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COLLOQUIA: WPCF-Resonance 2023

Preface

A. BADALÀ(1), G. VERDE(1), E. G. LANZA(1), L. REDIGOLO(1)(2) and M. RASÀ(1)(2)

(1) *INFN, Sezione di Catania - Catania, Italy*
(2) *Dipartimento di Fisica e Astronomia "Ettore Majorana", Università degli Studi di Catania Catania, Italy*

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Particle-particle correlations are a powerful tool to study the dynamics of nuclear collisions at different facilities, extending their investigations from the few tens of MeV per nucleon regime at GANIL and FRIB to the relativistic and ultra-relativistic domain of GSI/FAIR, RIKEN and the colliders at RHIC and LHC.

Correlation functions are used to probe the space-time properties of particle emitting sources, thus allowing to explore emission volumes and lifetimes. Researchers use intensity interferometry analyses of particle emissions in collision events. These techniques inherit their main ideas from the famous Hanbury Brown and Twiss effect, used in astronomy to measure the size of stars. When extended to particle and nuclear physics, intensity interferometry has contributed to significantly increase our understanding of energetic collisions and their link to the nuclear equation of state and to phase transitions in strongly interacting matter. The commonly used term *femtoscopy* emphasizes the aim to measure nuclear sizes, namely spatial distances of the order of a few femtometers, typically separating particles produced during an energetic collision. Moreover, directional femtoscopy analyses, where correlation functions are studied along different directions of the relative momentum vector, are sensitive to emission times as well, therefore providing tools to measure time intervals as short as 10^{-24}–10^{-21} seconds. Femtoscopy nowadays represents the most advanced technique to probe the space-time extent of particle emission sources, attracting the interest of a wide scientific community.

Another extensively explored field of research consists of using two- and multi-particle correlation to reveal resonances (at low and high energies) by invariant mass measurements. In the low energy regime of heavy-ion collisions (at a few tens of MeV/u), these measurements probes phenomena such as nuclear clusters and molecules, providing information about properties of unbound states, such as spins and decay branching ratios. These states can be used to determine emission temperatures in heavy-ion collisions or to study states of astrophysical relevance.

In high energy collisions ($\sqrt{s_{NN}} \approx$ tens or hundreds of GeV or some TeV), the measurement of resonances formed with u, d, s and c quarks and also exotic configurations (tetra or penta-quarks) is a fundamental tool to improve our understanding of the QCD and to probe partonic and hadronic matter. In particular, studying resonance characteristics and their modification could give insight on chiral symmetry restoration. Furthermore, hadronic resonances constitute a valuable probe for the properties of the medium formed in ultrarelativistic heavy-ion collisions. In particular, they provide information

on particle formation mechanisms, the properties of the hadronic medium at freeze-out, and they contribute to the systematic study of energy loss and recombination.

The present volume collects contributions by a wide community of scientists involved in both femtoscopy and resonance decay and production studies. The community gathered in Catania on November 6–10, 2023, to participate in the joint meeting of the XVI edition of the Workshop on Particle Correlations and Femtoscopy and of the IV edition of the Resonance Workshop. The event was organized by the Istituto Nazionale di Fisica Nucleare (INFN), Sezione di Catania and Laboratori Nazionali del Sud (LNS), together with the Physics and Astronomy Department "E. Majorana" of the University of Catania and the Technische Universität München (TUM).

The meeting, following the tradition of previous editions, was characterized by invited and contributed talks, presenting new results and ideas. The presented material, published on this volume, offers the opportunity to explore interdisciplinary aspects of nuclear and particle physics in the context of femtoscopy and resonance production and decay studies.

The presented results are based on experimental data collected at low/intermediate energy laboratories, such as FRIB, GANIL, GSI/FAIR, LNL, LNS, RIKEN, and at the relativistic/ultra-relativistic facilities of RHIC and LHC. The main scientific topics are listed below:

- Femtoscopy in A-A, p-A and p-p collisions
- Charge fluctuations and charge balance functions
- Correlations from conservation laws, flows, vorticity and initial conditions
- Equation of state, phase coexistence, clustering and critical phenomena in heavy-ion collisions
- Symmetry energy and nuclear transport effects on correlations
- Femtoscopy and time-scales in intermediate and low energy collisions
- Statistical methods and Bayesian analysis of data and models
- Invariant-mass spectroscopy, resonances and clusters in nuclear reactions with radioactive and stable beams
- Mesonic and baryonic resonances in e-e, p-p, p-A and A-A collisions
- Exotic resonances and candidates
- Innovative methods to identify (rare) resonances
- Dilepton resonances in particle and nuclear physics
- Chirality: dileptonic and hadronic resonance decays
- Final state interactions studies with femtoscopy

The joint workshop was characterized by a lively participation of students and young scientists, testifying an increasing interest in the community around the mentioned topics.