP). The Institute has also active contracts with many industries, with Governative Bodies and with the European Commission. Finally, ICCOM has operative contracts called PIRODE and "INDUSTRIA 2015", the first with the Ministry of Environment and the second with the Ministry of the Economic Development. Furthermore it coordinates, within the 7th Framework Programme, the European Project Marie Curie NANO-HOST (Initial Training Network) about the sector of the catalytic technologies through the heterogenization of single site catalysts.

ICEVO
Institute for Aegean and Near Eastern Studies

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The main research area of ICEVO (Institute for Aegean and Near Eastern Studies) is the basin of the Aegean Sea, the Near East and, in general, the Mediterranean Sea. Research activities focus on the reconstruction of the history of the ancient Mediterranean civilizations, mainly those of the Bronze Age (3200-1000 B.C.), using traditional historical approaches, new technologies and archaeometric analyses. ICEVO concentrates on archaeology and philology, therefore on the study of sites, graveyards, finds, texts and transcriptions of the Minoan and Mycenaean cultures and of those of Anatolia, Syria, Armenia and Iran. Part of the research involves the online publication of cuneiform texts of the 2nd millennium BC written in the language of the Hurrites, an almost unknown ancient population. ICEVO is the most important centre in the world for this branch of studies. Many are the relations and the collaborations with international research institutions and Italian and foreign universities. The most significant are those with: Harvard University; Institute for Aegean Prehistory, Philadelphia; Chicago Institute; British and American Schools at Athens; Greek and Turkish Culture Ministries; Freie Universität and Deutsches Archäologisches Institut at Berlin; Akademie der Wissenschaft und Literatur, Mainz; Musée du Louvre; Institut Catholique de Paris; National Academy of Sciences, Yerevan; Iranian Centre for Archaeological Research.

ICIB
Institute of Cybernetics “Eduardo Caianiello”

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The Institute of Cybernetics "Eduardo Caianiello" carries out research in the fields of Cybernetics, Physics, Information Sciences, Neurosciences and Biology. More specifically, its researches are focused on the following sectors: physics of coherent systems and superconducting devices, advanced information systems, natural and artificial systems' models. Furthermore, the institute develops innovative technologies, advanced devices and instrumentation prototypes. It had developed several collaborations with multiple foreign and Italian universities (Illinois, Yale, Cambridge, Madrid, Israele, New York, San Pietroburgo, Losanna, Dublino, Napoli, Salerno, Roma, Cagliari, Chieti, Milano, Palermo, Bologna); institutions and centers of scientific research (Russian Academy of Sciences, CNRS of Grenoble, INTAS - Lingby, Institute of Biocybernetics and Biomedical Engineering - Varsavia, Accademia delle Scienze - Praga, Max-Planck Institute, Belarusian Academy of Sciences, INFN, Stazione Zoologica A. Dohrn di Napoli); local and national public institutions and enterprises (ANSALDO CRIS, AtB-Advanced Technologies Biomagnetic, COMEFI, Pirelli Labs, PROMETE, COSMO FILM, SmithKline Beecham Pharmaceuticals).

ICIS
Institute of Inorganic Chemistry and Surfaces

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The research activities concern design, original synthesis and characterization of molecular compounds as well as materials including nanocomposite systems applied to the areas of the sustainable chemistry, health and quality of life. In particular, the activities are dealing with: the optimization of innovative materials and deposition processes from vapor phase for the production of thin films aiming at improving the efficiency of: fuels and photovoltaic cells, protective coatings and multifunctional self-cleaning and anti-fouling films able to recognize and destroy polluting and corrosive agents; the synthesis of new molecules containing metal ions as potential agents, in diagnostic: SPECT (99mTc), PET (64Cu) and MRI (Mn, LIS-reagents); in radiotherapy (188Re and 64Cu) and in oncology (Cu). Other additional research activities are focused on the development of suitable monitoring and maintenance procedures for the conservation of Cultural Heritage and on the environmental investigation of aquatic systems and other environmental matrices through radiochemical methods.
The Institute has important relationships and collaborations at both national and international level, with University Departments and Research Institutes. In particular with UNESCO, Institute of Inorganic Chemistry of the Russian Academy of Sciences, Universidade do Estado de Santa Catarina and Harvard Medical School.

ICRM
Institute of Chemistry of Molecular Recognition

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ICRM (Institute of Chemistry of Molecular Recognition) carries out research, technological development and training activities in the following areas: 1) biomolecules; 2) chemical biotechnologies; 3) mechanisms of bioregulation. The unifying theme of ICRM activities is the chemistry of molecular recognition, that can be defined as a multidisciplinary area which studies the principles and strengths that regulate and determine biospecificity and biorecognition at the molecular level. The area involves expertise in organic, bioorganic and computational chemistry, biochemistry and biotechnology. Advances in these fields are helpful for the discovery of innovative compounds and materials, as well as of new biotechnological methods to be applied in the pharmaceutical, diagnostic and food fields. Keywords describing the activity of ICRM scientists are: biocatalysis, structural biochemistry, bioinformatic, analytical microsystems, proteomics, dynamics and folding of peptides and proteins, bioactive natural compounds.
ICRM headquarters are in Milano and two U.O.S belong to the Institute, located respectively at the Policlinico Gemelli (Università Cattolica) in Rome and at the Department of Chemistry (Politecnico) in Milano. ICRM scientists are members of several International networks, with established collaborations with research centers and Universities in Italy, Europe, North America and South Africa.

ICTP

Institute of Chemistry and Technology of Polymers

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MAIN SECTION Pozzuoli (Naples)
SECONDARY SECTION Catania

The ICTP in Pozzuoli operates in the area through an organized network supporting collaboration between firms and research. Thanks to the technology transfer office it offers companies the possibility to request for technology not appearing in the market and for solutions to technical problems, the possibility to offer and ask for partnership for projects, and, mainly, it always puts companies in touch with consultant experts on the requested technology. The research groups are set up like spontaneous unions of research, technologists and technicians on specific projects and they are fundamentally dynamic structures with the most innovative scientific equipment. The ICTP's research activities are divided into the following lines within the internal department of molecular planning: 1.Synthesis of Polymer and the planning of Innovative Polymeric systems to raise performance for the Eco-Sustainable Development; 2.Correlation structure-properties and Innovative methods for the characterization of polymeric materials; 3.Development and characterization of natural and synthetic biodegradable polymeric materials. ICTP keeps strong relationship with universities, firms and National and International research centres (University of Massachusetts, Polish Academy of Sciences, University of Dublin, University of Georgia, Slovak Academy of Sciences, Hungarian Academy of Science, Fachhochschule Osnabrück Fachbereich Werkstoffe und Verfahren, Department of Chemistry of the University of Tennessee, Institut für Technik in Gartenbau und Landwirtschaft).

ICVBC

Institute for Conservation and Promotion of Cultural Heritage

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SECTIONS Milano, Roma

The main activity of ICVBC (Institute for Conservation and Promotion of Cultural Heritage) is dedicated to scientific methodology for conservation and valorization of cultural heritage. The institute develops new methods for diagnostic purposes always less invasive and easy transportable. At the same time the ICVBC develops new materials for the conservation and restoration of cultural properties. Researches concern new materials able to be employed in the different steps of conservations such as planned maintenance, restoration, preventive conservation. The cultural heritage is evaluated in the environment where it is placed and sometimes the evaluation of the environment where the cultural heritage is placed is itself object of evaluation. Thanks to the presence of experts in different fields of conservation and several years of activities, the ICVBC cooperates with many local, national and international organisms liable for protection, conservation and valorization of cultural heritage and with private organisms and firms working in the field of conservation and restoration of cultural heritage. Among these must be cited "Opificio delle Pietre Dure", "Soprintendenza ai Beni Archeologici della Toscana" and the "Soprintendenza al Polo Museale" in Florence; "Istituto Centrale Superiore del Restauro" in Rome; Italian Universities of Florence, Pisa, Roma, Torino, Milan, Parma and Varese, several foreign universities and research centers among which Nova University of Lisboa, Weizmann Institute of Science of Rehovot (Israel), North Caroline State University (USA), Netherland Institute for Cultural Heritage of Amsterdam. Finally the ICVBC cooperates with many domestic and international enterprises such as Geal srl - Pistoia, Lapi Chimici srl, Menci Software and HESP Technology in Arezzo, SINT Technology and Colorobbia in Florence.

Centre of Scientific Activity **IDAIC**

Institute for International and Comparative Agricultural Law

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The Institute for International and Comparative Agricultural Law (IDAIC) represents the prosecution of the Italian Observatory of Agricultural Law (OIDA) established in 1936 following up the activity begun in 1922 with the publication of the first issue in the Agricultural Law Review. After the merger of the IDAIC into the CNR, IDAIC is still characterized by: a strong specificity (the study of the agricultural law system with its economic, cultural, social and political implications); a broad international character (frequent relations with experts of law of agriculture in foreign Universities; the presence of foreign students in Florence at the IDAIC for studying); an organization of annual meetings (on problems related to law and economy of the agricultural system, environment protection and food safety). The results of the IDAIC can be listed as follows: the edition of quarterly journal of the Agricultural Law Review; the annual publication of one or more volumes; the teaching of the law concerning the agricultural, food and environmental system (a lessons course for the functionary staff of the Ministry for Agriculture, Food and Forestry); the organization of a library about 14000 catalog numbers (whose titles are visible on the website: www.idaic.it) and 207 titles of magazines, the most complete library in the world for the agricultural texts of law.

IDASC

Institute of Acoustics and Sensors "Orso Mario Corbino"

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Since its founding in 1936 the Institute of Acoustics and Sensors "Orso Mario Corbino" (IDASC) of the CNR, based in Rome, is a public reference for the development of the national and international Acoustic Science in the air, in water, materials, geophysics, and for the Sensors - micro and nano. It is among the Public Institutions of reference of the Ministry of the Environment and the system of Regional Agencies for Environmental Protection (ISPRA). The branch of SENSOR Lab in Brescia, designs and develops materials and processes for advanced devices and systems. SENSOR is widely recognized at international level as one of the most influential and active laboratories in the field of gas sensors based on metal oxide semiconductors and in the preparation of quasi-one-dimensional oxides as functional materials. The IDASC participates in national and international research projects such as PON, PNRA, Cultural Heritage, EU, NATO, etc. Many collaborations are with Italian and foreign Universities and Institutions. It is also a large activity conference organization. Since 1972 it is the head office of the Italian Association of Acoustics (AIA), that with 350 members connects the Italian community of acoustics; since 1977 it publishes the quarterly Italian Journal of Acoustics (ISSN 0393-1110). The Institute, since 2005, is head office of the International Group ICES.

IDPA

Institute for the Dynamics of Environmental Processes

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SECTIONS Milano, Padova, Dalmine (BG)

The Institute for the Dynamics of Environmental Processes (IDPA) operates in various areas characterized by different anthropogenic and natural phenomena, and carries out research on the processes of global change on a local and planetary scale. The Institute's mission is to contribute in an original way to the understanding of the evolution of the environment, by looking at it as a whole system in dynamic equilibrium characterized by physical, chemical, geological and biological processes. This is done by carrying out basic and applied research at high level of scientific consultant activity to companies and public bodies. The themes studied are pollution and chemical contamination of the environment, characterization of contamination processes that affect ground water aquifers, pollution in the work place and education establishments, the causes and dynamics of civil and forest fires, the evaluation and conservation of cultural heritage. The IDPA investigates geological systems with particular reference to geodynamic evolution, georesources and multiple risk assessment. The Institute also conducts scientific research in Antarctica, Arctic, Greenland, Kilimangiaro, Everest-K2 in the paleoclimate sector, as well as studies on the spread of contamination in built up areas, evaluating the impact of human activities on the environment and proposing remediation strategies.

IEIIT

Institute for Electronics, Information and Telecommunication Engineering

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SECTIONS Bologna, Genova, Milano, Padova, Pisa

IEIIT (Institute for Electronics, Information and Telecommunication Engineering) carries out advanced scientific and technological researches in the area of Information Engineering covering fields of telecommunications, computer and systems engineering, applied electromagnetics, electronics, control and systems. The activities are carried out in cooperation with several national and international research institutions and academia. Advanced researches at IEIIT are based on experience and know-how developed by its staff in more than 30 years of scientific activity carried out in the ICT domain. Most researches are performed in the framework of scientific projects supported by national and international institutions, medium and large enterprises, and involve the cooperation of a significant number of professors and researchers working with universities where the Institute sites are located. IEIIT results concern experimental soft products (simulation models, design methods, synthesis techniques) and hard products (new architectures of devices, sensors and systems) characterized in the IEIIT laboratories and useful for industrial applications, telecommunications, terrestrial and space scientific observations. The engineering approach adopted in the IEIIT research activities is particularly beneficial for the technological transfer and cooperation with firms.

