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Measurement of antiproton production cross sections for dark matter search at the AMBER Experiment at CERN

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Multiple and concurring evidences reveal that the vast majority of the matter content of the universe is non baryonic and electrically neutral. This component is usually called Dark Matter (DM), for its lack of electromagnetic interactions, and is measured to constitute the 25% of the content of the Universe. The Dark Matter origin and nature is one of the most intriguing puzzle still unresolved, however the most common hypothesis is that it consists of weakly interacting massive particles (WIMPs), supposed to be cold thermal relics of the Big-Bang.

The indirect detection of DM is based on the search of the products of DM annihilation or decay. They should appear as distortions in the gamma rays spectra and or in anomalies in the rare Cosmic Ray (CR) components. In particular antimatter components, like antiprotons, antideuterons and positrons, promise to provide sensitivity to DM annihilation on the top of the standard astrophysical production.

The galactic cosmic rays span an energy range from about tens of MeV up to hundreds of TeV, and include nuclei from proton to iron and nichel, antiprotons, leptons and gamma-rays. The interpretation of galactic cosmic ray data requires, as well as the correct modelling of their sources and of the turbulence spectrum of the galactic magnetic field, also the knowledge of the cross sections that regulate the production and destruction of cosmic rays interacting with the interstellar medium.
For many production and inelastic cross sections, data are scarce or definitely missing.

In particular, the antiprotons in the Galaxy are of secondary origin and produced by the scattering of cosmic proton and helium nuclei off the hydrogen and helium in the interstellar medium.
The only measured production cross section is the proton-proton one, while all the reactions involving helium have no laboratory data in the useful antiproton energy range (0.1-100 GeV). The empirical modelling of those cross sections induces an uncertainty in the antiproton flux of about 30-40%. This should be compared with the 10% accuracy of the AMS-02 high-precision data on the antiproton flux.

A dedicated measurement campaign aimed at measuring the exclusive cross section p + He, with particular interest for the channel antiproton + X, is crucial for the search of DM signals in the spectra of antiprotons in cosmic rays.

While some experimental datasets on p-p collisions are available, the very first dataset on p-He collision was collected in 2016 by the LHCb experiment at 6.5 TeV.
The AMBER fixed target experiment at CERN would contribute to this fundamental DM search, performing a unique and complementary measurement with proton beam of few hundreds of GeV/c impinging on a LHe target. The proposed experiment aims to measure the double differential antiproton production cross-section for proton beam energies supplied by the M2 beam line (20 –280 GeV/c), which will provide a complementary input to the LHCb TeV-scale results.

A programme for experimental determination of the antiproton production cross-section in p+4He scattering is included in the first phase of the AMBER experiment which was approved by CERN in 2020 and is scheduled to run from 2023 onward.

In-person participation

Yes

Primary authors: CHIOSSO, Michela (Istituto Nazionale di Fisica Nucleare); GIORDANO, Davide (Istituto Nazionale di Fisica Nucleare)

Presenter: GIORDANO, Davide (Istituto Nazionale di Fisica Nucleare)

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