Motivations for a Large Self-Interacting Dark Matter Cross Section from Milky Way Satellites

arXiv: 2203.10104

Maya Silverman[1], James Bullock[1], Manoj Kaplinghat[1], Victor Robles[1,2], Mauro Valli[1,3]

[1] Department of Physics and Astronomy, UC Irvine

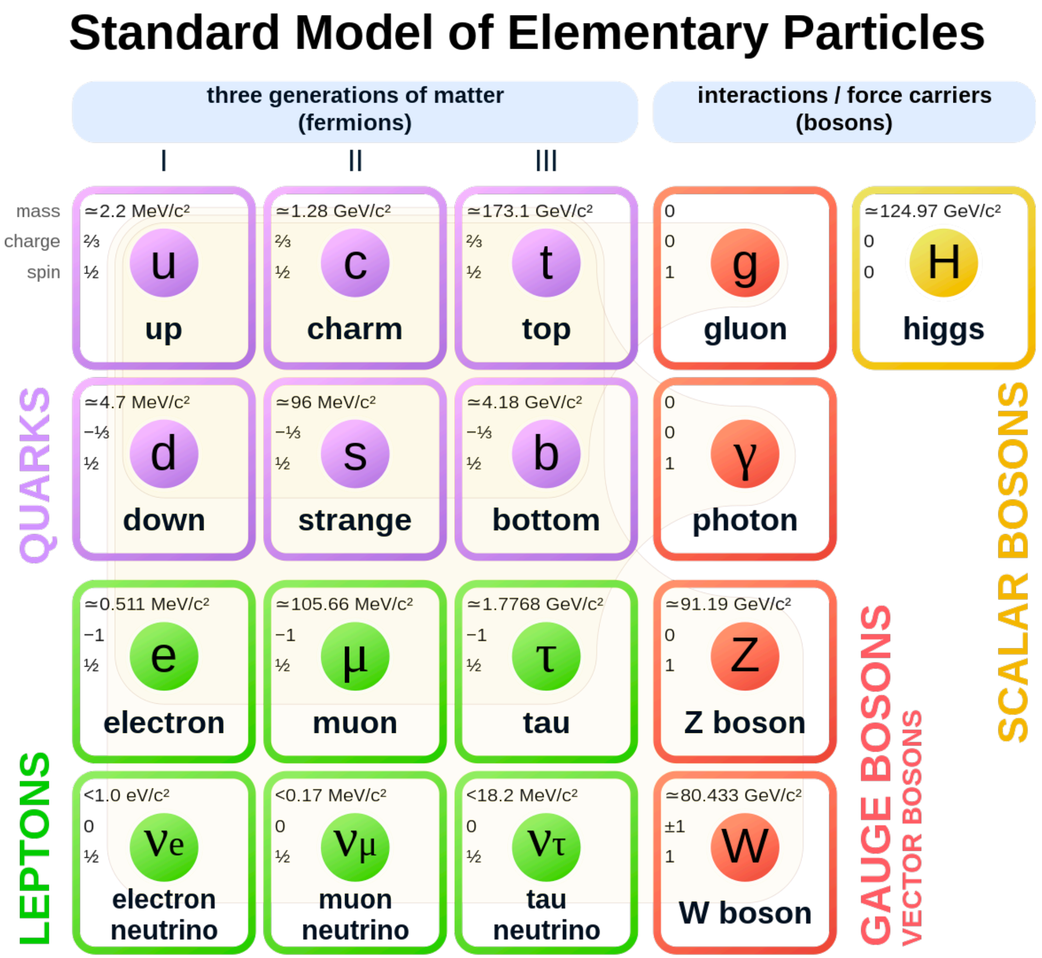
[2] Physics Department, Yale Center for Astronomy and Astrophysics