IENI

Institute for Energetics and Interphases

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The Institute for Energetics and Interphases (IENI) is characterized by a rich and interdisciplinary background in material science. In Padua and Pavia, sites with a deep electrochemistry background, the research is focused on ceramics and polymers in bulk or thin film for various devices (i.e. electrolyzers, Solid Oxide Fuel Cells – SOFC) together with thermoelectrics, innovative nanomaterials for batteries or supercapacitors, (electro)catalysts and nanofluids for enhanced heat exchange. Electrochemical impedance spectroscopy techniques are also intensively studied and applied in many materials science topics. IENI site in Lecco is one of the few centers in Italy committed to advanced metallurgy, where shape memory alloys, thermoelectric materials, metal foams and composites are studied and applied in the fields of energy and transportation. The IENI laboratories in Milan are devoted to the study of mechanical and micro-structural behavior of high performance materials in extreme conditions, the dynamics of fluids in combustion engines or in industrial burners and innovative diagnostics based on laser spectroscopy, useful for assessing the environmental impact of smoke and dust. The research group in Genova develops functional nanostructured ceramic materials useful in the production and recovery of energy or in electronic devices, and studies the properties of molten alloys in contact with other metallic and ceramic materials and the role of nanoparticles and surfactants on emulsions, on wetting, and their environmental impact. The IENI activities are carried out in collaboration with many international institutions and companies, including CNRS (LISE), Europea Microfusioni Aerospaziali, Ansaldo Energia, Enea, Univ. Berkeley, Ecole des Mines (ENSMP), ESA, Max-Planck Inst. for Colloids and Interfaces.

IEOS

Institute of Experimental Endocrinology and Oncology "G. Salvatore"

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The research activities of the Institute of Experimental Endocrinology and Oncology "G. Salvatore" (IEOS) are carried out in the areas of oncology, endocrinology and molecular pathology. In particular, the Institute is internationally recognized as a scientific excellence for its research achievements on endocrine cancers, differentiation and proliferation of thyroid cells, on the pivotal role of specific proteins in the process of cancer progression and in the onset of pituitary adenomas, on the molecular mechanisms causing the type 2 diabetes aiming at the identification of new genes involved in the disease. Over time, the IEOS contributed to provide new perspectives in diagnosis and therapy and recently it potentiated the studies on non-coding RNA, that are considered as a new class of regulators of gene expression with an important role in cellular differentiation and cancer development.
Research projects ongoing at the IEOS are supported by grants from AIRC, Telethon, Regione Campania, Unione Europea and MIUR. In addition, the Institute has several international collaborations, such as those with the Kimmel Cancer Center, Philadelphia Jefferson University, Ohio State University, Leon Berard Centre in Lyon, CNIO in Madrid and the NIH in Bethesda. Moreover, the Institute, together with some of the above-mentioned research centers, coordinates an international PhD program in Oncology.

IFAC
Institute of Applied Physics "Nello Carrara"

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The main goal of IFAC (Institute of Applied Physics "Nello Carrara") is the interdisciplinary study of novel applications of physical methods, such as photonic devices for communications, space-grade instrumentation for satellite payloads, balloon-borne and avionic instrumentation for Earth observation, digital solutions for e-access, biophotonics for therapy and surgery, laser techniques for industry material processing, optical sensors for environmental control, techniques and diagnostics for archaeometry and conservation of cultural heritage. The research follows theoric, experimental and applied approaches, with a strong attitude to develop new techniques and innovative prototypes. The institute is committed to pursue advanced research at international level, as well as technology transfer to the economy and production system. In fact IFAC cooperates with a number of high-tech enterprises mainly by means of regional projects. Presently IFAC carries out 15 international projects, 13 national projects, 9 projects by the Tuscany Region and 21 between contracts and conventions. The European projects POP ART, CHARISMA, LIGHT+TER, PHOTONICS4LIFE, SIOS, CARDIAC, e-ACCESS support the activities in the sectors of cultural heritage, biophotonics, climate, earth's observation and access to information, while the ESA projects COREH2O, SMAD, PREMIER, KLIMA, MIPAS, DOMEX-2 support the activities about remote detection, satellite instrumentation and research in Antarctica.

IFC
Institute of Clinical Physiology

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SECTIONS Milano, Massa Carrara, Lecce, Siena, Roma

The Institute of Clinical Physiology (IFC) comprises 450 personnel units (including 25 PhD students) with 94 tenured researchers (including 29 biologists, 22 physicians, 13 engineers, 12 epidemiologists, 6 chemists, 5 physicists, and 5 biostatisticians). In 2010, IFC attracted about 9 million Euros of contracts (12 from Framework Program 7 of European Union) and published 180 articles in international peer-reviewed journals (average impact factor 3.6). Headquarters are at the CNR Research Campus in Pisa (Italy) and two-thirds of the staff work there, while the rest are located in the detached units operating in five other Italian cities: Massa, Milan, Rome, Lecce and Siena. The four areas of knowledge (clinical-experimental medicine, molecular medicine, technosciences, and epidemiology) focus on a complementary way, from bench to bedside to population, on three main areas of interest: atherosclerosis; heart-lung failure; environmental medicine and public health.

IFN

Institute for Photonics and Nanotechnologies

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SECTIONS Roma, Trento, Padova, Bari

The Institute for Photonics and Nanotechnologies (IFN) carries out innovative research in the fields of photonics and of nanotechnologies considering both the fundamental aspects related to radiation-matter interaction and those applied involving development of new technologies for the realization of novel photonic devices, optoelectronic systems, and electronics devices.
These studies have significant implications in several key sectors for the economy and improving the quality of life such as, for example, material sciences, medicine, biology, environmental monitoring, broadband telecommunications and cultural heritage. In particular, activities are carried out on the interaction of the matter with extremely high intensity and ultrafast radiation, on lasers physics, on the development of advanced processes for micro-and nano-optoelectronics, and on the development of optical diagnostic techniques from the mid-infrared to X-ray for biomedical, cultural heritage, and space applications.
IFN is tightly integrated with the national scientific community and collaborates with the major international Universities and research centres through targeted projects funded by the main national and international agencies and foundations.

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The Plasma Physics Institute (IFP) is traditionally involved in research activities in the field of Thermonuclear Fusion and has acquired an internationally recognized expertise in the physics and technologies of high power electromagnetic (EM) wave heating of magnetically confined plasmas, based on the resonant wave-particle interaction at the electron cyclotron frequency (ECRH). IFP is a Research Unit of the EURATOM-ENEA-CNR Association on Fusion and as such is actively committed in the design and construction of the experimental prototype of fusion reactor ITER. The competences developed in the last twenty years in the field of millimeter-waves (MMW) allow IFP to participate, in collaboration with other EU laboratories, to the design and implementation of scientific instrumentation with a high technological content for ITER: e.g., the bolometric dummy loads for high power (up to 2MW), high frequency (170GHz) EM radiation, the ECRH Upper Launcher and its automatic control system, the EC beam combiner, the plasma position reflectometer and MMW components for the ICRH antenna. IFP has also a long standing experience in other fusion fields. i.e., in the physics of the wave-plasma interaction and of the energy and momentum transport in magnetized plasmas, and in the design, installation, and operation of innovative fusion plasma diagnostics. IFP closely collaborates with several EU laboratories: ENEA-Frascati, RFX-Padua, IPP-Garching, CRPP-Losanna, JET-UK. Finally, IFP has two magnetized plasma devices, with a cusp and a linear magnetic field configuration, respectively, which are used to investigate basic plasma processes and to train young researchers; several RF plasma reactors and a micro-torch for thin film deposition on various substrates; a surface laboratory for material characterization.

IFT
Institute of Translational Pharmacology

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Research activities of the Institute of Translational Pharmacology (IFT) focus on mechanisms of insurgence of human disorders, particularly of neoplastic, immuno-degenerative, infective and neurogenetic diseases, and on the development of innovative preventive/therapeutic strategies, also based on interdisciplinarity and 'translation to clinic'. Research topics of the Institute include: promotion of synergisms for studying molecular targets for diagnosis and therapy; development of biomarkers and pharmacogenetics; innovative therapeutic strategies and development of drug discovery and drug delivery platforms. The final goal is to apply the knowledge acquired for developing new technological platforms implementing the current diagnostic, preventive and therapeutic tools. Particular competence resides within the "drug discovery" and the study of new chemical entities for different therapeutic areas and in the regulatory science related to them. One of the leading expertise is the setting up and validation of new models useful for pre-clinical experimentation.
The Institute is part of a network of national and international researches, it has a number of agreements and collaboration with universities and institutions related to public health and cooperates with pharmaceutical companies committed to technological innovation.

IGAG
Institute of Environmental Geology and Geoengineering

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The institute of Environmental Geology and Geoengineering (IGAG) has its headquarters in Rome, at Roma1 Search Area - Montelibretti, Via Salaria Km 29,300, Monterotondo. In Rome it has two further seats at the Department of the Earth Sciences and Hydraulic, Transports and Roads of the University "La Sapienza." Other two seats are hosted at the Department of Geoengineering and Environmental Technologies of the University of Cagliari and at the Department of Georesources and Territory of the Polytechnic in Turin. The institute is therefore strongly rooted in the Universities with which has fruitful relationships of collaboration. Its staff comprises over 150 people among researchers, technicians and administrative personnel, of which 70 university associates. The main institutional research topics are: baseline and applicative studies concerning the recent planet history; geology of hydrocarbons, identification and exploitation of the mining resources and the geologic materials; mitigation of manmade risks and natural risks (seismic, volcanic and landslides); evolutionary geological, geomorphological and tectonic models of continental, coastal and marine areas; excavation and stabilization technologies, related to the health and safety at work, physical and mechanical characterization of rock amasses, surveys and monitoring of land-slide.

IGB

Institute of Genetics and Biophysics "Adriano Buzzati Traverso"

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The genetic research at the Institute of Genetics and Biophysics "Adriano Buzzati Traverso" is carried out with an integrated approach to morphological and molecular studies of biological macromolecules (DNA, RNA and proteins) in model organisms (prokaryotes and eukaryotes). Research activities are conducted within the fields of genetics and molecular biology, pathogenesis of human diseases, stem cell biology and biotechnology applied to agriculture and to the environment. The IGB can count on efficient and advanced laboratory facilities in its location in Naples. The multidisciplinary and expert personnel, the technologies and the scientific achievements contribute to make this Institute a leader in the disciplines of life sciences. The IGB also works to promote and disseminate scientific culture in Italy and abroad and collaborates with a number of important national and international partners such as the European Union, the European Science Foundation, the Ministry of Education, the National Institute of Health, the AIRC and Telethon. The Institute has a great amount of contacts with research groups from Austria, Canada, Denmark, Finland, France, Germany, Greece, England, Israel, Mexico, Panama, Spain, Sweden, Switzerland and USA. A consequence of this extensive network of partnerships and cultural exchanges with other laboratories gives the possibility to young researchers of IGB to interact and be trained within a group of internationally renowned scientists.

IGG

Institute of Geosciences and Earth Resources

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The Institute of Geosciences and Earth Resources (IGG) conducts research aimed at defining the temporal and spatial variations of the structure and composition of the various components of the Earth system, from the mantle to the atmosphere and the use of natural resources for a sustainable development. The researches in the fields of geology, geothermal energy, hydrogeology, geochemistry and mineralogy of the Institute are facilitated by an important analytical platform allowing applications of the knowledge acquired to assess the dynamics of the Earth system, as well as environmental applications to water resources, soil pollution, agri-food traceability, cultural heritage, global and climate changes. Other researches are aimed at optimizing the exploitation of the geothermal resource to produce electricity for domestic and industrial uses. The IGG collaborates with numerous Italian and foreign universities, with some ministries (Environment, Foreign Affairs, Cultural Heritage, Economic Development), several local government and Public agencies (APAT, Civil Defense, some ARPA) and private companies (Snam Progetti Spa and Enel SpA). Finally, the IGG is involved in projects coordinated by the National Research Project Antarctica, the National Group for Hydrogeological Disasters Defense, UNESCO, IAEA, ESA and the European Community.

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IGI
Institute of Ionized Gas

Institute of Ionized Gas (IGI) operates in the field of Controlled Thermonuclear Fusion (CTF).
Research activities at IGI are performed within the RFX Consortium whose members are CNR, ENEA, INFN, University of Padova. All R&D activities are fully integrated in the International, European and National programs aimed at the realization of ITER, the international project for the demonstration of physical and technological feasibility of CTF, and at the general advance in Physics and Technology of CTF. Among these activities the most relevant are: firstly, development and realization of the first Neutral Beam Injector for ITER and of the related Test Facility to be built at the CNR Research Area in Padova aimed to install, test and optimize the system before operation in ITER; secondly, operation of RFX, the largest and most performing (in terms of current, pulse length and active control system) experiment aimed at studying hot plasmas confined in Reversed Field Pinch magnetic configuration; thirdly, in the framework of EU-Japan "Broader Approach" agreement, realization of the power supply for protection and control of the magnetic system in the experiment JT60SA under construction in Japan; and finally, participation to the design of magnetic sensors and Laser diagnostics (LIDAR system) for ITER.
IGI has a significant commitment in student education and qualified expert training at National and European level.

