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Boosted Dark Matter in IceCube and at the Galactic Center

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We show that the event excess observed by the IceCube collaboration at TeV–PeV energies, usually interpreted as evidence for astrophysical neutrinos, can be explained alternatively by the scattering of highly boosted dark matter particles. Specifically, we consider a scenario where a ~ 4 PeV scalar dark matter particle φ can decay to a much lighter dark fermion χ, which in turn scatters off nuclei in the IceCube detector. Besides these events, which are exclusively shower-like, the model also predicts a secondary population of events at O(100TeV) originating from the 3-body decay $\varphi \longrightarrow \chi\chi a^-$, where a is a pseudo-scalar which mediates dark matter–Standard Model interactions and whose decay products include neutrinos. This secondary population also includes track-like events, and both populations together provide an excellent fit to the IceCube data. We then argue that a relic abundance of light Dark Matter particles χ, which may constitute a subdominant component of the Dark Matter in the Universe, can have exactly the right properties to explain the observed excess in GeV gamma rays from the galactic center region. Our boosted Dark Matter scenario also predicts fluxes of O(10) TeV positrons and O(100TeV) photons from 3-body cascade decays of the heavy Dark Matter particle φ, and we show how these can be used to constrain parts of the viable parameter space of the model. Direct detection limits are weak due to the pseudo-scalar couplings of χ. Accelerator constraints on the pseudo-scalar mediator a lead to the conclusion that the preferred mass of a is & 10 GeV and that large coupling to b quarks but suppressed or vanishing coupling to leptons are preferred.

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