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A New Computational Approach to Gamma-Ray Flux Modeling for WIMP Annihilation Detection

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The majority of the mass of the universe is composed of Dark Matter (DM),
whose unknown nature has to be determined via expansions of the standard model of particle physics (SM). A class of candidates frequently taken into account are Weakly Interactive Massive Particles (WIMPs): stable and massive particles coupled with SM via weak interaction. According to different models, WIMPs may annihilate each other, producing a shower of SM particles. The radiation created by this process may theoretically be observed as an additional high-energy component in regions with a high DM density, such as the galactic core or dwarf galaxies. The main challenge in characterizing such signals is the theoretical definition of both the spectral and spatial distribution of the diffuse source. This work introduces a new computational method to define the spatial distribution of the extensive gamma-ray flux resulting from WIMP pair annihilation, commonly referred to as the J-factor. This method has been developed and implemented in Python classes compatible with Gammapy, the official analysis tool used by the Cherenkov Telescope Array Collaboration. For WIMP masses of the order of TeV, the Cherenkov Telescope Array Observatory (CTAO) could be able to observe such radiation, thus providing information on the nature of DM. Additionally, the practicability of this method is showed presenting the detectability study of this signal with CTAO in the Large Magellanic Cloud, also considering an astrophysical background of various known sources.

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