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IGM
Institute of Molecular Genetics

Research at the Institute of Molecular Genetics (IGM) mainly concerns the fields of molecular genetics and biology of normal and pathological human cells, together with their biotechnological applications. In particular, the main research topics developed at IGM are: mechanisms of proliferation and death in human cells; DNA replication in mammalian cells; viral replication processes; molecular basis of genetic disorders: DNA repair and transcription syndromes, X-linked diseases, laminopathies and muscular dystrophies; maintenance of genome stability and cellular transformation; post-transcriptional regulation of gene expression during cell response to stress and tumor progression; genetic structure of human populations. Biotechnological applications mainly concern the development of instruments, techniques and protocols for in vivo and in vitro optical imaging, useful for biomedical applications and the visualization of complex biological processes, identification and development of new compounds with therapeutic properties, development of new therapeutic approaches for muscular dystrophies using muscle cells obtained from dystrophic patients and stem cell models. Several national and international collaborations are active in the Institute, as documented by EU grants and IGM participation to the EU network of excellence on alternative DNA splicing.

IGP
Institute of Population Genetics

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The Institute of Population Genetics (IGP) since 1995 leads a research project to identify genetic and environmental risk factors of the most common diseases in humans and to define individual predisposing profiles and response to drugs in order to enable more efficient prevention and treatment. For this goal, the IPG studies ancient populations of isolated villages in the Ogliastra area, considered "an island in the island of Sardinia", characterized by genetic homogeneity among the highest in the world due to their few ancient founders, different between villages, and impressive endogamy. The IPG in collaboration of its spin-off Shardna has created a multidisciplinary database with historical, demographic, clinical, epidemiological, genealogical and genetic information concerning 14000 individuals coming from ten villages and a corresponding Biobank (DNA and serum). This technological platform is one of the most relevant in the field of genomic medicine in genetic isolates. Innovative statistical analysis of these complex data helped to identify many genes and genomic regions associated either with disorders such as obesity, diabetes, hypertension and abnormal lipid profile or endophenotypes related to them. Many of these genes are promising pharmacological targets and effective diagnostic biomarkers. Many of our findings, although obtained in a relatively small number of people, have been confirmed in open populations studied by large international consortia, many of whom saw our participation. The success of our approach is due to the enthusiastic participation of the population whose local governments have created a consortium, Ogliastra Genetic Park, a model for similar initiatives in Italy and worldwide.

IGV
Institute of Plant Genetics

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The IGV (Institute of Plant Genetics) has multidisciplinary advanced competences for the: collection, analysis, management and use of plant genetic resources; study of genetic and epigenetic variation; construction of genetic maps; control of meiotic recombination; search and characterization of genes and transcription factors involved in metabolism, in sexual and apomictic reproduction, in plant-environment interaction and in all processes with applications in the food and pharmaceutical fields; isolation and study of microRNAs; genomic and bioinformatic analyses. The IGV manages the first and largest Italian plant genetic bank and aims at the development of knowledge and diffusion of conventional and innovative technologies useful to face and solve problems in the agro-food field, and to propose adequate solutions to improve people's quality of life.
IGV collaborates with European and extra-European institutions, such as the Leibnitz Institute of Plant Breeding (Germany), the John Innes Centre (UK), the CSIC (Spain), the network of CIHEAM Institutes, the University of Wisconsin and Purdue (USA), the Agricultural Research Organization (Israel). The IGV also collaborates with Italian universities, organisms and institutions: ENEA, CRA, Istituto Agronomico Mediterraneo, Ministry of Agriculture, Ministry of Education, University and Research, Regions and other local communities.

IIA
Institute of Atmospheric Pollution Research

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The research activity of IIA is in the field of atmospheric pollution in urban, industrial and rural areas as well as in remote areas including the polar regions. IIA is active in major international, European and national research networks of excellence and is primarily funded by national and international private and public institutions including the EC, Italian governmental bodies (i.e., Italian Ministries of Research, Environment, Defense, Foreign Affairs), regional governments in Italy, the CNR and private institutions. Within projects funded by national and international institutions, experimental campaigns have been carried out, in collaboration with leading European and North American universities and research institutes, in the Antarctic and the Arctic as well as in the Mediterranean Sea region (aboard the CNR oceanographic R.V.Urania).
Several European Research Projects have been started in 2010, among which the GMOS (www.gmos.eu) and the OFFICEAIR projects funded within the 7th FP, and the EXPAH Project within the LIFE+ Program.
In terms of technology transfer the IIA provides technical and scientific support to private and public institutions; during the last decade there have been leading projects aimed to develop air quality monitoring infrastructures in the Balkans and in China, just to cite few the Beijing Olympic Village in 2008 and the World Expo in Shanghai in 2010.

IIT
Institute for Informatics and Telematics

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The Institute for Informatics and Telematics (IIT) of CNR carries out research, development, technology transfer and training in the field of Information and Communication Technologies and of Computational Sciences. In line with the strategy of the EU Framework Programmes, IIT very naturally and clearly has its sight set on the Internet of the Future.
In IIT, research and applications are integrated synergically, promoting the development of added value services for the Internet of the Future. This approach contributes substantially to the self-funding of the research activities carried out by the institute. The number and quality of IIT scientific publications, along with its participation in relevant research projects at European and international levels, testify to the pre-eminent role assumed by IIT in research and development areas such as the "Internet of things" and "Internet of services". These range from high speed, mobile and pervasive telematic networks to issues of security and privacy, to innovative Web technologies, and also include new ICT issues relating to Internet governance.
IIT, through the Registry .it, is responsible for managing .it Internet domains, a crucial activity for spreading Internet culture in Italy.

ILC

Institute for Computational Linguistics "Antonio Zampolli"

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The Institute for Computational Linguistics "Antonio Zampolli" (ILC) is involved in research activities in the Humanities Computing since 1967. It implements systems in order to process huge amount of texts for: linguistic and lexicographical analyses; important scholarly editing digital sources from a cultural point of view, taking into account also the images; extracting semantic and ontological information from linguistic resources. These searches proceed alongside a linguistic computational sector, designed to develop systems, models and methods for natural language processing. The ILC is a partner of "Greek into Arabic" advanced grant ERC-Ideas", providing a contribution with its computer-assisted philology systems. The outcome and development obtained have made it possible to set up important relations with industrial companies as well as prominent national and international groups. The main collaborations are those with the European Commission, the Digital Renaissance Foundation in Florence, the European Science Foundation in Strasburg, the Fundação para a Ciência e a Tecnologia in Lisbon, the Consejo Superior de Investigaciones Científicas in Madrid, the Pushkinskij Dom Russian Academy of Sciences in St. Petersburg. A LEA (Laboratoire Européen Associé) will also be set up with the French CNRS.

ILIESI

Institute for the European Intellectual Lexicon and History of Ideas

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The Institute for the European Intellectual Lexicon and History of Ideas (ILIESI) is dedicated to the history of cultural and scientific terminology. It investigates several epochs under the assumption that at the root of the history of philosophy and of the sciences and more generally of the history of ideas lie textual corpora that have been developed within each discipline over the centuries. It considers technical uses and ambiguities, synchronic and diachronic inter-relations, translations and transpositions across lexical fields. ILIESI focuses on the phenomenon of migration, which accompanies the history of civilizations due to the continuous relations and reciprocal exchanges among diverse cultures, and thus translations of texts and methods. Hence the focus on individual terms and lexical families, the publication of lexicons, indices and concordances, the setting-up of databases and scientific data processing applied to technical terminology. Its current lines of research embrace the history of cultural terminology in connection with the Greek, Latin, Hebrew and Arab tradition, the history of Ideas, ICT methods for textual analysis. Agora (ICT Policy Support), Open Scholarly Communities on the Web (Cost Action 32), and PHerc (ERC Starting Grant) are the EC projects it is now hosting. ILIESI is partner with philosophers, historians of science and linguists all over Europe and the US and with research teams of the CNRS, CSIC, CNPq, MPI and the Library of Congress.

IM
Motors Institute

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The IM research activities are mainly aimed to improve the internal combustion engine efficiency and the pollutant emissions. Relevant themes are: study and optimization of combustion systems also by means of optical diagnostics and advanced computing, fuel engine interaction, reformulated fuels and bio-fuels, automotive components for a proper design and control of the combustion process (VVA, ionization sensors), fuel cells propulsion systems, optical techniques inside the engine combustion chamber and at the exhausts, nanostructured material for automotive applications, i.c.e noise: measurement and reduction, performance and emission of in real use vehicles, reliable methods for propulsion systems and components, multispecies remote optical monitoring of emission and tropospheric pollution, combustion process stability in steady-state combustors. The main IM's collaborations have been the following: Research Centres (VTT Finlandia, Institut fur Luft-und Raumfahrtmedizin, Strahlenbiologie, Koeln, Deutschland, GmbH, German Aerospace Center - DLR Stoccarda, CIRA, Institute of chemical kinetics and combustion, Russian Academy of Sciences, Novosibirsk, Russia, INFM Gas Sensor Laboratory); Universities (Costanza, Romania, Valencia, Stoccarda, Gotenborg, Napoli, Roma Tor Vergata, Istanbul, Wisconsin, Rennes, Salerno, Sannio, Brescia, Milano); Companies (Ferrari H.P.E. srl, PiaggioVeicoli srl, Elettronica Santerno spa, SOL spa, Loccioni, Proton Motori, Magneti, Ansaldo ricerche, TSI Inc. U.S.A.); Public Institutions (Azienda Napoletana Mobilità, Ministero Ambiente, Ministero salute, Consorzio TEST, Centro Regionale di Competenza della Campania "AMRA", Regioni Toscana e Campania, International Civil Aviation Organisation).

IMAA
Institute of Methodologies for Environmental Analysis

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The research activities of IMAA have been devoted to the development and integration of satellite, airborne and in-situ "Earth Observation" technologies in order to study environmental and geophysical processes. The multi-disciplinary approach allowed to study in a more innovative way environmental and geophysical processes characterized by a high level of complexity. This approach fits both the main strategic actions of GMES (Global and Monitoring and Environmental Security) Programme and the GEOSS (Global Earth Observation System of Systems) implementation plan. IMAA is firmly included in European research activities and its researchers have been involved in 20 projects funded within FP6 and FP7 programs. It should be pointed out the coordinating role of the EARLINET and ACTRIS infrastructural projects. The institute has been involved in designing research infrastructures of international significance: the Atmospheric Observatory which is one of the worldwide sites within the GRUAN network for the study of the high atmosphere; a system for receiving, processing and storing satellite images for geohazard and environmental monitoring; a Hydrogeosite Experimental test field, which is the first full-scale laboratory in Italy for studying hydro geophysical processes; geophysical and geochemical mobile laboratories and hyperspectral sensors for airborne platforms.

IMAMOTER

Institute for Agricultural and Earthmoving Machines

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SECTIONS Torino

Research performed at IMAMOTER (Institute for Agricultural and Earthmoving Machines) extends over eight main streams including: Innovation of components and fluid power systems; unstructured robotics and mechatronics; numerical and experimental analysis of structures and internal flow fields; control and monitoring of acoustic emissions from complex sources; analysis and reduction of vibrations and structure-born noise; design of machines and subsystems; mechanization and environmental impact of cultivations; standardization, certification and performance tests of agricultural and earthmoving machines.
IMAMOTER joins active scientific networks such as EUROSHNET (European Occupational Safety and Health Network), FPNI (Fluid Power Net International), AEF (Agricultural Electronics Foundation), and Societies such as ISTVS (International Society for Terrain-Vehicle Systems, NAFEMS, AIA (Italian Acoustic Association). IMAMOTER is a reference point for academia and industry for fostering and disseminating knowledge on agricultural and earthmoving machines. The Institute cooperates with many universities and technical schools in Italy (Ferrara, Modena and Reggio Emilia, Parma, Padova, Torino, Bari and Ancona) and abroad (Università Politecnica di Catalogna, Danish Technical University, JKU di Linz, University of Lublin and Monash University in Melbourne, and established consolidated links with many companies in different fields of industrial production (Fiat Industrial and Komatsu UE), small and medium enterprises, manufacturers associations, public administration (Ministries and Regional authorities), Public and private bodies (ISO, CEN, UNI, CUNA, ENAMA, INAIL, OECD, Cemagref and C.R.A.).

IMATI

Institute for Applied Mathematics and Information Technologies

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IMATI carries out research in numerous fields of Mathematics, Information Technology and their applications. In particular, the activities are related to Differential Modelling for Engineering; Modelling of Biomedical Phenomena; Mathematical Statistics and Probability; Geometric Modelling and Computer Graphics; Information Technologies; High Performance Computing. With its multidisciplinary expertises, IMATI represents innovative perspectives both for basic research activities as well as for applications. The Institute takes part intensively in International Research Projects and Networks, such as: the ERC Project "Innovative compatible discretization techniques for Partial Differential Equations" (GEOPdES), which aims at developing isoparametric techniques for electromagnetics, fluid dynamics and elasticity; the ERC Project "Mathematics for Shape-Memory Technologies in Biomechanics" (BIOSMA), which aims at studying models for shape memory alloys for biomedical applications; the ESF Project "SMARTeR: Shape Memory Alloys to Regulate Transient Responses in civil engineering"; the Network of Excellence AIM@SHAPE on processing knowledge related to digital shapes; the Coordination Action FOCUS K3D for coding and sharing 3D media content. Moreover, various research projects are funded by the Ministry for Research, INGV, Department of Civil Protection, Regione Lombardia and Liguria.