[3] C.N. Yang Institute for Theoretical Physics, Stony Brook University

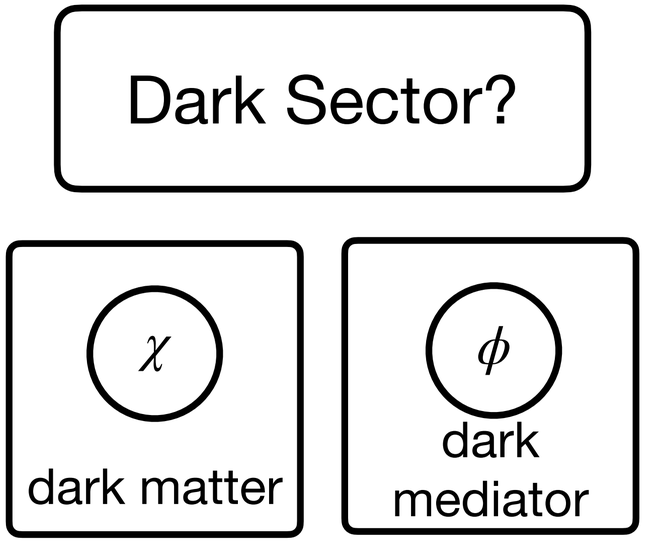
Maya Silverman
(she/her)
PhD Candidate
msilver2@uci.edu

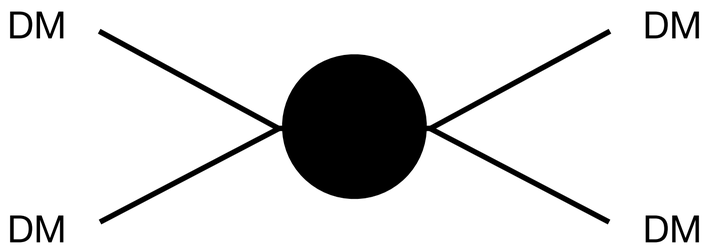
Dark Interactions
November 15th, 2022

Dark Sector



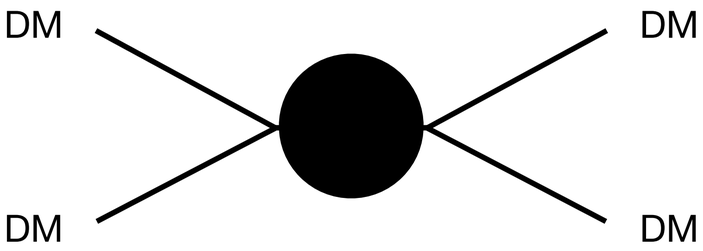
Portal





Motivating SIDM

Can we **constrain a dark matter** model that arises generically with the existence of a dark sector using **galaxy (sub)structure**?



σ/m : self interaction cross section over DM mass

Elastic scattering with velocity dependent cross sections are relevant for small scale structure!

Opportunity: Solve Small Scale Problems

Core-Cusp/Diversity Problem

- Can simulations reproduce the diversity in observed DM and stellar density profiles?

Too-Big-To-Fail Problem

- Are densities of massive observed satellites too low compared to predicted densities?

