Contribution ID : **53** Type : **Short communications**

Numerical Reconstruction of Dark-Matter Spikes around Black Holes and Their Connection to Gamma-Ray Observables

Thursday, 20 August 2026 15:00 (20)

The adiabatic growth of a black hole within a collisionless dark-matter halo can generate a steep central overdensity, or dark-matter spike, potentially enhancing annihilation signals by several orders of magnitude. We present an independent numerical reconstruction of the Gondolo–Silk formalism and its extension to intermediate-mass black holes by Bertone, Zentner, and Silk.

For the Gondolo–Silk scenario, the final density distribution is reconstructed from phase-space integrals while conserving angular momentum and radial action during the transition to a black-hole-dominated potential. We recover the isothermal solution and generate cusped profiles for different initial logarithmic slopes, including the full radial correction and spike-radius dependence.

Comparison with the published parametrization reveals normalization discrepancies for non-isothermal configurations, reaching approximately two orders of magnitude, while agreement improves in the isothermal limit.

We also implement the Bertone–Zentner–Silk framework with an NFW halo, annihilation plateau, inner cutoff, J-factor, and gamma-ray flux calculation. A parametric detector-response model then maps the predicted flux into reconstructed event distributions, providing an end-to-end framework for future gamma-ray sensitivity studies.

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Session Classification : HEP & Astrophysics & Astronomy