IMC
Institute of Chemical Methodologies

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The Institute of Chemical Methodologies (IMC) is active in the areas of the chemical and radiochemical researches using specific methodologies such as: radiation chemistry, chromatography, electrophoresis and gas chromatography, mass spectrometry, nuclear magnetic resonance. The study of reaction mechanisms and innovative methods of analyses have made possible the development of applications in important fields, such us: food, environment, biology, pharmaceutical and material sciences and cultural heritage. A key role is played by the Institute in developing procedures for chemical syntheses, purification and characterization of materials, chemical products and processes with considerable strategic importance and application of methodologies for studying the organization of complex systems on the basis of non-covalent interactions and designed to express established properties (sensing, catalysis, transport). The chemical methodologies are usually adapted to the specific needs characteristic of the study, require deep experience and interdisciplinary culture, such as those provided by the Institute.
The current researches are the result of numerous collaborations with universities, national and international research bodies which have been initiated agreements and special funds to support the scientific activities, in order to meet the new social and industrial needs of technological transfer.

IMCB
Institute for Composite and Biomedical Materials

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The Institute for Composite and Biomedical Materials (CNR-IMCB) scientific activities are focused on polymer and composite structures (natural, semi-synthetic, synthetic), at different organization of levels (from nano to macro) with specific multi-functionality, leading to the development of innovative products and processes for several industrial sectors (aerospace, biomedical, constructions, energy, electronic, packaging, transportation). The research activities are structured in the following three areas: Functional polymers, composite and nanostructures with tailored properties and processing; Processing and monitoring technologies; Biomaterials and Tissue Engineering. Technology transfer activity is also implemented to guarantee the dissemination and exploitation of scientific results. The Institute maintains strong collaborations with other Research Laboratories, Universities, National and International Industries, interested to applications of innovative composite materials. IMCB is involved in numerous national or international scientific projects in collaboration with Industries (Alenia Aeronautica, Fiat Avio, Elasis, Fidia Advanced Biopolymers) and with other important European laboratories (University of Kyoto-Japan, University of Sichuan – China, University of Loughbourough and University of Bath - UK, University of Twente - NL, University of Connecticut -USA).

IMEM

Institute of Materials for Electronics and Magnetism

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SECTIONS Genova, Trento

IMEM interprets an interdisciplinary vision and a research practice in material science, complementing refined growth synthesis and studies with theoretical modelling and device prototyping aiming at exploring and demonstrating functional properties, applications and technological perspectives. IMEM envisions a tight interplay between curiosity-driven basic and applied science with technological research, focusing the activity on materials, processes and devices for energy, sensing, bio-medicine and space. IMEM studies and develops: semiconductors, nanostructures and nanosystems for photovoltaics and sensing; magnetic and superconducting systems and devices; technologies for magnetic refrigeration, bioelectronics and advanced prosthetics. State of the art expertise and patents filed (Film4Sun Spin Off) make IMEM a partner in a wide network of collaborations with Universities and research centers (M.I.T. Boston-USA; Universities of Paris, Saragozza, Porto, Goettingen, Sheffield, Edinburgh, New Hampshire, Bergen, Roma, Torino, Modena, Pavia, Perugia; ESA; N.I.M.S.-Japan; Imperial College of Science-London; Donostia International Physics Center; Ecole Nationale Sup. de Chimie de Paris; I.N.RI.M.; ASI) as well as for the private sector (XGroup, Rial Vacuum, C.T.G. Italcementi Group, Ceramiche Marazzi, ST-Microelectronics, Infineon Technologies AG, 5NPlus, ENI - HENESIS, QUANTASOL-UK).

IMIP

Institute of Inorganic Methodologies and Plasmas

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IMIP is active in both theoretical and experimental research devoted to the characterization and control of elementary chemical-physical processes, which determine the reactivity of macroscopic systems and plasma. The activity in fundamental research triggers and merges with applications in material science (plasma and laser assisted deposition/treatment of materials), aerospace, energy (fusion and solar energy), environment and health. IMIP has an established experience in the development of methodologies for spectroscopic techniques and instrumentation, to be used in both laboratory and large research infrastructures, and reactors for plasma-chemistry applications. Among others, several collaborations are worth mentioning: Sincrotrone Trieste, Rome, Padova, Catania and Bologna University, Politecnico Torino and ENEA in Italy; Duke University, Georgia Institute of Technology and University of North Carolina in the USA; MPG-Institut für Plasmaphysik and Fritz-Haber Institut in Germany; CIEMAT in Spagna; Jozef Stefan Institute in Slovenja; CNRS, Laboratoire de Genie des Procedes Plasmas et Traitement de Surfaces and CEA (Commisariat a l'Energie Atomique) in France; Ioffe Institute, Troitsk Institute of Innovation and Fusion Research in Russia; Institute of Plasma Physics (AVCR) in Praga and IMRAM- Sendai University in Japan.

IMM
Institute for Microelectronics and Microsystems

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The Institute for Microelectronics and Microsystems (IMM) is engaged in the development of innovative solutions for microelectronics (materials and processing for sub-32 nm CMOS and non volatile memory technologies; materials, processes and devices for advanced power electronics; large area and plastic-based electronics; novel photovoltaic applications, etc.), sensing technology, optoelectronic microsystems and microfluidics.
IMM activity extends from basic research (investigation of innovative materials and processes) to technological concern (prototyping and/or technological transfer to enterprises).
Thanks to the participation of many European projects, IMM benefits from collaborations with prestigious international research government institutions, such as Laboratoire d'Electronique de Technologie et d'Instrumentation (LETI), Interuniversity MicroElectronics Center (IMEC), European Synchrotron Radiation Facility (ESRF), Centro Nacional de Microelecrónica (CNM), Lawrence Berkeley National Labs, and with a lot of top-level semiconductors companies, such us STMicroelectronics (ST), Numonyx, Philips, SILVACO, AMD, Tower Semiconductor, Siemens, as well as many others enterprises exploiting micro and nanotechnologies, such as Alenia Aeronautica, Alenia Aermacchi, Carlo Gavazzi Space, etc.

IN
Institute of Neuroscience

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SECTIONS Cagliari, Milano, Padova

The mission of the Institute of Neuroscience (IN) is to increase our knowledge of the nervous system at all levels. The IN also promotes the study and therapy of pathologies of the nervous system, carrying out both basic and applied research. The major research topics include: the development and plasticity of nervous circuits; the mechanisms and processing of sensory input (vision, olfaction, hearing); the physical correlates of cognition, understanding and memory; neuronal signal transmission and its modulation; glia-neuron and nerve-muscle interactions; the mechanisms of cell death and neurodegeneration; epilepsy; migraine; aging; the mechanisms of action of neurotoxins; the neurobiological bases of gratification and of alcohol and drug dependence; cellular signalling, in particular by Ca2+ and cAMP; the development of new ligands of receptors of the CNS. These investigations rely on molecular and cellular biology, genetics, chemistry, biochemistry, biophysics, electrophysiology, neuroanatomy, advanced microscopy, functional brain imaging, in silico modelling, behavioural and statistical studies. Researchers of the Institute have developed many new experimental protocols and instruments. This know-how is fundamental in securing for IN a top-tier position among the most relevant European institutions of research and advanced training in the neurosciences.

INO
National Institute of Optics

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SECTIONS Pisa, Trento, Sesto Fiorentino (FI), Napoli, Lecce

INO mission is to accomplish, advance and support Italian research, also at international level, in the strategic areas of Optics, Atomic Physics and Radiation-Matter Interaction. These objectives are pursued by creating new knowledge and skills in collaboration with Universities, companies and other research institutes, updating the business lines up with the great innovations that have recently characterized the sector. INO promotes the formation and growth in technical and professional areas of expertise and it develops research in Quantum optics, Non linear optics and Optics of high intensity, Optical systems and sensors, Interferometry and metrology, Quantum gases and ultra-cold atoms, Micro and nano optics, Spectroscopy and metrology, Sources and Science of vision with predictable consequences for the economy in key sectors such as energy, security, health, environment, aerospace, art diagnostics and more. The Institute also directs its activities towards innovation, technology transfer, technical and scientific advice and the patenting; it participates in national and international projects of basic and applied research, strengthening and expanding its network of collaborations with Italian and foreign universities, research institutions and private and public companies. Headquartered in Florence, INO has individual organizational branches in Lecce, Naples, Pisa, Sesto Fiorentino and Trento and more labs in Venice, Florence ("Opificio delle Pietre Dure"), Careggi and Capalle.

Centre of Scientific Activity INSEAN
Institute for Naval Architecture and Marine Engineering

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INSEAN-CNR is a Research Institute active in the field of marine and maritime engineering. Established in 1927, it has a permanent staff of 130 people, including 50 researchers and engineers and 65 technicians. INSEAN has a number of large experimental facilities for hydrodynamic and fluid-structure interaction testing that represents a relevant infrastructure to support the technical and scientific development in the field, and stands out in the world for its size and the advanced measurement systems, including two large hydrodynamic basins (480 m and 220 m long, respectively) and a large free surface cavitation channel. INSEAN relevant research activities include numerical modeling and code development, which can benefit of 4 large and up-to-date parallel clusters for a total number of 852 processors. Research topics and applications are aimed at areas of interest of the integrated European marine and maritime policy: innovative materials and processes for marine vehicles, optimization of marine vehicles, advanced studies for maritime transport and marine environment, dynamics of marine vehicles, propulsive systems, structural dynamics and fluid structure interaction, offshore structures, marine renewable energy, hydrodynamics of unconventional vehicles and high speed, underwater robotics, free surface flows and coastal dynamics, environmental impact assessments and reduction.

IOM
Institute of Materials

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The Institute of Materials carries out interdisciplinary research on the atomic scale physical properties of materials and systems of nanometric size. The main activities include design, numerical simulation, synthesis and analysis of molecular systems, nanostructured materials, soft matter and biomaterials and the development of prototypical devices. The possible applications of the materials and devices that we study and of the methods that we develop are in the fields of energy (photovoltaic, hydrogen production), biomedicine, nanotechnologies for electronics, environmental applications (detection and capture of pollutants) and for cultural heritage (characterization of artistic finds and their degradation). The IOM runs labs at the Italian Synchrotron radiation Facility in Trieste and at the European Facilities ESRF and ILL in Grenoble (Fr) and develops advanced instruments and methods for research at the synchrotron radiation and neutron sources. IOM is a leader in the field of nanoscale numerical simulation; with SISSA forms the Italian CECAM node and develops new computational methods and numerical algorithms to study materials and molecular systems. Every year many tens of international research groups have access to the Institute facilities, and therefore a very large number of national and international collaborations are active, some of the most important being with IIT and CINECA (IT), Johnson & Johnson, Princeton University, MIT, Columbia University (USA); Oxford University (GB), TU Munich and TU Marburg (GER), EPFL (CH), CEA and CNRS (FR).

IPCF
Institute for Chemical and Physical Processes

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The Institute for chemical and physical processes (IPCF) carries out interdisciplinary research on soft-matter, complex and disordered systems, surfaces and interfaces, composite and nanostructured materials, supramolecular architectures and biosystems. Research is aimed at the development of systems with different degree of complexity and at the advancement of knowledge on their properties, behavior and applications. Activities regard the study of different phenomena such as self-assembling, surface interactions, relaxation and transport, and, more generally, the analysis of dynamics, transformations, structures, reactivity and interactions of soft-matter systems with radiation. IPCF research themes include property-designed nanomaterials, theoretical-computational models and analytical techniques, new experimental methodologies and advanced devices. Research at IPCF is addressed towards subjects of high social impact (health, energy, environment) requiring materials with new functionalities, advanced industrial technologies, innovative experimental and theoretical approaches. IPCF takes advantage of the presence of regional labs (PolyLab in Pisa, Licryl in Cosenza), research & development centers (SOFT and SMC in Rome) and of an extended network of worldwide collaborations with industries, universities and research centers, among which the Synchrotron Radiation Facility and the Institut Laue Langevin.

IPP
Institute for Plant Protection

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The mission of the Institute for Plant Protection (IPP) is to study plant stress factors, to understand the mechanisms of resistance to stresses, and to implement environmental-friendly methods for plant defense against biotic factors and protection against abiotic stressors. IPP activities contribute to improve agricultural production and sustainable use of plant resources. IPP holds multidisciplinary expertise in the fields of ecophysiology, biochemistry and genetics of plants and their enemies. Research has been recently focused on biocontrol of forest pathogens and alien invaders. Plant protection against environmental stresses is another active area of research, especially aiming at assessing the impact of climate change on cultivated and natural plants. Recent successful research at CNR has produced international publications on leading generalist and specialized journals, patents about clones resistant to plant pathogens, and funding by international research programs coordinated by the Institute (ESF-EUROVOL) or with IPP core-partnership (EC 7th FP).

