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Investigating unidentified sources in the 4FGL-DR4 Fermi-LAT catalog as potential dark matter subhalos

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We explore the prospects for indirect dark-matter (DM) detection through gamma-ray emission from the annihilation of weakly interacting massive particles (WIMPs). Within the ΛCDM cosmological framework, hierarchical structure formation predicts the existence of DM halos and subhalos. If WIMPs constitute DM, they are expected to annihilate within subhalos, emitting gamma rays detectable by instruments such as the Fermi-LAT and Imaging Atmospheric Cherenkov Telescopes (IACTs). Since 2008, Fermi-LAT has cataloged over 7100 gamma-ray sources, with a third lacking clear astrophysical association. This opens the exciting possibility that some of these unassociated sources (unIDs) may actually be DM subhalos below a certain mass threshold, in which they are anticipated to not retain baryons and remain completely as dark satellites from our galaxy, emitting exclusively in gamma rays. Using the 14- years Fermi-LAT catalog (4FGL-DR4), we conduct a search for subhalo candidates among the 2428 unIDs in this catalog. We first implement filtering based on expected properties of DM subhalo to reduce our sample, and then consider different scenarios depending on the level of restriction of these rejection criteria. Through an exhaustive spectral Fermi-LAT data analysis with the Fermipy software, we find that none of the sources significantly prefers a DM interpretation. Then, in the absence of a clear hint, we place conservative constraints on the $\langle\sigma v\rangle$ – m_χ DM parameter space, that allows us to discard thermally-produced WIMP particles below 5 GeV in a conservative scenario, and below 90 GeV when assuming the sensitivity reach of the method.

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