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Enhanced Cosmic-Ray Cooling in AGN from Dark Matter Deep Inelastic Scattering

The diffusion of high-energy cosmic rays (CRs) through the dark matter (DM) spikes of active galactic nuclei entails significant energy loss via interactions with DM. While previous studies of sub-GeV DM have focused on elastic scattering, this process becomes insufficient at higher proton energies and DM masses. In this work, we investigate the CR-DM deep inelastic scattering (DIS) as mediated by a vector portal. We calculate the DIS contribution to the CR energy loss rate and derive stringent exclusion limits on the CR-DM scattering cross-section for DM masses between 10^{-6} GeV and 1 GeV. For higher CR energies and mediator masses, the resulting CR cooling timescales are reduced by orders of magnitude after involving the DIS contribution, producing stringent constraints that surpass most of current experimental limits.

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