IRAT
Institute for Service Industry Research

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The scientific activity of the CNR-IRAT is organized into the following four lines: innovation and value creation; identity and development of the territory; urban planning strategies for the contemporary city and migration. The majority of the projects mentioned are considered action-research projects for two fundamental reasons. Firstly, because the activities are or will be rigorously carried out with other local economic and institutional actors. Secondly, because in some cases training activities are expected. The Institute has a high international profile that has grown through the participation in European Union Programmes such as EU Programme Framework; INTERREG and ADAPT II. Over the years IRAT has developed a prestigious network of national and international cooperation, among which we highlight: The Heriot-Watt-Logistics Research Centre (Edinburgh), The International Association of Maritime Economics (IMEA), Institut National de Recherche sur les Transports et leur Securité (Paris), The London Metropolitan University, The British Columbia University, École Supérieure du Commerce Extérieur (Paris),The Association for Tourism and Leisure Education (ATLAS), The International Association of Scientific Experts in Tourism (AIEST).

ISTITUTODIRICERCHE
SULLACOMBUSTIONE
CONSIGLIO NAZIONALE DELLE RICERCHE

IRC
Institute for Research on Combustion

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The current research activities of the Institute for research on combustion (IRC) are developed in the present context of energy and environmental problems, related to the use of fossil fuels, biomasses and wastes. Essential for sustainable development are the implementation and/or development of combustion technologies devoted to: energy saving, diversification of energy sources and reduction of pollutant emissions. The Institute is involved in research activities on the fundamental and practical study of combustion processes relevant to both energy conversion and prevention and control of fires, explosions, accidental releases.
At the present time, advanced technologies of combustion as fluidized bed combustion, mild and catalytic combustion, as well as innovative methods of monitoring and treatment of exhaust for the abatement of pollutant as fine and ultrafine particles, NOx and for CO2 capture, are the main object of the research activities of IRC.
The Institute has established over the years a rich network of cooperative activities with companies as ENEL,ENI, FIAT,EDF, Alstom, many universities, public and private research centres and government authorities, in Italy and worldwide. It is involved in several national and international cooperative research projects in energy and environmental fields.

IREA

IREA
Institute for Electromagnetic Sensing of the Environment

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The Institute for Electromagnetic Sensing of the Environment (IREA) carries out research activities aimed at the development of methodologies and techniques for acquisition, processing, fusion, interpretation and representation of data acquired by remote and in-situ electromagnetic sensors, allowing several applications including environment and territory monitoring, non invasive electromagnetic diagnostics of manufactures and biological systems as well as the risk evaluation of the electromagnetic field exposure. Thanks to its multidisciplinary expertises (sensor development, image and signal processing, computer science, geomatics, electromagnetics, biology) IREA is well established in the national and international research context relevant to the ICT and the Earth Observation fields. The Institute has a very relevant scientific production and takes part in many national and European projects. It is involved in two centres of competence of the Campania Region (CeRICT and AMRA) and gives its technical and scientific support to the Lombardy Region in the NEREUS net. Furthermore, IREA takes part to the National Inter-University Consortium for Telecommunications (CNIT), to the Inter-University Research Center for Interaction between Electro-Magnetic Fields and Biological Systems (ICEMB) and it is a centre of competence of the Italian Civil Protection Department (DPC).

IRGB

Institute of Genetics and Biomedic Research

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The Institute of Genetics and Biomedic Research (IRGB), formerly Institute of Neurogenetics and Neuropharmacology (INN), consists of the main Institute in Sardinia and a research unit in Milan.
At the time being, IRGB's leading activity in the main Institute is in Genetics and Molecular Biology and IRGB's scientific interests focus primarily on four wide ranges in research: firstly, the ProgeNIA project, a longitudinal study of a large cohort of Sardinian subjects; secondly, identification of the genes involved in the pathogenesis of complex diseases; thirdly, Thalassemia, the most frequent monogenic disease in Sardinia; and finally monogenic diseases, common within the Sardinian population. From the logistic point of view, the main institute of Genetics and Biomedical Research has three locations in Sardinia, namely Cagliari, Lanusei and Pula. Milan Unit's research activity has developed along the genomics field with particular attention to the applications to human health. Therefore the Milan activity can be characterized as Translational Genomics. The following themes are pursued: genetics of monogenic and polygenic diseases; oncology, genome stability and epigenetics; new antibiotics; role of sarcomeric proteins in cardiac and skeletal muscle function and disease; bioinformatics and computational biology. UOS official location is in Milan, but some research groups work at the LITA institution in Segrate, while others work at the Istituto Clinico Humanitas (ICH) in Rozzano (Milan). Long term research personnel belonging to the main Institute are 21, the one of UOS are 4.

IRPI

Research Institute for Geo-Hydrological Protection

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Padova, Torino

IRPI (Research Institute for Geo-Hydrological Protection) designs, coordinates, and executes research and technological developments on natural hazards, chiefly geo-hydrological hazards (i.e., floods, inundations, landslides, soil erosion, coastal and glacial instabilities, water resources). The activities are conducted at all geographical and temporal scales, and in different geological, geomorphological and climatic environments, with the aim of improving the current understanding of potentially hazardous phenomena, and the interactions with the human environment. The Institute develops innovative solutions, products, and technologies for hazard assessment and risk mitigation, for land planning and environmental management, it executes field research, and it maintains monitoring networks and databases useful to Ministries and public administrations. IRPI participates to the activities of the National Space Program, coordinates European and National projects financed by the Executive Research Agency and the Italian Space Agency, and participates to the VIGOR project for the assessment of the geothermal potential in Italy, financed by the Ministry for Economic Development. Since 2005, IRPI is a centre of excellence of the National Department of Civil Protection, an Office of the Prime Minister, for which it maintains an early warning system for possible landslide occurrence in Italy.

IRPPS

Institute for Research on Population and Social Policies

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The Institute for Research on Population and Social Policies (IRPPS) is an interdisciplinary research institute. Our activity combines a mix of analytical, theoretical and empirical studies, across disciplinary boundaries in three main research fields: firstly, relationships between population trends, social and economic development; secondly, social dynamics and policies in the welfare system; thirdly, changes in knowledge, technology and society (ICTs).
Our research activities focus on population studies, demographics and migration issues, social and demographic behavior; social integration; gender studies; welfare systems and social policies; studies on science, technology, innovation and higher education policies, science and society relationships; creation, access and diffusion of knowledge; information and communication technology; models and systems of access to information and technology; electronic health care; globalization. The main strategic objectives of the Institute consist in: performing research to suit the needs of society and providing tools and cognitive methods for applying research results in a broad socio-economic context. The Institute collaborates with Italian and foreign universities and institutions, participates in policy and research networks (OECD, EU, Unesco, European Science Foundation) and is party to a number of contracts from the EC, public agencies and local authorities and private corporations.

IRSA

Water Research Institute

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The Water Research Institute (IRSA) was established in 1968 with a mandate to carry out research activities in the fields of management and protection of water resources and in developing methodologies and technologies for water purification and treatment of wastewater. In the institute, distributed on three centers (Rome, Bari and Brugherio), operate over 55 researchers, 28 technicians and 10 administrative in permanent position; it must then be added personnel in temporary position that can be estimated in around 60 unities. The research activities can be currently sorted in the following thematic areas: Contaminant fate and effects; Aquatic ecosystem functioning and response to impacts; Municipal and industrial wastewater treatment; Sludge and solid waste management; Remediation of polluted sites; Sustainable management of water resources; Groundwater, rock and surface ecosystems interactions. The impact of these activities is significant not only in the strictly scientific environment, but also in the technical advisory area through the provision of skills and knowledge to different stakeholders at different level. IRSA participates in bilateral research activities for the protection of common waters (Italy-Switzerland) and multilateral (Himalaya and Karakoram) and it is the Italian representative in the European network of water research organizations (EurAqua), in the Water Supply and Sanitation Technology Platform (MSMG) and in the International Water Association (IWA).

IRSIG
Research Institute on Judicial Systems

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The Research Institute on Judicial Systems (IRSIG-CNR) was set up in 1992. IRSIG's mission is to study and carry out research in the field of justice, both as a scientific endeavor and as a service for policies and measures to be undertaken for a better administration of justice. At the European level, IRSIG's scientific effort is also directed at facilitating the convergence of justice systems within the European Union. In contrast with the dominant formalistic approach to the study of legal and judicial institutions, the research activity carried out by IRSIG is not confined to merely studying the laws that formally regulate the structure and the functioning of the judicial systems, but it is directed primarily at analyzing and evaluating the "law in action", the working practices and performance of legal institutions, the policies of innovation and change for judicial reforms.
The research methods used are mainly empirical and comparative, with an interdisciplinary approach, which involves the intertwining of different fields of knowledge such as: law, organizational theory, political science, management, information and communication technology, public policy analysis, and social psychology. IRSIG has been repeatedly engaged in extensive empirical field research and technical assistance projects to improve the functioning of the administration of justice in several countries.

ISA
Institute of Food Science

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The activities of the Institute of Food Science (ISA) are devoted to the research, valorization, training and technological transfer of the food science, by using basic and innovative approaches. The main activities of the Institute are related to: characterization of the "Mediterranean diet"; epidemiological studies; food technologies; food and health; food safety and traceability; improvement of food quality and preservation; bioinformatics for the study of human pathologies, and studies of food intolerances. Through a well equipped center of mass spectrometry, one of the most modern and important in Europe, and owing to the expertise also in functional genomics, proteomics and metabolomics, ISA is involved in different regional, national and International projects, such as IDEFICS, based on the studies on the influence of nutrition, physical activity, environmental, genetic and social factors on children pathologies; HORTIBIOPACK, supported by the EU Commission through the 7th FWP and focused on the development of innovative biodegradable packaging system to improve shelf life, quality and safety of high-value sensitive horticultural fresh production; NOCHEMFOOD, on the use of natural extracts as substitutes of chemical additives in the manufacturing of sausages; MACOILs, to map and compare the chemical, physical, organoleptic and healthy features of eight eating oils. The specific and numerous expertises of the institute allow it to cooperate with the national and international scientific community, as well as with local and government authorities, Regions, SMEs, and to supply useful information for the consumer associations.

ISAC

Institute of Atmospheric Sciences and Climate

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A wide range of expertise is present within the Institute of Atmospheric Sciences and Climate (ISAC) which can be summarized in the following headlines: Climate modelling, climate historical reconstruction and its variation, impacts of climate change on environment and society; Atmospheric composition: observations and processes from the local to the global scale and their effects on air quality, climate, ecosystems and human health; Meteorology: theory, observations and models; Theory and models of atmospheric transport processes at different scales and their connections to air quality and climate; Natural, environmental and anthropic risks of cultural heritage; Satellite observations of sea surface and system development for the sustainable use of marine resources.
ISAC manages three Observatories for atmospheric studies and two Global GAW-WMO stations (i.e. O. Vittori Observatory at Mt. Cimone and Nepal Climate Observatory-Pyramid in the Himalayas), which are part of European and international Networks for regional and global air quality and climate change studies.
ISAC is part of more than one hundred national, European and international projects, in several cases with a coordination role, collaborating with Universities and Research centres, including ENEA, INGV, Italian Air Force Meteorological Service, DPC, ISPRA, Regional ARPA, ASI, Alenia Spazio, EV-K2-CNR in Italy; ESA, CNRS, ECMWF, UK Met Office, Max Planck Institutes, DLTR, GKSS, IMK in Europe; UFRGS, UFSM in Brazil e NOAA, NASA, NCAR in USA.

ISAFoM

Institute for Agriculture and Forest Systems in the Mediterranean

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The ISAFoM (Institute for Agriculture and Forest Systems of the Mediterranean) carries out research for the study of physical, chemical and biological processes that determine the functioning and dynamics of agricultural ecosystems and forestry, to develop technical solutions to improve production processes, the total quality of products, and promote environmental protection and functionality of forests. The multidisciplinary approach (biological, physiological, biotechnological for cultivation, modeling) of ISAFoM concerns the issue of sustainability of agricultural crop production and forestry systems, allows to carry out studies and researches from environment to single plant and invests nearly herbaceous and arboreal agricultural and forestry species of primary economic importance in the Mediterranean climate area (olive, grain legumes, tomato, artichoke). The ISAFoM is a research facility organized to be competitive and integrated in the European research system, and reinforces the central role in the areas of its competence through a strong network of collaborations with some of the most prestigious Italian and international research institutions, Ministries, Regions, Universities (Campobasso, Caserta, Catania, Florence, Naples, Padua, Perugia, Piacenza, Pisa, Potenza, Reggio Calabria, Viterbo) and through links with International Institutions in Europe and abroad (Argentina, Belgium, Germany, Greece, Israel, Netherlands, Peru, Portugal, United Kingdom, Czech Republic, Spain, USA).

ISC

Centre of Scientific Responsibility ex Institute for Complex Systems

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The study of complex systems refers to the emergence of collective properties in systems with a large number of parts in interaction among them. These elements can be atoms or macromolecules in a physical or biological context, but also people, machines or companies in a socio-economic context. The science of complexity tries to discover the nature of the emerging behavior of complex systems, often invisible to the traditional approach, by focusing on the structure of the interconnections and the general architecture of systems, rather than on the individual components. This activity is inherently interdisciplinary and has its roots in the fields of condensed matter and statistical physics. From this physical background it then extends also to complex materials, biophysics, informatics and socio-economic disciplines. The activity is both theoretical and experimental and it refers also to applied and technological areas. ISC represents a well recognized scientific hub at the international level with many collaborations and joint projects with other leading institution. Examples of this role have been the organization of the international conference STATPHYS23 in Genoa in 2007 and the many projects and grants at the national, European and international level. Particular attention is given also to the educational role in terms of PhD and the divulgation of scientific culture.

