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Modelling the flux distribution function of the extragalactic gamma-ray background from dark matter annihilation

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The one-point function (i.e., the isotropic flux distribution) is a complementary method to (anisotropic) two-point correlations in searches for a gamma-ray dark matter annihilation signature. Using analytical models of structure formation and dark matter halo properties, we compute the gamma-ray flux distribution due to annihilations in extragalactic dark matter halos, as it would be observed by the Fermi Large Area Telescope. Combining the central limit theorem and Monte Carlo sampling, we show that the flux distribution takes the form of a narrow Gaussian of 'diffuse'light, with an 'unresolved point source'power-law tail as a result of bright halos. We argue that this background due to dark matter constitutes an irreducible and significant background component for point-source annihilation searches with galaxy clusters and dwarf spheroidal galaxies, modifying the predicted signal-to-noise ratio. A study of astrophysical backgrounds to this signal reveals that the shape of the total gamma-ray flux distribution is very sensitive to the contribution of a dark matter component, allowing us to forecast promising one-point upper limits on the annihilation cross section. We show that by using the flux distribution at only one energy bin, one can probe the canonical cross section required for explaining the relic density, for dark matter of masses around tens of GeV.

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