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The Direct Detection of Boosted Dark Matter at High Energies and PeV events at IceCube

We study the possibility of detecting dark matter directly via a small but energetic component that is allowed within present-day constraints. Drawing closely upon the fact that neutral current neutrino nucleon interactions are indistinguishable from DMnucleon interactions at low energies, we extend this feature to high energies for a small, non-thermal but highly energetic population of DM particle χ, created via the decay of a significantly more massive and long-lived non-thermal relic φ, which forms the bulk of DM. If χ interacts with nucleons, its cross-section, like the neutrino-nucleus coherent cross-section, can rise sharply with energy leading to deep inelastic scattering, similar to neutral current neutrino-nucleon interactions at high energies. Thus, its direct detection may be possible via cascades in very large neutrino detectors. As a specific example, we apply this notion to the recently reported three ultra-high energy PeV cascade events clustered around $1 - 2$ PeV at IceCube (IC). We discuss the features which may help discriminate this scenario from one in which only astrophysical neutrinos constitute the event sample in detectors like IC.

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