ISCIMA

Institute for the Study on the Italic and Ancient Mediterranean Civilizations

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ISCIMA (Institute for the study on the italic and ancient Mediterranean civilizations) combines the best in Italian tradition of archaeological, philological and historical studies, passed on to us by Sabatino Moscati and Massimo Pallottino, with the most advanced techniques in interdisciplinary research, in its activities both in Italy, the Levant and in North-Africa. ISCIMA focuses its interest on the historical field of archaeology, collecting and editing of scientific publications in paper form for journals and in digital form for international on-line series. ISCIMA is a promoter and coordinator of important interdisciplinary projects: i.e. the archaeological missions in Etruria, Sabine, Sardinia, Tunisia, Algeria and Lebanon. Besides, ISCIMA is responsible for the Thesaurus Linguae Etruscae and the database of the Punic Phoenician inscriptions. ISCIMA collaborates with a lot of prestigious museums such as The Louvre, The British Museum, Ny Carlsberg Glyptotek, Copenhagen, the Metropolitan Museum, New York and the Museé National de Beyrouth. The Institute constantly promotes stimulating cultural initiatives.

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ISE
Institute of Ecosystem Study

The Institute's basic and applied research activity is in the field of water and land ecosystems, and how these react to the impact of global climate change and anthropogenic pressure. Its main objective is to generate the scientific knowledge which must precede any protective and corrective measures on the environment, in support of the authorities responsible for applying such measures.
The two main areas of research are: firstly, the structure and functioning of water and land ecosystems and secondly, techniques for the protection and recovery of water and soil quality. The research performed by the ISE is a valuable support to the authorities responsible for environmental protection (ARPA, municipalities, provinces, regions); the Institute has also consolidated partnerships with ministries (Agriculture, Forestry and Environment), Italian and international universities (Whuan in China, Girona in Spain, Rio de Janeiro in Brazil, Tlemcen in Algeria), international organizations (European Union, United Nations-Economic Commission for Europe, the International Commission for the Protection of Italian-Swiss Waters, Ev-K2-CNR, World Conservation Union (IUCN), CONICET Argentina and CSIC Spanish) and, finally, industries and private companies (Waters SpA, Antico Frantoio Toscano, Autostrade SpA for Italy, Consorzio Leather Depur, Snamprogetti SpA, Montefibre SpA).

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ISEM
Institute of History of Mediterranean Europe

The Institute of History of Mediterranean Europe (ISEM) examines how Mediterranean Europe has shaped its identity. It does it from the privileged viewpoint of the Italian peninsula in a long chronological framework, from the Middle Ages until the present times. The Institute addresses issues arising from the relations and the reciprocal influences of the European countries that dwell on the northern Mediterranean shores.
ISEM has a long tradition in the field of edition of historical sources within a longue durée perspective and a well recognizable attention to the constant relationship between the Mediterranean and Atlantic worlds. Recently, a special attention has been devoted to the relationship between Catalonia, Sardinia, and the Italian peninsula; the maritime and commercial expansion of the Republic of Genoa; the Europe's expansion outside of itself; frontier issues; and the intellectual relationships between the Italian peninsula and the Spanish America.
ISEM takes part in CNR's strategic project "Migrations". Since 2008, it has been publishing an online refereed journal, RiMe (Rivista dell'Istituto di Storia dell'Europa Mediterranea). Since 2011 it has also been publishing an online book series, "Europe and the Mediterranean. History and Images of an International Community."

ISGI
Institute for International Legal Studies

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Research at the Institute for International Legal Studies (ISGI) covers the most relevant sectors of public international law and European Union law, as connected sector. Legal analysis is focused particularly on the following sub-areas: laws of United Nations, laws of regional integration, environmental, energy and sustainable development laws, human rights, laws of space activities, bio-law.
One of the main tasks is monitoring the Italian contribution to the evolution of customary international law. It is reflected in the research on the Italian Practice of International Law (www.prassi.cnr.it).
Key areas of research include also training and expert consultancy in cooperation with national and international institutions such as the Ministry of Foreign Affairs and the Ministry of Welfare, Health and Social Policies, the Asser Institute of the Hague, ESA, UNIDROIT and UNESCO.
The ISGI's research assumes a "chain methodology", namely from external legal sources to domestic law, and an interdisciplinary approach.

ISIB
Institute of Biomedical Engineering

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The research activity of ISIB is related to the prevention, diagnosis, care and rehabilitation of human health. The main research topics are: communication disorders, methods and mathematical models for investigating metabolism and diabetes with its complications; EKG signal analysis; electromagnetic fields and their influence on human health; instrumentation for advanced diagnosis; and modeling of complex stochastic systems.
As regards the study of communication disorders, ISIB is internationally renowned for the screening of hearing impairment in the newborn and in the elderly; and for the development and use of tests for evaluating the internal ear function. ISIB is also an international reference institution as regards studies on metabolic disorders and diabetes, mostly concerning the methods for the evaluation of insulin resistance and pancreatic beta cell function. In the field of diagnostic imaging, ISIB has patented new devices and established a CNR spin-off company (Li-tech SpA).
Cooperative studies are constantly undertaken between ISIB and international organizations such as World Health Organization, Centers for Disease Control and Prevention (USA) and with universities and research centers worldwide (Medical University of Vienna, Austria; Lund University, Sweden; Trinity College, Dublin, Ireland; University of Texas, USA; Institute of Endocrinology, Prague, CZ). Finally, research and consulting agreements exist between ISIB and some multinational pharmaceutical-companies, among which: Novo-Nordisk; Novartis; Takeda; Eli-Lilly.

ISM
Institute of Structure of Matter

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The activity of the Institute of Structure of Matter (ISM) is devoted to the engineering and fabrication at nanometer scale of new functional materials (thin films, nanoparticles, nanotubes), to the study of their physical (magnetic, optical, transport) and chemical (chemisorption, catalysis) properties in view of their applications in energy (fotovoltaics, light batteries, fuel cells), magnetic and magneto-electronic devices (recording media, sensors), environment and biomedicine. The materials are fabricated by a number of chemical (colloidal chemistry, Langmuir-Blodgett, spin-coating, electrochemical deposition) and physical methods (Molecular Beam Epitaxy, Pulsed Laser Deposition, vapour deposition in ultra high vacuum). Investigations of the structural, physical and chemical properties of the materials are carried out by means of advanced diagnostic techniques developed by the Institute (X-ray and microprobe techniques, magnetometry, absorption and photoemission spectroscopies) using linear and circular polarized synchrotron radiation (ISM's beam lines at Elettra) and by theoretical calculations through a materials modelling approach. ISM is active in National and European projects, has close contacts with companies (ST-Microelectronics, Assing…) and has fruitful collaborations with many prestigious institutions of different countries, among which the University of Vanderbilt in Nashville (USA), where advanced ISM's spectrometers have been installed, and the Atomic Center of Bariloche (Argentina), with which a joint laboratory on nanomagnetism has been recently formed.

ISMAC
Institute for Macromolecular Studies

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The research at ISMAC (Institute for Macromolecular Studies) focuses on the synthesis and properties of synthetic and biological macromolecules for innovative applications in life sciences, energy saving, packaging, textile, rubbers and optoelectronics. The Institute expertise includes catalysis, supramolecular organization of macromolecules on a nano and micro scale, molecular, structural, electronic, and spectroscopic characterization, theory and modelling, design of new functional polymers, and prototypes development. ISMAC reaches high levels in nanotechnologies, in the realization of organic photovoltaic cells, films for packaging with novel properties, novel biodegradable materials from renewable sources, conductive carbon nanotubes based materials, blends with nanofillers for tyres, textiles of new generation, and in investigations of biological events related to pathological processes for new therapeutic strategies. In these two years ISMAC has participated to 6 European projects, 8 national (FIRB and PRIN) and 25 regional projects (funded by Lombardy and Piedmont and bank foundations) and has many important contracts with national and foreign polymer and textile industries. Numerous collaborations with national research groups and universities and with international universities (in EU and bilateral projects) are well established.

ISMAR
Institute of Marine Sciences

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ISMAR (Institute of Marine Sciences) conducts research in physical, chemical, and biological oceanography, marine geology, technology and fisheries biology. The research is conducted in polar, oceanic and Mediterranean regions, focusing on the following themes: the evolution of oceans and their continental margins, studying submarine volcanoes, active faults, submarine slides and the potential impacts of their activities onshore; the influence of climate change on oceanic circulation, acidification, bio-geochemical cycles and marine productivity; submarine habitats and ecology, and the increasing pollution of coastal and deep-sea environments; the evolution of fish stocks with a view to keeping commercial fishing within sustainable limits and improving sea culture and aquaculture practices; natural and anthropogenic factors impacting economically and socially on coastal systems from pre-history to the industrial epoch.

ISMN
Institute for Nanostructured Materials

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The ISMN (Institute for Nanostructured Materials) commitment is to develop nanostructured materials and systems in strategic research areas such as: Sustainable Development and Environmental Safety; Health; Converging Technologies. In the last years, ISMN activities have been addressed to the molecular design of new catalysts for the abatement of environmental pollution; innovative materials for fuel cells applications and the production of energy from biomass and hydrogen; the development of polymeric, lipid, oxide and metallic nanoparticles for drug-delivery; the development of hybrid systems for regenerative medicine; the production of organic and hybrid nanostructures for advanced multifunctional devices; converging technologies for electronics, photonics, bio-diagnostics, nanomedicine. ISMN research activities are carried on in collaboration with international and national Companies, Research Centers, Universities, such as IBM, SONY, PHILIPS, BASF, MERCK, SAES Getters, THALES, Cambridge Display Technology, STMicroelectronics, ENI, FIAT, ALENIA, PFIZER, SOLVAY/SOLEXIS, Scriba Nanotecnologie srl e Organic Spintronics srl, Princeton University, Los Alamos National Laboratory, National Cancer Institute-USA, Northwestern University-USA, EFPL-Lausanne, EMPA–Materials Science & Technology, CSEM di Zurigo, IMEC-Belgio, Cambridge University, Oxford University, Centre de Recherche des Musèes de France, Museo del Louvre-Parigi, Museo Egizio del Cairo, Istituti Ortopedici Rizzoli-Bologna.

ISN
Institute of Neurological Sciences

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The Institute of Neurological Sciences (ISN) is dedicated to neuroscience. Here multidisciplinary teams of biologists, geneticists, neurologists, neuroradiologists and clinical scientists generate information about the nervous system and apply that knowledge to understanding and treating neurological diseases. ISN focuses its main research activity on the integrated study of the nervous system by genetic and molecular biological analyses, and conventional and functional magnetic resonance techniques. The main current research program of the Institute is now focused on describing the brain morphology associated with neurological diseases as revealed by volumetric and functional imaging studies. Moreover, ISN continues to be attentive on using and developing the latest genetic tools and gene mapping methods to identify genetic mutations and novel gene loci that either influence disease susceptibility or other aspects of the disease phenotype (eg. severity).

ISOF
Institute for Organic Syntheses and Photoreactivity

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ISOF is a strategic institute in the Molecular Design Department of CNR. Chemistry is the building block of nanosciences and advanced sciences and technologies convergence – ISOF plays a major role in this field. ISOF aims to develop and apply molecular science and sustainable chemical manufacturing to the EU's energy and climate objectives at a local level, whilst also improving quality of life and local economies. ISOF tasks are: Design and synthesis of molecular and supramolecular structures with programmed functions; Studies of fundamental processes in complex systems of chemical, physical and biological interest. The ISOF carries out projects and proactive actions that range from the development of new synthetic methodologies to the organic functional materials, polymers, molecular photoscience and life sciences, as well as the interactions between ionising radiation and materials. ISOF's targets are: design, synthesis and characterisation of multiphase/multiscale functional materials and auto assembling bio-hybrids of various complexities; Bio-organic processes: study of cellular function and damage mechanisms that occur with the formation of free radicals; Molecular photoscience: study of the processes that involve electronic excited states in molecules and materials from the fundamental development in knowledge to the relevant applications of devices; Synthetic and natural macromolecular systems; Disruptive technologies: biotronics and graphene.

ISPA
Institute of Sciences of Food Production

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ISPA is a worldwide renowned centre of excellence acting in the fields of scientific research, innovation and technology transfer aimed to improve safety and quality of agro-food products. By creating synergistic actions between research and production sectors, ISPA fosters technological innovation paths of national and foreign agro-food enterprises. In the field of food and feed safety, ISPA is involved in developing innovative methodologies for detection of mycotoxins, toxigenic fungi, microbial pathogens and allergens in commodities (cereals, wine, pasta, milk, baby foods, dried fruits). In the area of food production, research is mainly aimed at improving nutritional and organoleptic quality, adding value to typical local products (dairy, bakery and meat products, fruits and vegetables). Innovative lines of probiotic and functional foods using traditional products are being developed. The Institute is also involved in research activities aimed at studying microbial diversity, applying biotechnological tools for the production of biomolecules (antioxidants, proteins, enzymes), at developing innovative techniques to improve quality and preservation of fruit and vegetables.
Strategic cooperative partnerships include world leader Institutions in the area of agro-food (FAO, EFSA, FSA, USDA) as well as with SMEs and large enterprises (Barilla, Syngenta, Bayer, Thermo, Copaim) within programs promoted by local, national and European funding bodies.