N-Body Simulation with SIDM

Dark Matter + Baryonic Disk and Bulge

$$M_{\rm vir} = 10^{12} M_\odot$$

$$m_{\rm DM} = 3 \times 10^4 M_\odot$$

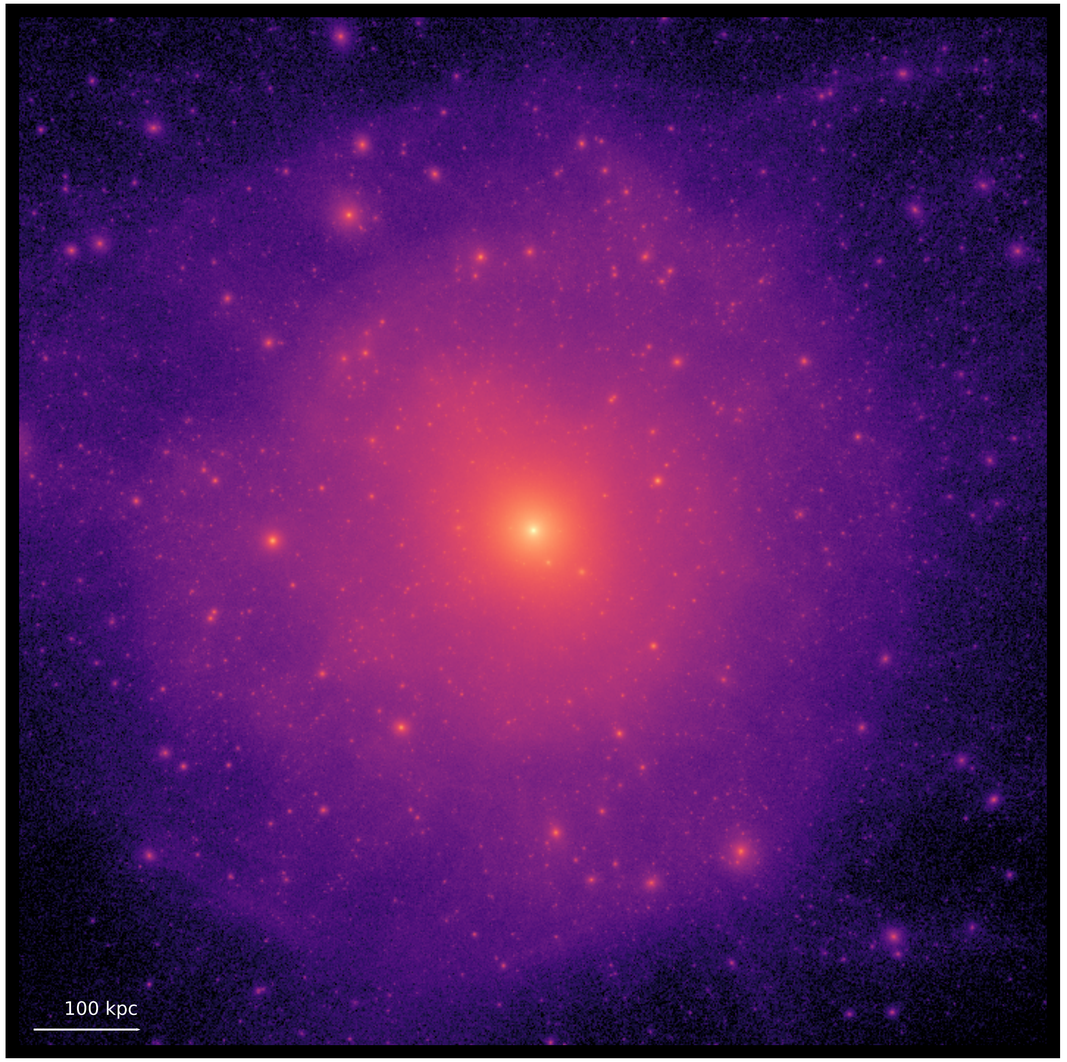
$$M_* = 4.1 \times 10^{10} M_\odot$$

~~$\sigma/m = 1\ {\rm cm}^2/{\rm g}$~~

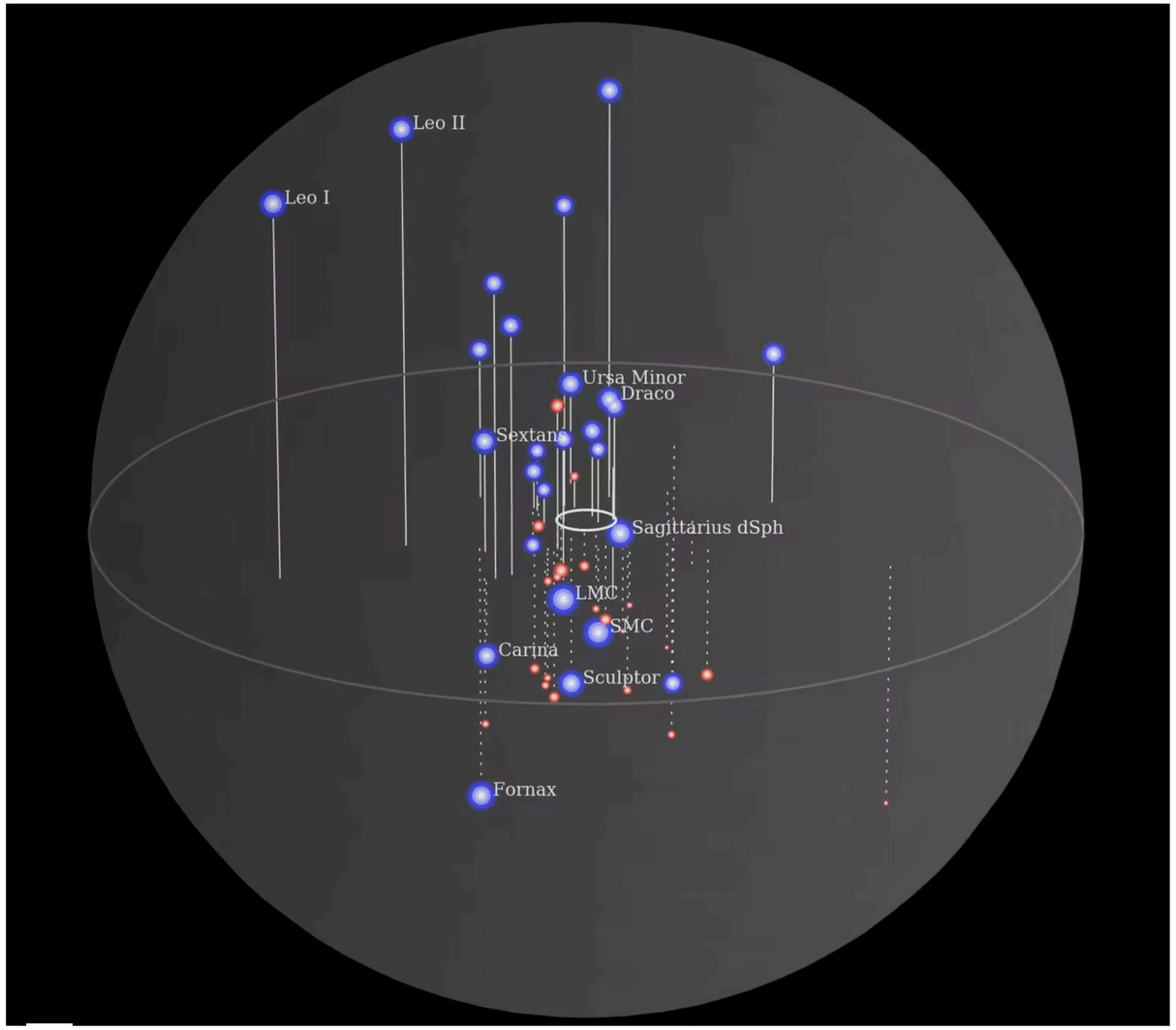
