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The dark first structures

The first structures of particle dark matter form by gravitationally condensing out of the smooth mass distribution of the early universe. This formation mechanism leaves these *prompt cusps* with uniquely compact *r*^{-1.5} density profiles and links their properties tightly with the primordial mass and velocity distributions. Although they are the oldest elements of cosmic structure, prompt cusps largely persist through the growth and clustering of dark matter halos around them, making them the densest and most abundant dark matter systems today. I will present the basis for prompt cusps in simulations and theory, and I will discuss how they bring new opportunities to test the nature of dark matter and the physics of the early universe. For example, if the dark matter annihilates, then prompt cusps dominate the annihilation rate, while if the dark matter is warm, then the cusps can influence the kinematics of dwarf galaxies. I will also discuss the influence of early structure formation for an alternative dark matter candidate –primordial black holes (PBHs) –based on a new simulation that fully resolves the inter-PBH dynamics. For example, gravitational interactions involving PBH binaries can eject PBHs at extreme speeds, making a component of "hot dark matter" that suppresses the growth rate of structure up to galaxy scales.

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