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Using Microhalos to Probe the Universe's First Second

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As remnants of the earliest stages of structure formation, the smallest dark matter halos provide a unique probe of the primordial density fluctuations generated during inflation and the evolution of the early Universe. Any enhancement to the small-scale matter power spectrum will trigger the formation of dark matter halos far earlier than otherwise expected. Consequently, observational limits on the abundance of early-forming ultra-compact minihalos (UCMHs) place a powerful upper bound on the amplitude of the small-scale power spectrum, which in turn constrains inflationary models. Numerical simulations of UCMH formation reveal that these constraints need to be revised: UCMHs do not have the steep power-law density profiles predicted by spherical collapse. The abundance of microhalos also encodes information about the evolution of the Universe prior to Big Bang nucleosynthesis because deviations from radiation domination accelerate the growth of small-scale density perturbations. The resulting population of microhalos significantly boosts the dark matter annihilation rate, making it possible to use gamma-ray observations to learn about the evolution of the Universe during its first second.

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