ISPAAM
Institute for Animal Production Systems in Mediterranean Environments

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The ISPAAM (Institute for Animal Production Systems in Mediterranean Environments) studies both animal production and pasture in the Mediterranean area. It's the only Institute of the CNR institutionally devoted to animal production. The primary objective of the ISPAAM is to improve the sustainability of forage-livestock systems through the optimization of the ratio yield/product quality to meet the needs of consumers and markets, respecting the environment. This activity allows us to harmonize the work conducted by various Institutions in the field of livestock, with the objective of planning the entire national system. The Institute is interested in livestock production with interdisciplinary approaches and systems that include both animal and vegetable productions, with particular attention to quality products and genetic improvement of both livestock and plants, giving preference to biological and extensive farms. All research activities are carried out in collaboration with numerous national and international institutions, including: INRA, France; UNI-UTAD, Portugal; UNI, Vet. Med., Glasgow, UK; Res Instit. Biol. Farm Anim., Germany; UNI, Vet. Med Canada; UNI, Dept. Vet. Pathobiol, Texas; Dept. Microbiol. Immunol. - Albert Einstein Coll. Med.; Dept Bioch. Bioph. - UNI Minnesota; Inst. Med Technol. UNI, Finland; EPE, Dept. Agric., Australia; UNI Reading University, USA; EPE INIA, Chile.

ISPF

Institute for the History of Philosophical and Scientific Thought in Modern Age

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The ISPF (Institute for the History of Philosophical and Scientific Thought in Modern Age) attends to the study of Italian and European philosophic and scientific thought from the early modern age up to the present time. It is concerned with the methodological questions involving the edition of philosophic and scientific texts and it focuses its activities on the edition, both hard print and digital, of Giambattista Vico, Antonio Vallisneri and Girolamo Cardano's works. The institute research activities are spread on several fields such as: the scientific and philosophic culture and language in modern age; Vallisneri's heritage in scientific culture; the history of philosophic historiography; the historical, cultural, linguistic and lexicographical aspects of intellectual and cultural migrations. Besides its activity of hard print and digital editing, it also works on sources analysis and catalogues; it publishes bulletins directed to the international scientific community, providing regular updates to the development of the researches; it organizes seminars, conferences and meetings, both national and international, as well as other cultural activities in collaboration with Universities and secondary schools. ISPF collaborates actively with a number of Italian and international institutions, such as the Goren-Goldstein Judaica Center, the University of Milan, the National Edition of Vallisneri's works, the University of Naples, the Regional administration of Campania, the University of Cagliari, the ESF European Science Foundation and CERPHI-Cnrs in Lyon.

ISSIA

Institute of Intelligent Systems for Automation

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The Institute of Intelligent Systems for Automation (ISSIA) was founded on April 2002, as a consequence of the national reorganization of CNR. The Institute is primary for its advanced knowledge about intelligent systems considering also the spin-off for industrial and social areas such as robotics, finalized to the development of intelligent machines capable of autonomously operating in unstructured and uncertain environments, automation for increasing performances, productivity and security of complex systems, signal and image processing in the field of integrated hardware and software systems for the acquisition and processing of multispectral, multitemporal and multiplatform information and systems for the measure and the support to decisions based on soft-computing in complex applications. Studying and developing complex intelligent systems involve the rise of new scientific opportunities and inter-disciplinary themes of research in the field of computer science (elaboration of information), physics (optics and light-matter interaction), cybernetics (computational neural models), electric and electronic engineering (sensors, actuators, control, electrical driving, power electronics, electromagnetic compatibility), mechanic engineering, artificial intelligence, digital signal and image processing, robotics, automation, operating research. The Institute is actually involved in several European projects, Italian projects and industrial grants for research activities.

ISSIRFA

Institute for the Study of Regionalism, Federalism and Self-Government

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The Institute for the Study of Regionalism, Federalism and Self-Government (ISSIRFA) is aimed at improving our understanding of issues concerning regionalism and federalism. The Institute is interdisciplinary (law, public finance and political science) and comparative. The Institute monitors systematically the following themes: reform processes in regional and local government; intergovernmental relations; fiscal federalism; legislative, regulatory and other activities by the regions in fields where they have competences (economic development, health and social services, environment, cultural and artistic heritage, migration); relations between regions and local governments and the European Union; research and innovation. The Institute is involved in the transfer of knowledge by way of the publication of periodic reports and of specialised consultancy. The ISSIRFA website plays an important role in this regard and publishes an on-line journal. There is a large Institute library and documentation centre open to the public. Finally, the Institute is frequently consulted by Parliament, the Conference of Speakers of the Assemblies of Regions and Autonomous Provinces, and the Legislative Offices of the Regional Assemblies. The Institute has relations with universities and research centres in Italy and abroad. It is a member of the International Association of Centres for Federal Studies (IACFS).

ISSM

Institute of Studies on Mediterranean Societies

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The mission of the Institute of Studies on Mediterranean Societies (ISSM) is the economic, social and historical research on societies of the Mediterranean world. In particular its research focuses on the exploitation of natural resources and sustainability, demographic evolution and migration flows, regional disparities, commerce, finance and labour market during the early Modern and Modern ages. Its approach is mainly economic and historical and is aimed at promoting cooperation among the Euro-mediterranean countries. The Institute publishes every year a Report on Mediterranean Economies (publisher Il Mulino, Bologna) and the international journal "Global Environment". The Institute cooperates with several Italian Universities and Italian and foreign research institutions such as the Italian Association for Regional Research (AisRE), the Maison des Hautes Etudes di Aix-en-Provence, the Maison Méditerranéenne de Sciences de l'Homme, the Southern Institute for History and Social Sciences (IMES), and the Association for the Development of Industry in Southern Italy (SVIMEZ).

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Institute of Cognitive Sciences and Technologies

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SECTIONS Padova, Trento

The ISTC (Institute of Cognitive Sciences and Technologies) conducts research and development, technological transfer and training activities in the fields of cognitive, communicative and language processes. As the birthplace of Cognitive Sciences in Italy, the ISTC studies various aspects of the acquisition, processing, deficit, and multimodal technologies in the communication sector; it analyzes speech and linguistic variability theories and cognitive development mechanisms, learning and socialization mechanisms in children and in nonhuman primates. Other areas of scientific research are artificial systems (intelligence, life and society), knowledge technologies (neural networks, autonomous robotics), social cognition (attitudes, motivations, transmission, cultural processes), environmental quality, health and society (prevention, education, integration, disability, technology design). The ISTC has an established network of international collaborations with many research centres (Santa Fe' Institute, Max Plank, Karolinska Institute, IRIT CNRS, PRI-Kyoto, AT&T lab & Bell Lab, CSRL in Colorado, CSLU in Oregon, I' Haskins Lab in New Haven, CSIC-IIIA of Barcelona, Complex Systems I. of Cambridge, IPO in the Netherlands) and universities (Lisbon, Manchester, Beirut, Surrey, Utrecht, Amsterdam, Paris, Nijmegen, Madrid, Barcelona, Montreal, Osaka, Aix-en-Provence, Yale, California, Amherst, Atlanta, London).

ISTEC
Institute of Science and Technology for Ceramics

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SECTIONS Torino

The research activities at ISTEC (Institute of Science and Technology for Ceramics) are focused on scientific and technological sectors related to ceramic materials. Innovation in materials and processes, training and teaching are the key issues. Multidisciplinary approaches of the studies are addressed to ceramics for applications in the fields of transport and mechanics (thermo-protection materials for space application, wear-resistant high strength-high temperature resistant materials, electrical-electronics (piezo-ceramics), energy-related sectors (ceramics for HT SOFCs), biomedicine (load-bearing prostheses and scaffold for reconstructive surgery), new materials for buildings (ceramic tiles with functional surfaces, geopolimer materials, new compositions and waste recycling in refractories), restoration and conservation of cultural heritage (ceramics, mosaics, architectural heritage, multi-media technologies). ISTEC has developed strong expertise for new products- new technologies and technology transfer to industries, in the frame of direct research contracts, of National or European projects. Well assessed relationships have been established with Institutions for scientific collaborations, among these, to mention a few: NASA, US Air Force –AFOSR, Shanghai Institute of Ceramics, Institut für Angewandte Geowissenschaften, Istituti Ortopedici Rizzoli, University Hospital, Basilea, Corning University New York, CSIC- Madrid, Technical University of Eindhoven, University of Seville (Spain), University of Stockholm, etc.

ISTI

Institute of Information Science and Technologies "Alessandro Faedo"

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ISTI (Institute of Information Science and Technologies "Alessandro Faedo") is responsible for research, technological transfer and teaching activities in the sector of Computer Science and more generally in the field of Information and Communications Technologies (ICT).
The interdisciplinary activities of the Institute can be classified in 5 thematic areas: Networking, covering all aspects (e.g. wireless, internet) and including new related technologies (e.g. domotics); Knowledge, focused on multimedia content search and intelligent content access, social networking, pervasive digital libraries; data mining, ubiquitous and adaptive user interfaces; Software, aimed at the testing and validation of software systems, and the evaluation and certification of ICT products and processes; Visual and High Performance Computing covering computer graphics, imaging, 3D scanning and surface reconstruction; Flight and Structural Mechanics concerning astrodynamics, physics of asteroids, space debris modelling, flight control of stratospheric balloons, satellite reentry forecasting, thermo-mechanics of solids.
ISTI is currently involved in about 90 projects with the European Commission, and Italian state and regional authorities, and also collaborates with many industries and companies including Fiat Auto, Ericsson Italia, Alstom Trasporti, ST Microelectronics, Finmeccanica-Alenia Aeronautica.

ISTM

Institute of Molecular Science and Technologies

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The Institute of Molecular Science and Technologies (ISTM), with headquarters in Milan at the chemical departments of the University of Milan, is also composed of two sections in Padua and Perugia, and two units research with third parties (URT), respectively, in Florence and Catania. Research activities are primarily aimed at deepening and diffusion of knowledge in the field of chemical sciences (inorganic, organic, industrial, physical chemistry, theoretical and computational). In the field of nanostructured materials ISTM has all the skills to make contributions as both basic and applied research in sustainable chemistry, miniaturized electronics, optoelectronics, information technology, nanomedicine and diagnostics, energy storage and conversion of solar energy. Specificity of the Institute is an established synergy with local and national academies not only for research but also for higher education. At the international level it has been activated a number of prestigious collaborations including those with the Danish National Research Foundation, Max-Planck Institute in Dresden, The Getty Conservation Institute, Academy of Sciences of the Czech Republic, Russia and Bulgaria, CNRS Montpellier, and many universities (Princeton, Melbourne, EPF Lausanne, ETH Zurich, Oviedo, Zaragoza, Cardiff, Oxford, Belfast).

ITABC

Institute of Technologies Applied to Cultural Heritage

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Institute of Technologies applied to Cultural Heritage (ITABC), founded in 1981, is a leading center in the field of interdisciplinary research methods devoted to the study, conservation and enhancement of Cultural Heritage.
Main goals of the Institute are as follows: advances in research for the reconstruction and contextualization of archaeological landscape using GIS, remote sensing, virtual reality, and multimedia; characterization of archaeological sites and historical artefacts using geological and high resolution geophysical methodologies; cataloguing, analysis, and study of ancient coins and monetary treasures; study and analysis of metallic handmade artefacts; analysis, documentation, evaluation, recovery, conservation, and exploitation of historical buildings through multidisciplinary research.
ITABC is coordinator or partner in several EU research projects and has active agreements with many Italian and foreign Universities (Catania, Florence, Foggia, Genoa, Milan, Palermo, Rome, Athens, Kings College-London, Oxford, Paris-Sorbonne, Salamanca, Valencia, Vienna, Boston, Chicago, Dallas, Providence, University of California, Xijang, others), leading public research centers (CINECA, ENEA, ICR, INFN, The British Museum, CNRS, CSIC, CULTNAT, The Cyprus Institute, Fraunhofer-Gesellschaft, ICCROM, NARA, NASA) and private enterprises (ESRI, GEOTOP, MENCI, SYREMONT).