$\sigma/m = 5\ {\rm cm}^2/{\rm g}$

(Proposed to solve diversity problem)

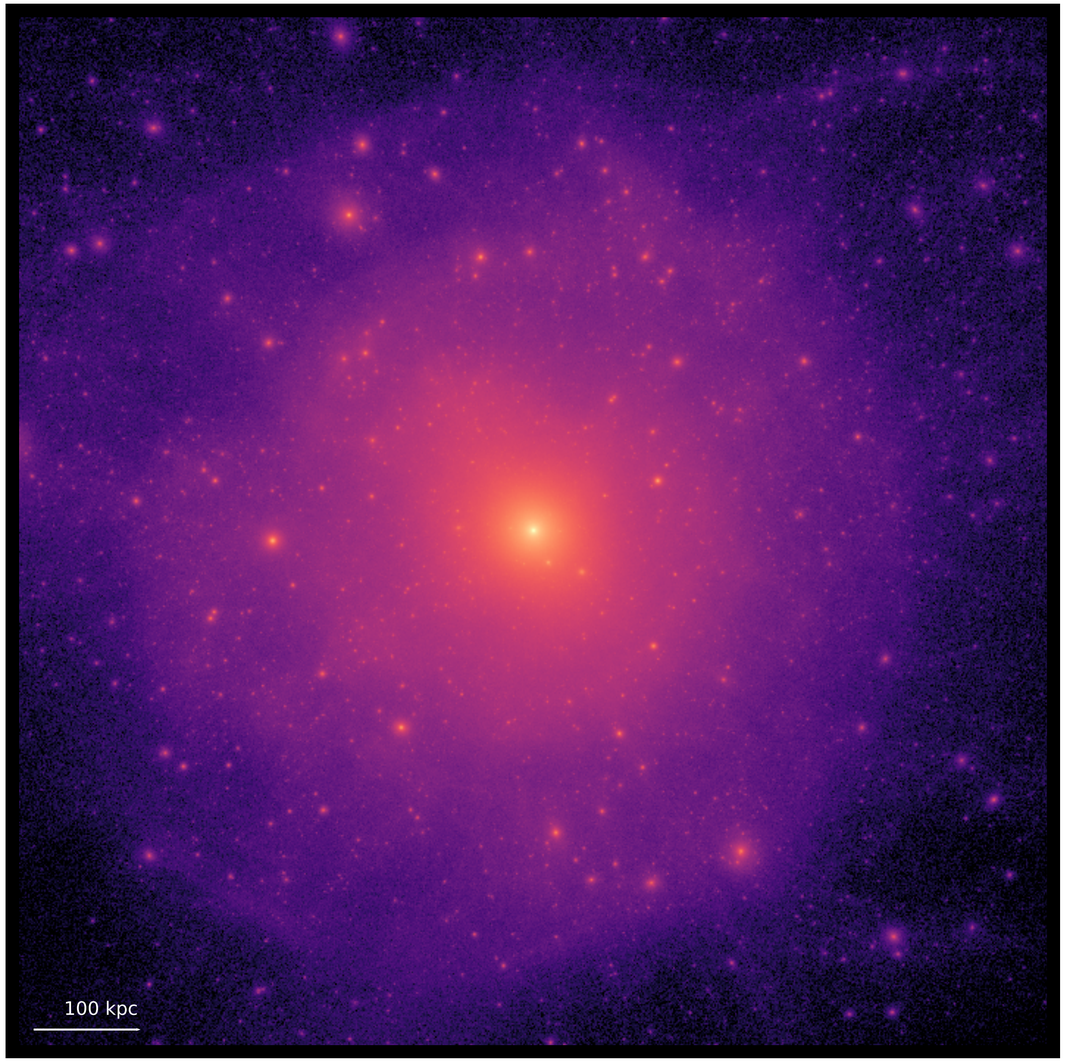
Explore much larger cross sections!



