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Impact of baryons on the population of galactic subhalos and implications for dark matter searches

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In standard ΛCDM cosmology, dark matter (DM) halos are teeming with numerous substructure, or subhalos, as a natural consequence of the way structure formation works in ΛCDM. If massive enough, both halos and subhalos host visible galaxies, while lighter ones would host no stars or gas at all and would remain dark (dark satellites). In this work, we have used Auriga - a set of state-of-the-art cosmological hydrodynamical simulations of Milky Way-size systems - to study the impact of baryons on the Galactic subhalo population. A DM-only simulation counterpart of Auriga, also available, allows us to compare results with and without baryons. Since the resolution of these simulations is limited, we applied an algorithm to repopulate the original simulations with low-mass subhalos well below the resolution limit. The survival of low-mass subhalos to tidal forces is unclear and under fierce debate nowadays, so in our study we stay agnostic to it and consider two different degrees of subhalo resilience to tidal stripping ('fragile' and 'resilient' subhalos). We find baryons to alter the Galactic substructure significantly, by decreasing its overall abundance by a factor ~ 2.4 (fragile) and ~ 1.9 (resilient) and the concentration of individual subhalos by ~ 1.5 with respect to their DM-only counterparts. This has important consequences for e.g. indirect searches of DM, in particular those focused on the use of unidentified gamma-ray sources to set constraints on the DM particle properties. We find the DM annihilation cross-section constraints - based on DM-only simulations and the same setup of subhalo resilience - to worsen by a factor ~ 3.8 in the most realistic case of including baryons. Yet, a stronger resilience of subhalos to tidal stripping improves these DM limits by a factor ~ 4.6 and ~ 11.4 compared to the DM-only and hydrodynamical 'fragile' cases, respectively. Our results show the importance of including baryons to properly characterize the Galactic subhalo population, and to propose the most optimal subhalo search strategies, not only via its potential annihilation products but also their gravitational signatures (e.g. stellar streams, lensing).

Collaboration(s)

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