ITAE

Institute of Advanced Energy Technologies "Nicola Giordano"

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The Institute of Advanced Energy Technologies "Nicola Giordano" (ITAE) of Messina has the role of promoting and developing innovative, highly efficient, and low pollutant energy technologies and processes, compatible with both fossil fuels and renewable energies.
The research activity spans from materials synthesis to manufacturing of new devices, in the following fields: production, storage, and use of hydrogen; air conditioning by non-electromechanical processes; electrochemical storage of energy (supercapacitors and batteries); exploitation of solar energy (photovoltaic cells, photodecomposition, solar collectors, solar cooling); and exploitation of waste heat from internal combustion engines (trigeneration, automotive air conditioning).
In the energy field, the Institute is an international and national technical reference, as attested by the cooperation with many industry groups (Ansaldo, FIAT, De Nora, Nuvera, Pirelli, ENEL, ENI, Tozzi, SAES Getter, ST Microelectronic, Johnson Matthey, Daimler Crysler, Toyota, Viessman, Werke GmBH &Co, Solvay, Electro Power System, Mitsubishi, Fiamm, Iveco, Rivoira, Indesit, SOL) and research entities (CNAM, CNRS, Aachen University, ECN, University of Warwick, Polytechnic of Turin, Polytechnic of Milan, Kosef - Korea, Indonesia Institute of Science, IHTE, Institute Borescow - Russia, IGT, Princeton University, Fraunhofer ISE - Germany, CIDETEQ - Mexico).

ITB
Institute of Biomedical Technologies

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SECTIONS Bari, Cagliari, Padova, Pisa, Roma

The Institute of Biomedical Technologies is a multidisciplinary institute including biologists, physicians, chemists, physicists and engineers. Research focuses on oncology, genetic and neurodegenerative diseases, stem cells, immunology, neuropharmacology, bioinformatics, proteomics, genomics and e-health. Major findings include: identification of mechanisms involving β-amyloid and neuromelanin in brain aging and neurodegenerative processes in Alzheimer and Parkinson's diseases; therapeutical properties of new opioid and cannabinoid compounds; role of cancer stem cells in tumor initiation and development; contribution of adult stem cells to tissue repair following heart damage; mechanisms of pathological inflammation and assays of immunological risk; mechanisms of genetic diseases and DNA repair; identification of tumor genes and genomic sequencing of many pathogens by microarrays and Next Generation Sequencing; new methodologies for Systems Biology and molecular modeling, specialized data bases and algorithms for data analysis; molecular characterization of biomarkers of neoplastic and age-related diseases by LC-MS approaches; E-health studies on conceptual models and architecture of health informative systems. ITB is well placed in the National and International scientific context and has established multiple collaborations with public and private research institutions.

ITC
Construction Technologies Institute

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The ITC carries out activities dealing with research, technological exploitation, technical evaluation and certification, technological transfer and training in the building and construction sectors with a particular focus on the investigation of either new or traditional materials, new methodologies and tools to assess construction components, systems and works from a performance-based perspective. The institute is actively involved in the improvement of the built-up environment: areas of expertise are methodologies and tools for the energy-environmental sustainability, seismic safety and enhancement of the historical and architectural heritage, recovery and damage prevention.
ITC collaborates with Italian Ministries (Economic Development, Infrastructures and Transport, Interior, Environment, University and Research); polytechnic institutes and Italian Universities in addition to ITACA and other Regional Administrations; main professional and business associations (Federcostruzioni and Finco); International Council for Research and Innovation in Building and Construction, European Network of Building Research Institutes, International Union of Testing and Research Laboratories for Materials and Structures, European Organization for Technical Approvals, Union Européenne pour l'Agrément Technique dans la Construction, World Federation of Technical Assessment Organisations, Institut International du Froid, CEN, ISO, European Group of Official Fire Laboratories, GNB/CPD.

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ITD
Institute of Educational Technology

ITD is the only CNR institute fully dedicated to research studies in educational technology. The Institute is strongly interdisciplinary, with expertise in areas such as informatics, mathematics, physics, linguistics, psychology and pedagogy. ITD's research studies cover a wide range of well recognized educational issues. These include the use of technology for improving the learning of scientific concepts or for promoting the inclusion of students with special needs; new emerging competencies; new methods of learning enriched by technology, e.g. collaborative learning, learning with tangible devices, game based learning, mobile learning, etc. ITD's main research areas include: school of the future; e-inclusion; e-learning; new skills for the knowledge society; digital literacy; professional training.
ITD has a consolidated presence in the European research sector, having participated with continuity in EC framework programmes over the past twenty years. Currently the Institute coordinates two EC projects and participates in a number of different projects, including four Networks of Excellence devoted respectively to Technology Enhanced Learning, Serious Games, E-inclusion and Virtual Museums. ITD has also taken a leading role in many local and national programs. The Institute publishes Italy's leading scientific journal on Educational Technology, TD (http://www.tdmagazine.itd.cnr.it/).

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ITIA
Institute of Industrial Technologies and Automation

ITIA-CNR, as a promoter of Industrial Innovation, performs strategic activities of Scientific Research and Technological Development for the Competitiveness and Sustainability of Italian and European Manufacturing Industries.
ITIA, contributing and supporting the European Technological Platform MANUFUTURE initiative, finalized in development of added high value manufacturing based on research and innovation, works on the development and co-evolution of new Products/Services, Processes and Production Systems and related enabling technologies in tightened collaboration with Enterprises, Universities, Research Centres and Institutions within National, European and International Programmes, Projects and Industrial Contracts.
On the basis of the new Manufuture strategical vision, ITIA-CNR has focalized its competences on the following main research areas: automation, mechatronics, industrial and service robotics, microsystems, controls, diagnosis, monitoring and new generation supervising systems, virtual design methods of products, process and factory design (including virtual and augmented reality), management and business paradigms.
The Institute performs RTD&I activities for the design, the development and the industrial verification of new machines, robots and production systems in various sectors, including automotive, white-goods and "Made in Italy" (shoes, furniture, textile, etc.). One of the main focus is to consider the Factory as a competitive and sustainable Product with a high added value, the Factory of the Future.

ITM
Institute on Membrane Technology

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The mission of the Institute on Membrane Technology is the multidisciplinary research, development, technology transfer and high education in membrane science and engineering as well as the application of membrane operations in various fields, including water treatment, gas separation, bioartificial organs, biotechnology, agro-food. ITM is internationally recognized for its skills in membrane preparation (organic, inorganic, mixed matrix, biohybrid membrane), transport phenomena, molecular membrane separation, catalytic membranes, catalytic membrane reactors, membrane contactors (including membrane emulsification and membrane crystallizer), integrated membrane processes, membranes in regenerative medicine and tissue engineering. Membranes are applied in most strategic fields, such as energy, environment, health, chemical manufacturing. In these areas, membrane technology reached a leading role with an annual growth higher than 20%. ITM strongly contributes to this development, playing a leading role also at the international level. ITM has established solid relationships with other Research Institutions, Universities and private companies in Italy, Europe (CNRS, University of Tewnte, -Lisbon, -Leuven, -Terragona; Helmholtz-Zentrum Geesthacht, IBET, VITO, SINTEF); China (CAS and CAAS), South Korea (KRICT, Hanyang Unversity); Japan (Tsukuba University), Saudi Arabia (KACST).

ITTIG
Institute of Legal Information Theory and Techniques

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ITTIG is the major legal sciences institute within the CNR, besides being the oldest one, as created in 1968. It carries out studies and research developing applications connected to the use of information and communication technologies in the area of law. This scientific activity has interdisciplinary perspectives where legal science and practice interconnect closely with information technologies, linguistics, documentation and communication sciences. ITTIG's recent activities have been focused on two main areas: Legal Informatics considered in a restricted way and Information Technology Law. ITTIG carries on analysis on strategies, policies, action lines on European, national and regional normative framework for the development of the information society and e-government services, aiming at ensuring new forms of governance of public institutions, access to public information heritage and promotion of new citizenship rights within the information society scenario. Further, it offers its expertises for advising corporate bodies and institutions in the field of administrative innovation and simplification and to Public Administrations and enterprises (Italian Parliament, Regional Assembly of Tuscany, Molise and Umbria, Italian Court of Cassation; Ministry of Justice and DigitPA - former C.N.I.P.A.). Finally, the Institute builds up and disseminates databases of national and international importance as well as specialized softwares and tools for managing online legal information.

IVALSA
Trees and Timber Institute

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The Trees and Timber Institute of the National Research Council was created in September 2002 by the merging of three previous institutes: the Institute for the Propagation of Tree Species (IPSL), the Institute of Wood Research (IRL) and the Institute of Wood Technology (ITL). It is the biggest Italian institute for research in the wood-forest sector.
The staff of IVALSA comprises 70 people, divided between the two branches in Trento and Florence. The research activities cover the technological development of wood, building, dendrochronology and preservation of the cultural heritage, protection and valorization of the forests, assistance for companies, education and documentation service.
The laboratories are equipped with innovative and advanced testing machinery and perform activities of consultancy and certification.
IVALSA collaborates with many Universities for the accomplishment of master or doctoral theses and participates in many national and European research projects. Moreover, IVALSA takes part in standardizing processes for the entire area of wood on both the national and European level.
IVALSA is a meeting place for scientific and technical confrontation, the natural reference point for the wood sector and for whomever is dealing with wood as a designer, building contractor, researcher or specialist.

IVV
Plant Virology Institute

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The IVV performs basic research on plant viruses, virus-like agents and diseases caused by these pathogens on different crop plants. These studies are oriented towards the exploration of the molecular mechanisms and gene functions involved in plant-virus interactions, using plant molecular biology approaches and new techniques such as high-throughput genome sequencing, transcriptomics and proteomics. In the research on virus resistance and the production of proteins for biomedical purposes to develop vaccines for medical and veterinary purposes, IVV is internationally recognised. The development and the use of diagnostic kits are also major interests: these have important impact on the identification of viruses in crops and in the certification of propagation material. The IVV provides advisory services to the Ministry of Agriculture and Forestry Policies and various Italian regions. The institute actively collaborates with several National and International organisations such as: European Molecular Biology Organization; ENEA; Rheinisch Westfaelische Technische Hochschule Aachen and the Federal Research Centre for Cultivated Plants in Germany; INRA in France; University of California, North Carolina State University, Oklahoma State University and the SDA-ARS Floral and Nusery Plants Research Unit; the SASA in Scotland; the Agricultural Biotechnology Center in Hungary; IMIDRA and CSIC in Spain; University of Essex, and the John Innes Centre and the University of East Anglia in UK.

NANO
Nanoscience Institute

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SECTIONS Lecce, Modena

The Nanoscience Institute, comprising the three centers NEST-Pisa, NNL-Lecce, and S3-Modena, gathers all the scientific expertise synergistically required for an understanding of physical phenomena at the nanometric scale and for their exploitation for technological innovation. Its primary objective is the fundamental study and the manipulation of systems at the nanometric scale. The research activities include the synthesis and fabrication of nanostructures and devices, the experimental and theoretical-computational study of their properties and functionality, and of their interfaces at a microscopic and mesoscopic scale, as well as their integration in complex functional systems. The results are used to develop multidisciplinary applications in several fields, in particular energy and the environment, the nano (bio) technologies, nanomedicine, also through projects, technologies and prototypes of industrial interest and, in some cases, of pre-production. The Institute is committed to the promotion of communication and education in the area of the nanoscience. A distinctive feature is its strong collaborations with Universities, research centers, and Italian and foreign companies.

OVI
The Italian Dictionary

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The Italian Dictionary (OVI) can rightly be defined as 'the Italian historical dictionary institute'. It publishes on its website the "Tesoro della Lingua Italiana delle Origini" (TLIO), a dictionary of Early Italian up to the end of the 14th century. Future steps will entail carrying on the work through following epochs and keeping up to date the dictionary. The OVI research activities all revolve around the pivot constituted by the TLIO redaction, a permanent workshop for the study of Italian throughout its history. The compilation is carried out from a huge textual database, constantly growing and open for free online consultation. This database has grown into the main tool for research in philology and history of the Italian language, as witnessed by its being chosen as the source of the "Lessico Etimologico Italiano" produced at the University of Saarbrücken. Other OVI research tools developed in situ are the softwares GATTO, a local-platform database for the management of textual corpora, and GattoWeb, for online interrogation. Outside OVI, the most important GATTO corpus is the Archivio di Testi Siciliani Antichi (ARTESIA) of the University of Catania. OVI collaborates with the Accademia della Crusca and with the Universities of Zurich and Notre Dame (Indiana, USA), and also with Italian Universities which send PhDs for stages in dictionary compilation.

SPIN

Institute for Superconductors, Innovative Materials and Devices

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SPIN (Institute for SuPerconductors, INnovative materials and devices) is active in the study of superconductors and of other innovative materials and of their application in the fields of electronics and energy: oxides, organic, hybrid and other complex materials exhibiting superconducting, magnetic and other properties for the development of novel nano- and micro-device concepts and prototypes. A relevant characteristic of the Institute is the extensive use of linear, nonlinear and ultrafast laser techniques for materials synthesis and characterization.

SPIN is endowed with an impressive set of advanced scientific instruments, including nearly 20 thin film deposition systems, 3 clean rooms, 3 high-field and-low temperature STM systems, numerous laser sources emitting from IR to UV and ranging from CW mode to femtosecond pulses.

The scientific research is supported by well-equipped electronic and mechanical workshops, library, www, e-mail, network-storage services and GRID computing. SPIN has a wide network of collaboration with national and international institutions. Collaborations with industrial partners and technology transfer activities are developed, also through the participation in regional networks. Training and education at undergraduate and PhD level are carried out in close collaboration with the Universities hosting the local SPIN Units.