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Amplified J-factors in the Galactic Center for velocity-dependent darkmatter annihilation in FIRE simulations

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We use FIRE-2 zoom cosmological simulations of Milky Way size galaxy halos to calculate astrophysical J-factors for dark matter annihilation and indirect detection studies. In addition to velocity-independent (s-wave) annihilation cross sections σv, we also calculate effective J-factors for velocity-dependent models, where the annihilation cross section is either either p-wave (∝v2/c2) or d-wave (∝v4/c4). We use 12 pairs of simulations, each run with dark-matter-only (DMO) physics and FIRE-2 physics. We observe FIRE runs produce central dark matter velocity dispersions that are systematically larger than in DMO runs by factors of ~2.5–4. They also have a larger range of central (~400 pc) dark matter densities than the DMO runs (ρFIRE/ρDMO□0.5–3) owing to the competing effects of baryonic contraction and feedback. At 3 degrees from the Galactic Center, FIRE J-factors are 5−50 (p-wave) and 15−500 (d-wave) times higher than in the DMO runs. The change in s-wave signal at 3 degrees is more modest and can be higher or lower (~0.3–6), though the shape of the emission profile is flatter (less peaked towards the Galactic Center) and more circular on the sky in FIRE runs. Our results for s-wave are broadly consistent with the range of assumptions in most indirect detection studies. We observe p-wave J-factors that are significantly enhanced compared to most past estimates. We find that thermal models with p-wave annihilation may be within range of detection in the near future.

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