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The abundance of core–collapsed subhalos in SIDM: insights from structure formation in ΛCDM

Dark matter halos can enter a phase of gravothermal core–collapse in the presence of self-interactions. This phase that follows a core–expansion phase is thought to be subdominant due to the long time-scales involved. However, it has been shown that the collapse can be accelerated in tidal environments particularly for halos that are centrally concentrated. Cosmological simulations in ΛCDM give us the full distribution of satellite orbits and halo profiles in the universe. We use properties of the orbits and profiles of subhalos from simulations to estimate the fraction of the subhalos in different host halo environments, ranging from the Large Magellanic cloud(LMC)–like hosts to clusters, that are in the core–collapse phase. We use fluid simulations of self–interacting dark matter (SIDM) to evolve subhalos in their hosts including the effect of tidal truncation at the time of their pericenter crossing. We find that for parameters that allow the interaction cross-section to be high at dwarf scales, at least 10 % of all subhalos are expected to have intrinsically collapsed within Hubble time up to the group mass host scales. This fraction increases significantly, becoming at least 20% when tidal interactions are considered. To identify these objects we find that we either need to measure their densities at very small radial scales, where the subhalos show a bimodal distribution of densities, or alternatively we need to measure the slopes of their inner density profiles near the scale radius, which are much steeper than NFW slopes expected in cold dark matter halos. Current measurements of central slopes of classical dwarfs do not show a preference for collapsed objects, however this is consistent with an SIDM scenario where the classical dwarfs are expected to be in a cored phase.

[1] Shah, Neev, and Susmita Adhikari. The Abundance of Core–Collapsed Subhalos in SIDM: Insights from Structure Formation in ΛCDM. arXiv, 30 Aug. 2023. arXiv.org, http://arxiv.org/abs/2308.16342.

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