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Evolution of Mass and Structure in Dark Matter Halos: Scaling Laws from Dwarfs to Galaxy Clusters

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We investigate the mass evolution of dark matter subhalos in Milky Way–like galaxies using ultra-high-resolution N-body simulations (Kazuno et al. 2024). Subhalos undergo early accretion followed by tidal stripping, losing over 80% of their mass by z = 1. Their orbits closely resemble those of Milky Way satellites, as revealed by Gaia EDR3, reinforcing the CDM paradigm. In contrast, Kaneda et al. (2024) examine internal structure. The radius of maximum circular velocity emerges as a critical scale where observed surface densities align with CDM predictions from the concentration–mass (c–M) relation. This agreement reflects the universality of dark matter halo scaling relations, including the near-constant central surface density seen from dwarf galaxies to galaxy clusters. Remarkably, despite baryonic feedback, observational evidence from UFDs and SPARC rotation curves confirms that these relations persist down to halo masses below 10^8 M⊙, highlighting their robustness across a broad mass range.

References

Kazuno, Mori, Kaneda & Otaki, PASJ, 76, L39 (2024); Kaneda, Mori, Otaki (2024), PASJ, 5, pp. 1026–1040; Ogiya, Mori, Ishiyama, & Burkert, ApJ, 440, L7 (2014)

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