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Soliton mergers and radio transients —A new window on dark photon dark matter

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Ultralight dark photons can form stable, compact clumps that possess macroscopic coherence, called solitons. When two such solitons collide and merge, the merged object can suddenly convert its stored dark-sector energy into ordinary radio photons through a process called parametric resonance. The merger rate scales steeply with local soliton number density (merger rate ∝ density^2), so regions near supermassive black holes — where dark matter can form dense, spiky profiles —are especially important for producing detectable bursts.

We use the lack of such narrow, powerful radio transients in existing surveys to set concrete limits. For dark photon masses that correspond to radio frequencies (~10^{-6}–10^{-4} eV), current nondetections imply that at most a few percent of dark matter can reside in these solitons. Alternatively, if a large fraction of dark matter were in solitons, the coupling that converts dark photons to ordinary photons must be extremely small. These bounds come from comparing predicted burst rates and energies with radio telescope exposure and nonobservation.

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