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Boosted Dark Matter Searches via Dark-Strahlung

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Summary

We propose an unprecedented search channel for boosted dark matter (BDM) signals coming from the present universe, which are distinct from simple neutrino signals including those coming from the pair-annihilation or decay of dark matter. The signal process is initiated by the scattering of high-energy BDM off an electron/nucleon. If the dark matter is dark-sector U(1)-charged, the scattered BDM may emit a dark gauge boson (called "dark-strahlung") decaying into a Standard Model fermion pair. We, for the first time, point out that the existence of this channel may allow for the interpretation that the associated signal stems from BDM, not from the (dark-matter-origin) neutrinos. We find that despite its subleading nature, the BDM with a large boost factor may induce an O(10-20%) event rate of the lowest-order simple elastic scattering of BDM, in the parameter regions unreachable by typical beam-produced dark matter. We further find that the dark-strahlung channel may even outperform the leading-order channel in BDM searches, especially when the latter is plagued by substantial background contamination. We argue that cosmic-origin BDM searches readily fall in such a case, hence taking full advantage of dark-strahlung. As a practical application, we study experimental sensitivities at DUNE far detectors, showing remarkable usefulness of dark-strahlung.

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