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Dark matter particle mass and properties from scaling laws in galaxy rotation curves and N-body simulations

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We present a theory to estimate dark matter particle mass, size and other properties based on the scaling laws identified from galaxy rotation curves and N-body simulations (Illustris project etc.). The existence of energy cascade in the hierarchical formation of dark matter halos leads to a two-thirds power law for kinetic energy and a four-thirds power law for halo core density with the length scale r. Both scaling laws can be directly confirmed by N-body simulations and rotation curves. For collisionless dark matter with gravity as the only interaction, these scaling laws can be extended down to the smallest scale, where quantum effects become important. This extension suggests a possible heavy dark matter scenario with a particle mass of $\sim 10^{12}$ GeV. Potential extension of the theory to self-interacting dark matter is also presented to identify constraints on the cross section of self-interaction.

Accompanying slides and datasets for this work can be found at https://doi.org/10.5281/zenodo.6569901.

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