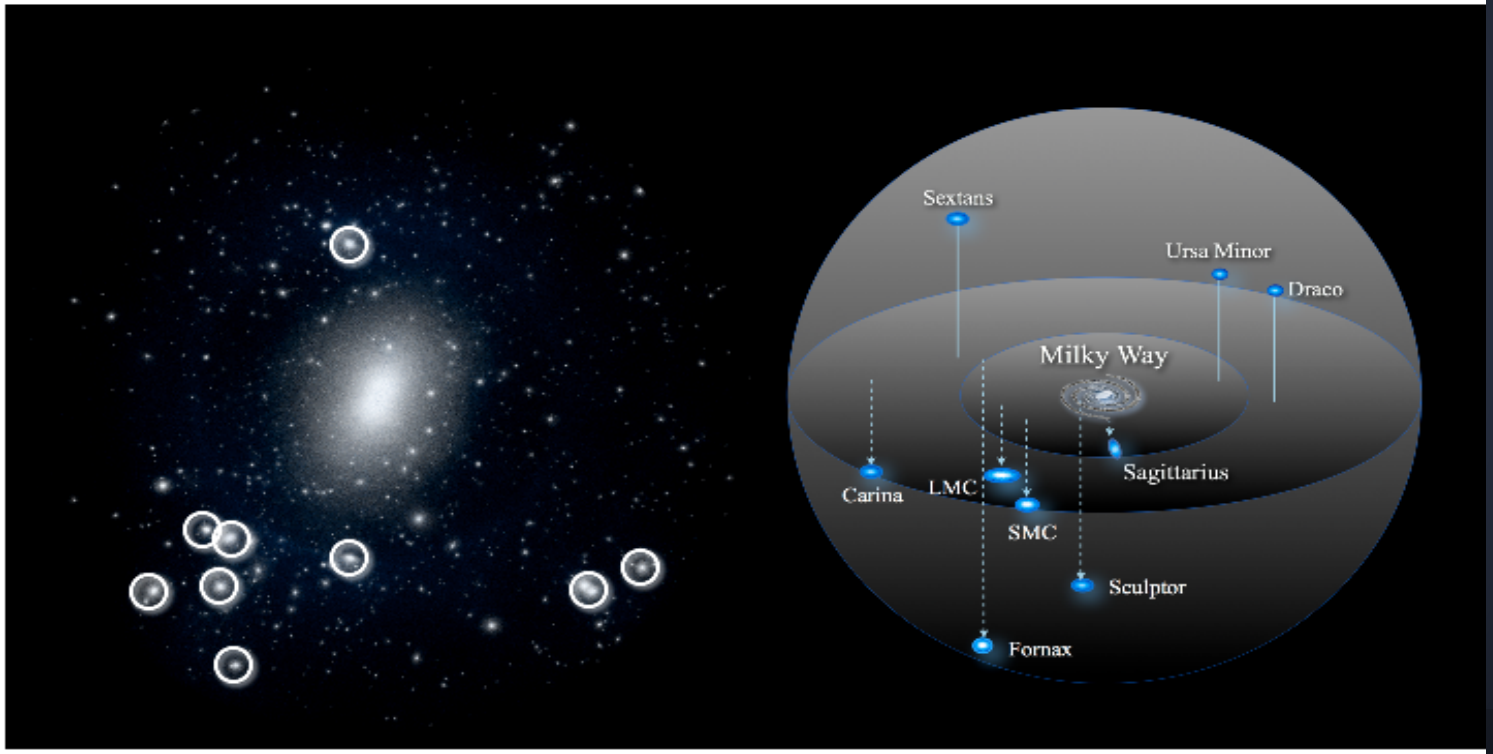
Small Scale Problems

Harry Desmond, Sungwoo Hong, Hector Olivares, Andrew Pace, Stephen Portillo, Jing Ren

Problem(1): Missing Satellites

Weinberg, David H 2013



Problem(2): TBTF

- Milky Way Satellites:

Boylan-Kolchin, Bullock, Kaplinghat (2011, 2012)

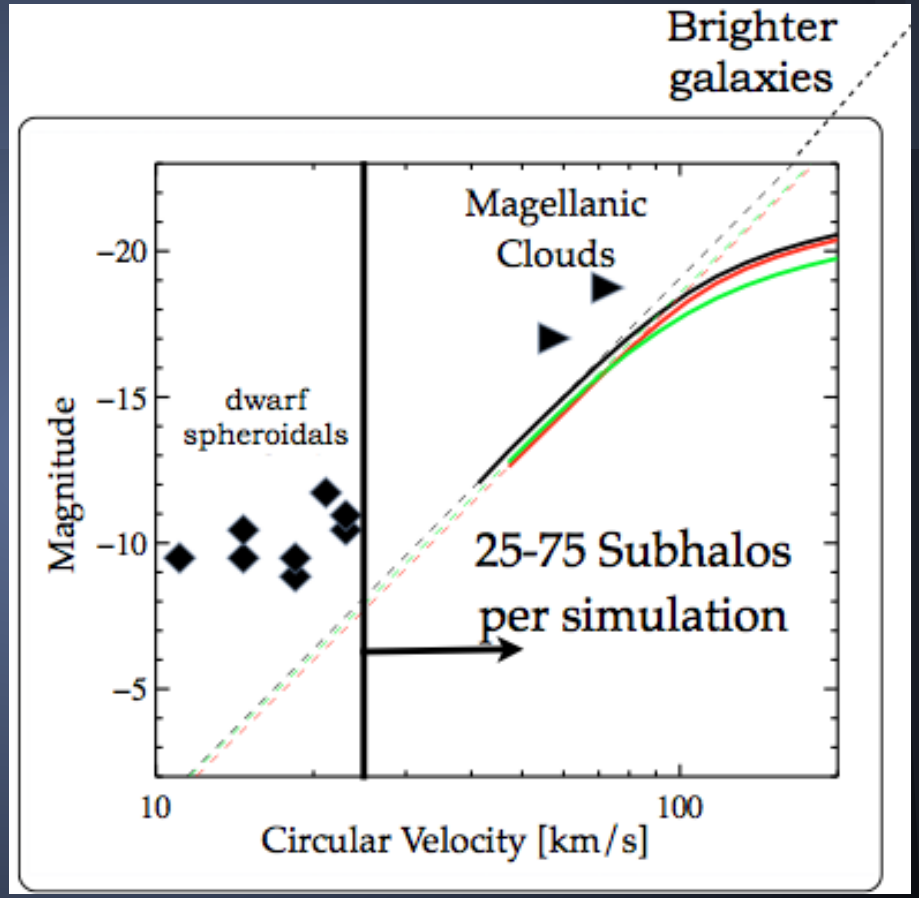
- M31 Satellites:

