Baryonic Impacts on Self Interacting Dark Matter

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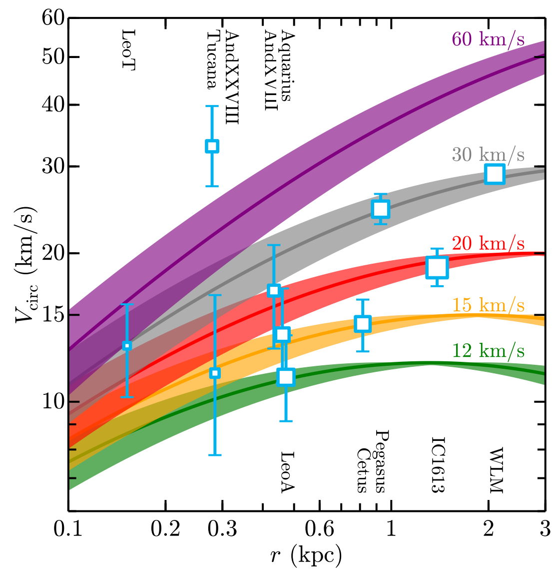
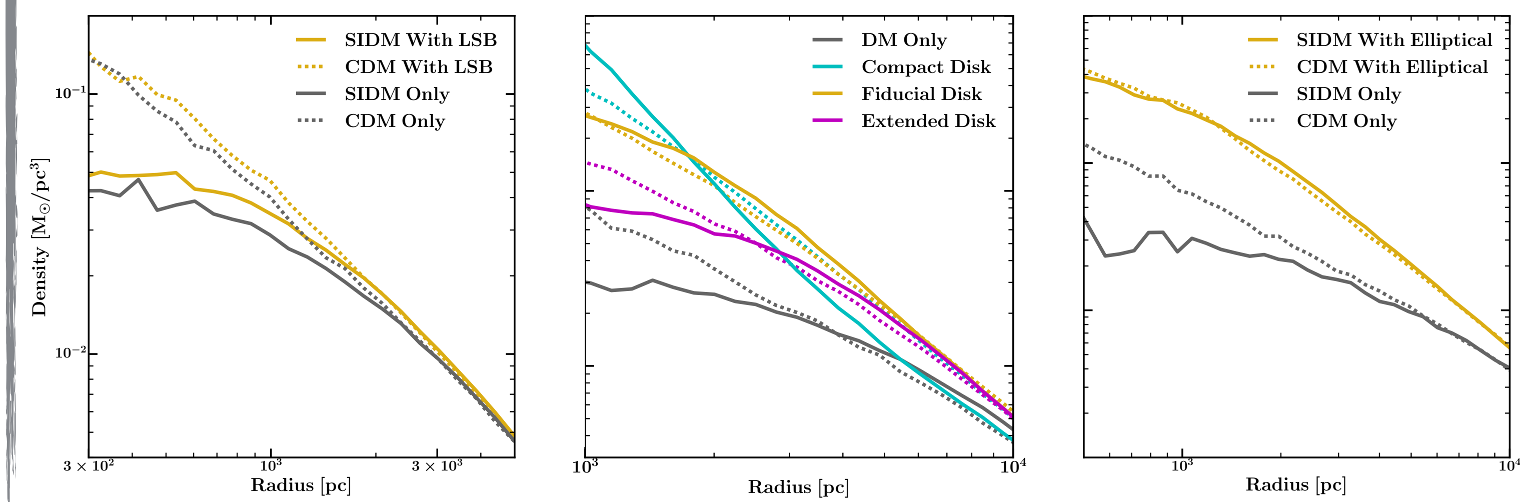
Introduction

While the standard cold dark matter paradigm has been very successful explaining the large-scale universe, the detailed microphysical nature of the dark matter particle remains poorly constrained. Alternatives to non-interacting dark mater have been proposed to alleviate issues at small scales (e.g. the Missing Satellites and Too Big to Fail problems) and dark matter only simulations have provided evidence that self-interacting dark matter (SIDM) models can solve Too Big to Fail. However, baryonic physics is expected to have different effects on cold and self-interacting dark matter halos. To model these effects I have run high-resolution simulations of idealized host halos for LSB, Milky Way-like and Elliptical galaxies with gravitational potentials grown in the halos to represent the galaxies.



