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Study of light-nuclei in cosmic rays with the PAMELA experiment: Preliminary results

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Summary. — An important issue for the long-duration satellite mission PAMELA, in orbit from June 2006, is the determination of fluxes and secondary-to-primary ratios for nuclei up to oxygen in the energy range 200 MeV/n–150 GeV/n. The study of the light-nuclei component of the cosmic radiation is strictly connected to a better understanding of the propagation properties, which has great importance for the study of signatures of new physics in CRs. In particular, cosmic rays of primary origin such as carbon and oxygen may interact with the interstellar medium to produce secondary spallogenic fragments such as lithium, beryllium and boron. The measured ratio of secondary-to-primary cosmic rays can be used to compute the mean amount of interstellar matter that cosmic rays have encountered before reaching the Earth; moreover, the shape of this ratios as a function of energy is seriously modified by changes in the propagation coefficients. Some results about the observation capability of the instrument for nuclei and a preliminary estimation of secondary-to-primary ratios will be presented in this work.

PACS 29.40.Mc – Scintillation detectors.
PACS 96.50.S- – Cosmic rays.

1. – The PAMELA mission

PAMELA is a satellite-borne experiment built to detect charged particles in cosmic rays with particular attention to antiparticles [1]. PAMELA has been in orbit since June 15th 2006. All the detectors are working nominally and analysis is in progress to achieve many scientific goals: principally the search for antimatter in primary radiation, the search for dark-matter sources but also the measurement of fluxes and ratios of the different components of the cosmic radiation and the study of interactions of the radiation itself with Sun and Magnetosphere. To reach all these scopes, PAMELA is composed by several instruments perfectly integrated: a Time-of-Flight system, a magnetic spectrometer, a silicon-tungsten electromagnetic calorimeter, an anticoincidence system, a shower tail catcher scintillator and a neutron detector.

2. – Light nuclei in cosmic rays

The study of the nuclear component of the cosmic radiation at energies higher than 200 MeV/n is a main topic for the PAMELA experiment. It is strictly connected to a better understanding of the propagation properties, which has great importance for the study of signatures of new physics in Cosmic Rays [2]. For example, indirect signals of dark-matter pairs annihilating in the halo of our Galaxy could be found in antiproton, antideuteron or positron CRs but this research is limited by the uncertainties in the propagation parameters and fluxes of charged particles located in the whole diffusive halo [3]. The PAMELA experiment will contribute to this issue measuring light-nuclei fluxes and ratios with good accuracy, also in some unexplored energy range. To achieve those scientific goals we can use and combine measurements of $\mathrm{d}E/\mathrm{d}x$ and momentum of the passing particles from three main subdetectors of PAMELA: the magnetic spectrometer [4], the calorimeter [5] and the Time-of-Flight system [6].

For example, the measurement of the energy loss of passing particles inside the planes of the ToF is a powerful tool for identification of light nuclei. Starting from such measurement, the algorithm to reconstruct Z of the nucleus is complex because many intrinsic topics of the instrumental components, such as attenuation length, Birks saturation of scintillators, saturation of PMTs, etc., produce deviation from the linearity of the response of the detector. Those effects have to be taken into account, evaluated and corrected; only after that it is possible to define Z starting from measured β and $\mathrm{d}E/\mathrm{d}x$ according to Bethe-Bloch equation. Actual work on data analysis of nuclei is based on ToF system as main charge detector; the value of Z reconstructed by the magnetic spectrometer is instead used to select heavier nuclei in the background of protons and helium. Z evaluated in the calorimeter is used to study the efficiency of the selection cuts. To evaluate the energy of the passing nucleus we can instead apply two different methods: we can derive it from the rigidity measured by the spectrometer or from the measured β from ToF; the first method is really powerful especially in the higher part of the explored energy range, the second one can be instead very useful in the lower part (up to about 3 GeV/n). Preliminary results on the estimation of secondary-to-primary nuclei ratios (mainly B/C, but also Be/C and Li/C) in the energy range from 1 GeV/n up to 30 GeV/n are consistent with previous results from other experiments; work is still in progress in order to enlarge the energy range and evaluate the systematic.

REFERENCES

[1] Picozza P. *et al.*, *Astropart. Phys.*, **27** (2007) 296.
[2] Maurin D. *et al.*, *Galactic Cosmic Ray Nuclei as a tool for Astroparticle Physics*, arXiv:astro-ph/0212111v1.
[3] Bottino A., Donato F., Fornengo N. and Scopel S., *Phys. Rev. D*, **70** (2004) 015005.
[4] Adriani O. *et al.*, *Nucl. Instrum. Methods A*, **511** (2002) 72.
[5] Boezio M. *et al.*, *Nucl. Instrum. Methods A*, **487** (2002) 407.
[6] Osteria G. *et al.*, *Nucl. Instrum. Methods A*, **535** (2004) 152.