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Constraining Dark Matter Annihilation with Cosmic Ray Antiprotons using Neural Networks

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The interpretation of data from indirect detection experiments searching for dark matter annihilations requires computationally expensive simulations of cosmic-ray propagation. In this work we present a new method based on Recurrent Neural Networks that significantly accelerates simulations of secondary and dark matter Galactic cosmic ray antiprotons while achieving excellent accuracy. This approach allows for an efficient profiling or marginalisation over the nuisance parameters of a cosmic ray propagation model in order to perform parameter scans for a wide range of dark matter models. We identify importance sampling as particularly suitable for ensuring that the network is only evaluated in well-trained parameter regions. We present resulting constraints using the most recent AMS-02 antiproton data on several models of Weakly Interacting Massive Particles. The fully trained networks are released as DarkRayNet together with this work and achieve a speed-up of the runtime by at least two orders of magnitude compared to conventional approaches.

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