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Dark Matter Constraints from the Kinematics, Structure, and Light of SDSS Satellite Galaxies

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The nature of dark matter (DM) on small scales remains uncertain, but recent theoretical and observational advances now allow us to constrain its properties more tightly. In this talk, I present two complementary approaches. First, we show that the correlation between internal velocities and sizes of dwarf galaxies is a sensitive probe of small-scale DM physics. Using modified DM power spectra, motivated by inflationary production mechanisms, we demonstrate that such models can alter dwarf galaxy structure without affecting overall abundance. Applying semi-analytic models to Milky Way and SDSS satellites, we constrain the power spectrum at comoving scales $4 < k/\mathrm{Mpc} < 37$, ruling out deviations from scale invariance larger than a factor of ~2.5.

Building on this, I present a forward-modeling framework that incorporates additional observables, including luminosities, to further constrain small-scale structure. We test three scenarios, Cold DM, Warm DM, and a blue-tilted ("lumpy") model, and connect halo predictions to satellite properties via a probabilistic galaxy–halo connection. Comparing to SDSS data with a likelihood-based approach, we jointly probe dark matter and low-mass galaxy formation. Together, these results offer new and robust constraints on the small-scale matter power spectrum.

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