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Prescriptions on antiproton cross section data for precise theoretical antiproton flux predictions

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The cosmic-ray flux of antiprotons is measured with unprecedented accuracy by the space-borne particle spectrometers AMS-02. Its interpretation requires correct description of the dominant production process for antiprotons in our Galaxy, namely, the interaction of cosmic-ray proton and helium with the interstellar medium. In the light of new cross section measurements by the NA61 experiment of $p + p \to \bar{p} + X$ and the first ever measurement of $p + \mathrm{He} \to \bar{p} + X$ by the LHCb experiment, we update the parametrization of proton-proton and proton-nucleon cross sections.

We find that the LHCb pHe data constrain a shape for the cross section at high energies and show for the first time how well the rescaling from the pp channel applies to a helium target. By using pp, pHe and pC data we estimate the uncertainty on the Lorentz invariant cross section for all relevant antiproton production channels in the Galaxy. We use these new cross sections to compute the antiproton source terms. The uncertainties on the total source term is at the level of $\pm$20\% and slightly increase below antiproton energies of 5~GeV. Since this exceeds the uncertainties on the antiproton flux which is measured by AMS-02 at an accuracy of 5\% in an energy range from 1 to 400~GeV, we finally quantify the necessity of new data on antiproton production cross sections, and pin down the kinematic parameter space which should be covered by future data. Our results are discussed both in the center-of-mass reference frame, suitable for collider experiments, and in the laboratory frame, as occurring in the Galaxy. We find that cross section data should be collected with accuracy better that few percent with proton beams from 10 GeV to 6 TeV and a pseudorapidity η ranging from 2 to almost 8 or, alternatively,with p_T from 0.04 to 2 GeV and x_R from 0.02 to 0.7.

Summary

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