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Unveiling dark sub-haloes in the Galactic plane with the Cherenkov Telescope Array Observatory

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Numerous observations point towards the existence of dark matter (DM) at astrophysical and cosmological scales, yet the fundamental nature of this elusive component of our universe remains unknown. Theory and simulations of galaxy formation predict that DM should cluster on small scales in bound structures called sub-halos or DM clumps. Sub-halos are abundant in the Galaxy and can produce high-energy gamma rays as final products of DM annihilation. Recently, it has been highlighted that the brightest halos should also have a sizeable extension in the sky. In this study, we examine the prospects offered by CTAO for detecting and characterizing such objects. From simple models for individual sub-halos and their population in the Milky Way including tidal effects, we examine under which conditions such sources can be identified in data collected by the Galactic plane survey proposed by the CTAO consortium. We use a full spatial-spectral likelihood analysis to derive the sensitivity of CTAO to extended DM sub-halo emission. We find that the brightest sub-halos of the Galactic population are detected at the 5σ level for annihilation ($b\bar{b}$) cross-sections $\langle\sigma v\rangle \sim 1 \times 10^{-24}$ cm^3/s of TeV-scale DM. This minimal cross-section for detection is almost sufficient to discriminate such a sub-halo from a point-like astrophysical source. We also assess the CTAO sensitivity prospects for the full sub-halo population depending on their resilience to tidal effects in the Galactic potential.

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