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Pulsar Timing Array Evidence for Self–Interacting Dark Matter in Super-Massive Black-Hole Mergers

Pulsar timing arrays (PTAs) have now revealed a nano-hertz stochastic gravitational-wave background whose amplitude and spectral shape are consistent with a cosmic population of merging super-massive black-hole (SMBH) binaries. Explaining how such binaries bridge the "final parsec"separation before gravitational radiation dominates remains a key challenge. Following the mechanism proposed by Alonso-Álvarez *et al.* (2024), we investigate whether dynamical friction from a dense spike of *self-interacting dark matter* (SIDM) surrounding each SMBH can simultaneously solve the final-parsec problem *and* imprint the mild low-frequency turnover hinted at in current PTA data.

We perform the first full-likelihood Bayesian analysis of this scenario using the NANOGrav 15-year data set. Employing a custom-corrected version of the holodeck pipeline, we sample
the joint posterior of SMBH-population, host-galaxy and SIDM parameters with an MCMC and marginalise over astrophysical uncertainties. The velocity-weighted cross section per unit mass is
constrained to

$\langle \sigma v/m \rangle = 10^{2.9\pm0.5}\,\mathrm{cm}^2/(\mathrm{g\,km\,s}^{-1}), This range is fully compatible with independent inferences from dwarf-galaxy cores and galaxy-cluster offsets, favouring a Yukawa-like velocity dependence mediated by an$ O(10–100)MeV dark photo
binaries within a Hubble time, whereas collisionless cold-DM spikes are disrupted too early.

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