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S-matrix bootstrap bounds on self-interacting dark matter

Self-interacting dark matter turns the structure of galactic halos into a direct requirement on a low-energy scattering amplitude. We show that, for weakly coupled scalar dark matter, this requirement implies a much stronger mass bound on the dark matter particle than partial-wave unitarity alone. Using analyticity, crossing symmetry, locality and partial-wave unitarity, we compute the maximal allowed threshold amplitude with a dispersive primal S-matrix bootstrap, assuming only a weakly coupled EFT below a scale Λ and allowing arbitrary UV particle content above Λ. For the benchmark self-interaction cross section $\sigma_{\rm self} = 10^{-24}(M/\mathrm{GeV}), \mathrm{cm}^2$, the mass of a generic weakly coupled scalar satisfies $M <\approx 0.3, \mathrm{GeV}$ in the controlled EFT regime. If dark matter is a derivative-dominated pseudo-Nambu-Goldstone boson, the mass bound is lowered to the MeV scale or below, depending on the hierarchy M/Λ. The results presented here are based on recent joint work with Qing Chen and Shuang-Yong Zhou, arXiv:2607.13141.

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