

## Strong-Field Dynamics and Multimessenger Signatures of Ultralight Dark Matter

Ultralight bosons near compact objects can form gravitationally bound states, some of which grow exponentially by extracting black hole rotational energy or through relaxation from ambient waves. These states can reach field amplitudes approaching the Planck scale, leading to non-perturbative phenomena analogous to early-universe cosmology and to observational signatures far stronger than those from local dark matter detection, including electromagnetic features in black hole imaging and gravitational-wave imprints of the surrounding environment. Two examples of strong-field phenomena will be discussed. First, accreting axion clouds can enter a saturation regime in which the field approaches the decay constant, with relativistic axion emission balancing the accretion and encoding the underlying self-interactions. Second, high-energy neutrinos propagating through a dense scalar background with non-diagonal couplings can undergo parametric resonance, leading to distortions in the observed flavor ratios.

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