Compare Observations to Simulation

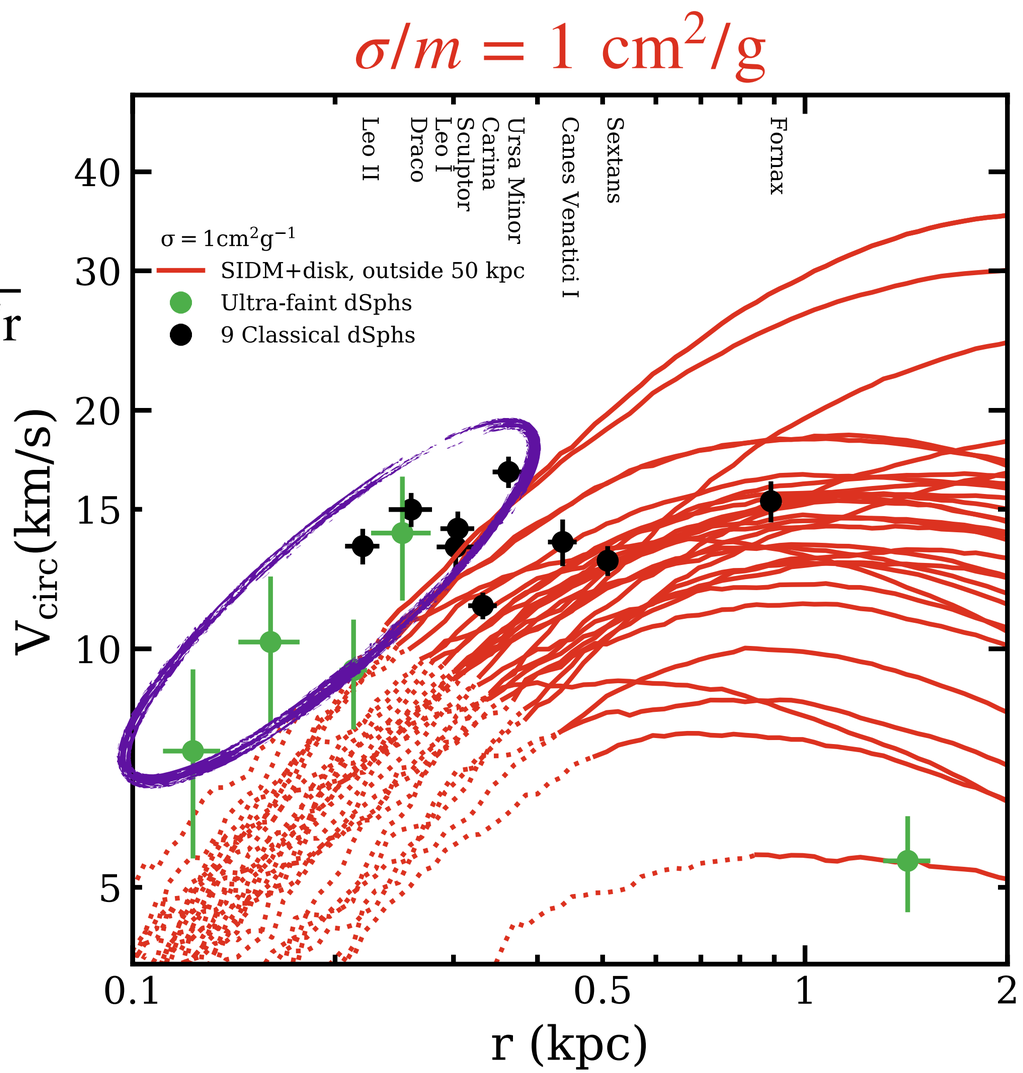


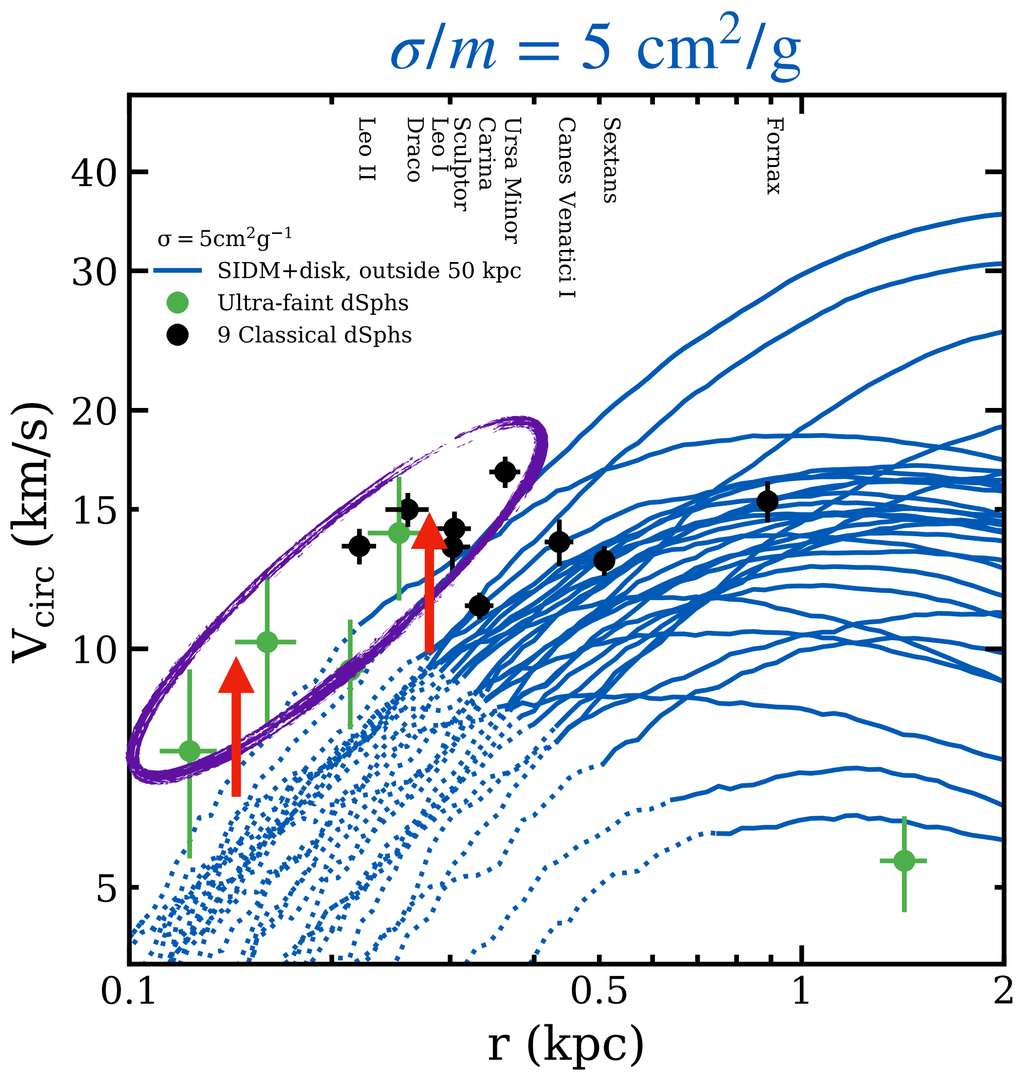
Bullock & Boylan-Kolchin (2017)