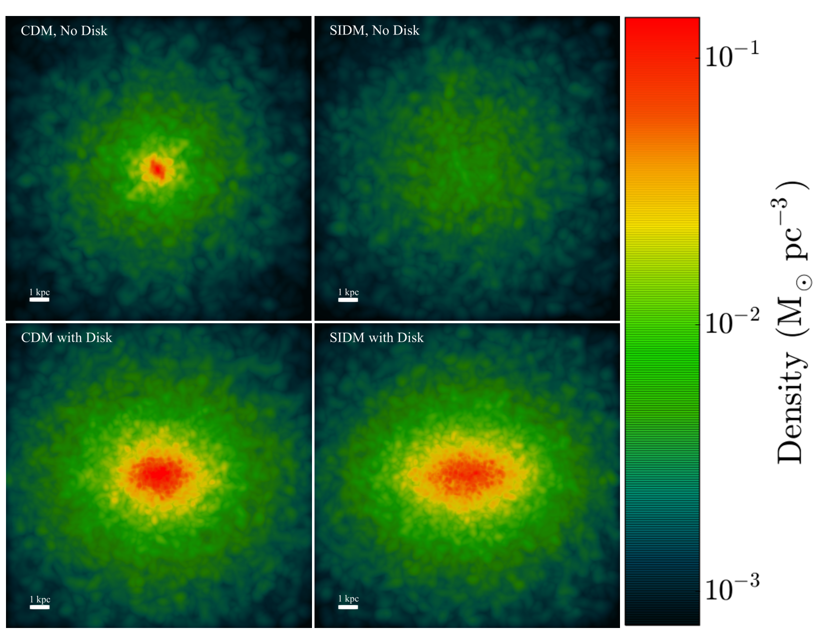
Too Big to Fail, Illustrated.
From Garrison-Kimmel et al. (2014b)

SIDM halos are susceptible to contraction



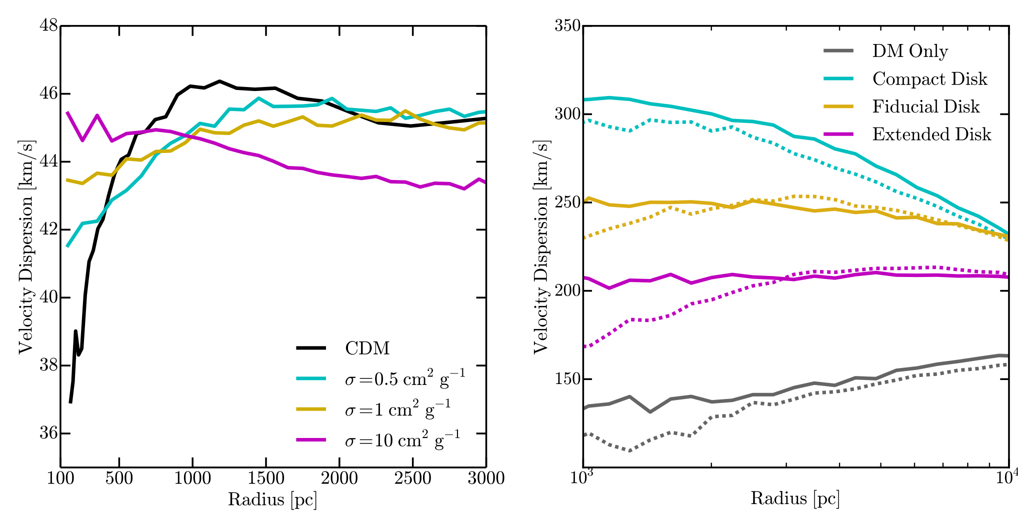
Plotted are density profiles of our idealized LSB, Milky Way and Elliptical halos in CDM (dashed) and SIDM (solid) with and without their respective gravitational potentials.

Simulations



Edge-on visualizations of the dark matter density in an idealized Milky Way sized halo for both CDM (left) and SIDM (right). Halos simulated with a Milky Way-like disk potential are shown in the bottom row.

Thermal structure sets core size



Left: Velocity dispersion profiles for dwarf halos simulated in CDM and SIDM from Elbert et al, 2015. Right: Velocity dispersion profiles of our simulated Milky Way halos in SIDM (solid) and CDM (dashed).

Conclusion

SIDM particles exchange energy in halo centers to create isothermal cores, but if the center is already heated due to baryonic contraction less energy exchange can occur, and so the impact of dark matter self interactions is lessened. The exception is if the baryonic contraction is great enough to produce a negative thermal gradient; in this case the SIDM halo may undergo core-collapse and become denser than the corresponding CDM halo. However, halos hosting less dense galaxies (such as dwarfs and LSBs) will undergo relatively little contraction, and so SIDM can have a large impact in these regimes. However, the smaller halos that host these more extended galaxies may be more vulnerable to disruption from stellar feedback. More work is underway to asses the impact of feedback in this regime.

References: Rocha, M; Peter, A. H. G; Bullock J. S; Kaplinghat, M; Garrison-Kimmel, S; Oñorbe, J; Moustakas, L: 2013 MNRAS 430, 81
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