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Scrutinizing the evidence for dark matter in cosmic-ray antiprotons

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Global fits of primary and secondary cosmic-ray (CR) fluxes measured by AMS-02 have great potential to study CR propagation models and search for exotic sources of antimatter such as annihilating dark matter (DM). Previous studies of AMS-02 antiprotons revealed a possible hint for a DM signal which, however, could be affected by systematic uncertainties. To test the robustness of such a DM signal, in this work we systematically study two important sources of uncertainties: the antiproton production cross sections needed to calculate the source spectra of secondary antiprotons and the potential correlations in the experimental data, so far not provided by the AMS-02 collaboration. To investigate the impact of cross-section uncertainties we perform global fits of CR spectra including a covariance matrix determined from nuclear cross-section measurements. As an alternative approach, we perform a joint fit to both the CR and cross-section data. The two methods agree and show that cross-section uncertainties have a small effect on the CR fits and on the significance of a potential DM signal, which we find to be at the level of 3 sigma. Correlations in the data can have a much larger impact. To illustrate this effect, we determine possible benchmark models for the correlations in a data-driven method. The inclusion of correlations strongly improves the constraints on the propagation model and, furthermore, enhances the significance of the DM signal up to above 5 sigma. Our analysis demonstrates the importance of providing the covariance of the experimental data, which is needed to fully exploit their potential.

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