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Primordial black hole as cosmic accelerator of light dark matter

Current multiton dark matter (DM) detectors are largely incapable of detecting light dark matter from the Galactic halo due to the energy threshold limitations of their recoil measurements. However, primordial black holes (PBHs) can evaporate via Hawking radiation to particles whose energies are set by the black hole temperature. Consequently, weakly interacting light dark matter (or dark radiation) particles produced in this manner can reach the Earth with sufficient flux and kinetic energy above the experimental thresholds. This opens up a novel avenue to probe the light dark sector in terrestrial experiments. In this work, we explore this possibility by considering fermionic DM produced through PBH evaporation and investigate its electron recoil signatures in direct detection experiments. We analyze both energy independent (constant) and energy dependent (scalar and vector mediated) DM-electron interactions, highlighting the strong dependence of the recoil spectra on the underlying Lorentz structure of the interaction. In addition, we also account for the attenuation effects due to loss of kinetic energy while DM traverses through Earth’s crust, which can significantly modify the incoming DM flux. Incorporating these effects carefully, we place constraints on light DM using the electron recoil data from XENONnT, LZ, and PandaX-4T.

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