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Constraining axion couplings with the Hulse-Taylor binary system

The orbital evolution of the Hulse-Taylor binary neutron star system is described with high precision by General Relativity, in which gravity is the only long-range force and gravitational waves provide the dominant energy-loss channel. We use this precision test of relativistic binary dynamics to derive new constraints on axion couplings to stable neutron-star constituents: neutrons, electrons, and muons. In the presence of exotic long-range forces and additional radiation channels, the measured orbital decay constrains the strength of quadratic axion-fermion interactions.

Axions enjoy a perturbative shift symmetry that is broken by non-perturbative effects responsible for the axion mass. Such shift symmetry breaking can induce quadratic couplings between axions and fermions. In an ambient axion dark-matter background, these couplings mediate enhanced long-range, spin-independent forces, while also allowing binary systems to lose energy through dipole and quadrupole emission of axion waves. For light QCD axions and for models in which non-perturbative effects correct lepton masses, our bounds can be recast as limits on the axion decay constant.

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