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Exploring Sub-GeV Dark Matter Boosted by Diffuse Supernova Neutrino Background: Insights from XENONnT and LUX-ZEPLIN Experiments

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In recent years, there has been a growing interest in the direct detection of sub-GeV dark matter, which is theoretically well-motivated. However, probing sub-GeV cold dark matter particles has posed a persistent challenge, as their typical momenta are insufficient to induce recoils above the thresholds of conventional direct detection experiments. Notably, even very strongly interacting dark matter within this mass range has been suggested to elude all observational bounds. However, recent studies have unveiled a novel approach to explore this elusive realm, wherein dark matter particles, typically non-relativistic, acquire semi-relativistic velocities. Here, we focus on the specific case of dark matter boosting through its interactions with the diffuse supernova neutrino background in the galaxy. This mechanism introduces a high-energy dark matter component capable of interacting with both electrons and nuclei in the detector, triggering a detectable recoil signal. Our study |1| meticulously analyzes data from the XENONnT |2| and LUX-ZEPLIN (LZ) |3| experiments, culminating in the derivation of robust constraints on the scattering cross sections of sub-GeV boosted dark matter with both electrons and nucleons. Additionally, we emphasize the imperative nature of considering Earth's attenuation effects for both electron and nuclei interactions, while also highlighting the substantial role played by finite nuclear size effects in the context of nuclear scattering. Lastly, we present a comparison of our findings with existing constraints, illuminating the complementarity and significance of the LZ and XENONnT data in probing the sub-GeV dark matter parameter space, thereby emphasizing their potential to unveil this enigmatic realm.

References

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