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Cold dark matter halo concentrations and their implications for substructure annihilation boosts

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In the standard cosmology, there exists a strong connection between the internal structural properties of dark matter (DM) halos and their formation epochs. Such information can be expressed in terms of a single key parameter known as concentration. We compute the natal halo concentrations that naturally arise in the model by Prada et al. (2012), which links the concentration with the r.m.s. of the matter fluctuations. We then examine the mass-concentration relation, c(M), given by this model at present time over a huge range of halo masses, i.e. from Earth-mass microhalos up to galaxy clusters, and check its predictions against results from N-body cosmological simulations. Despite little knowledge of halo concentrations below 1e10 Msun in simulations, the model works remarkably well; indeed, it is compatible with all the available data down to Earth-mass microhalos within 1-sigma errors. Both the simulation results and the model show a clear flattening of the c(M) relation at lower masses that excludes the use of simplistic power-law c(M) models below the mass resolution of current simulations. This fact has important consequences e.g. for gamma-ray DM searches, as it implies more moderate enhancements of the DM annihilation flux due to DM substructure - the so-called substructure boost - than usually assumed. Recent works that derived or used substructure boosts >1000 for galaxy clusters and >200 for Milky Way-sized halos relied on such power-law extrapolations, and thus are clearly disfavored. We obtain much more moderate boosts, i.e. <50 for galaxy clusters and <20 for galaxies like our own. DM annihilations in dwarf galaxies are not significantly boosted by the presence of sub-substructure. These numbers have a critical impact on current DM searches as well as on future DM search strategies.

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