Subhalo Circular Velocity Profiles vs dSphs

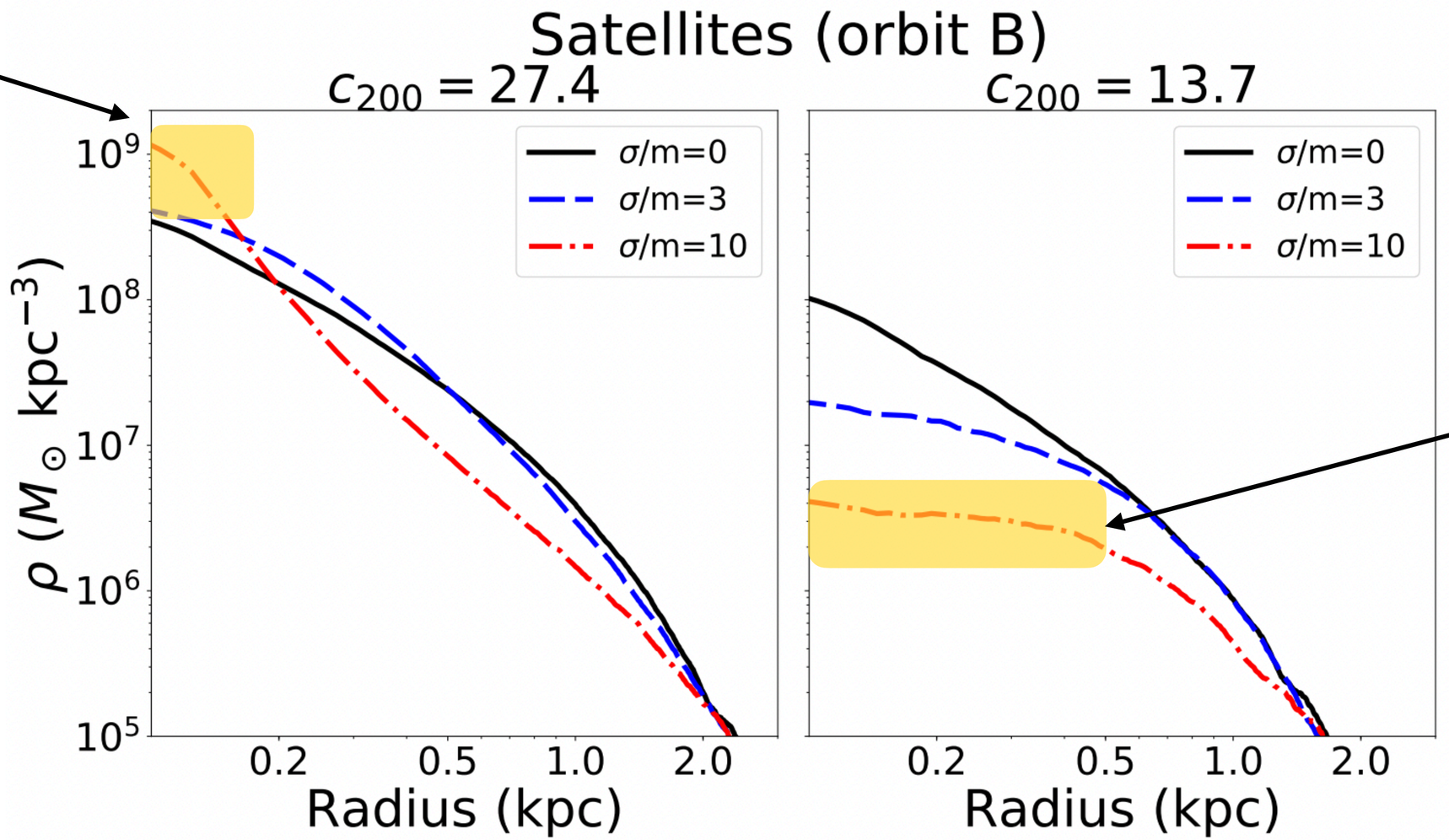
$$V_{circ} = \sqrt{GM/r}$$





Core Collapse: generic consequence of SIDM

Dense region at small radii



Isothermal region with extended low density core

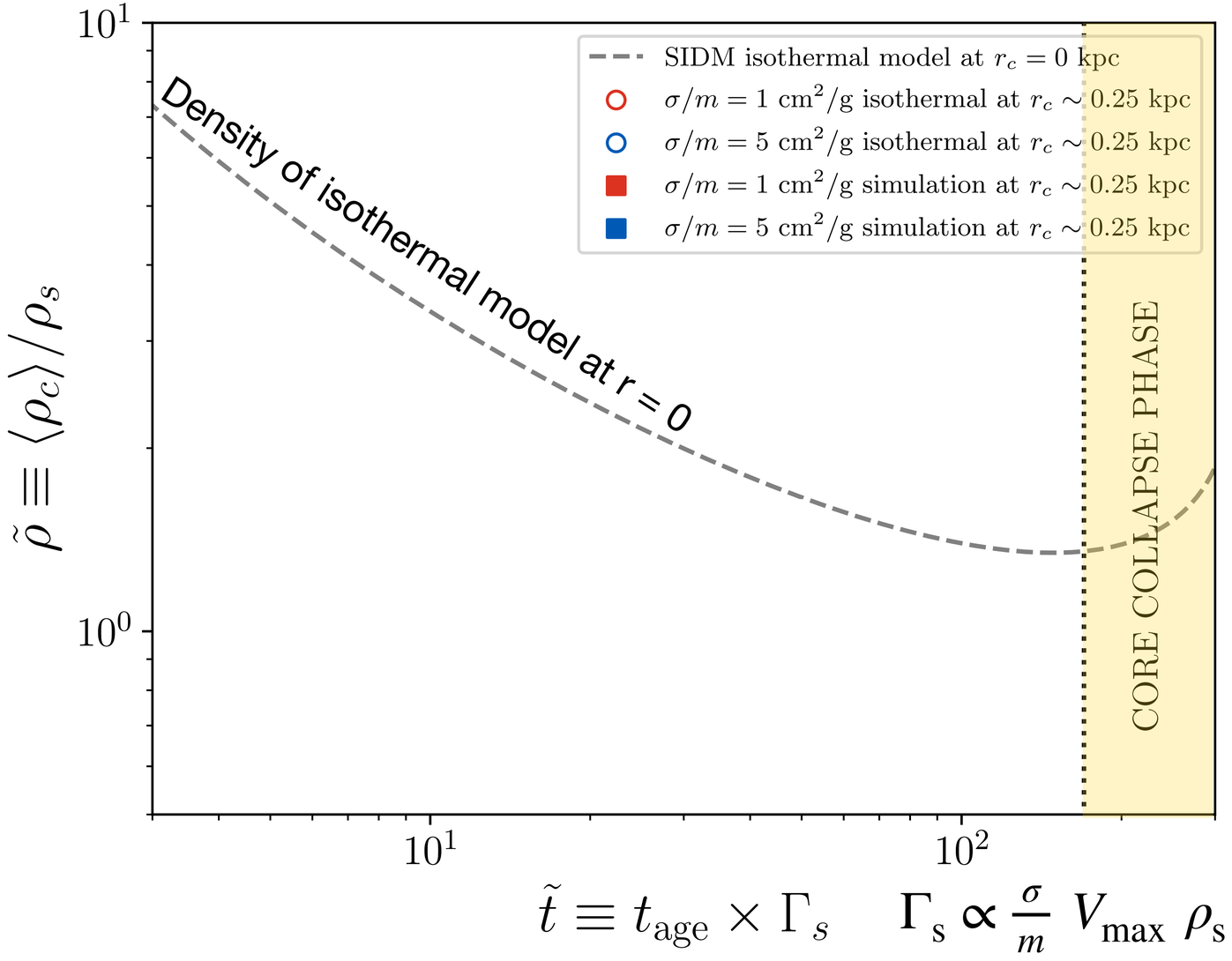
Kahlhoefer et. al. (2019)

Core Collapse Timescale

- ■ simulated subhalos
- ○ isothermal model

$\sigma/m = 1\ \mathrm{cm}^2/\mathrm{g}$

$\sigma/m = 5\ \mathrm{cm}^2/\mathrm{g}$



Conclusion

- Need core collapse for SIDM to match observations
- No core collapse in simulation with $\sigma/m = 5\ \mathrm{cm}^2/\mathrm{g}$
- Next:
  - Larger σ/m for low velocity scales (~10 km/s)
  - Velocity dependence