Tollerud et al (2014)

- Field Galaxies:

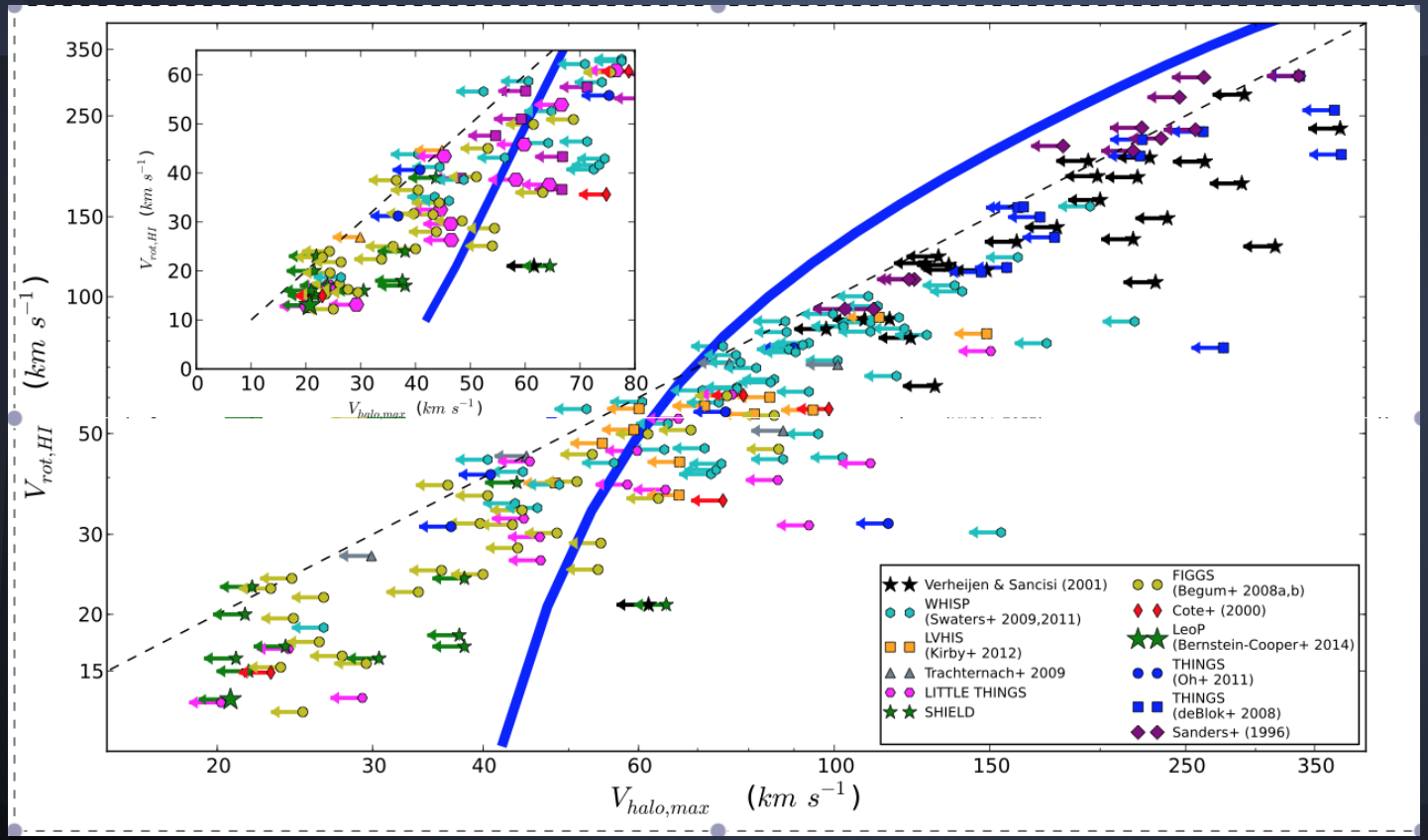
Garrison-Kimmel et al (2014)

Papastergis et al 2014 (1407.4665)



From Louis Strigari's talk

TBTF in the field

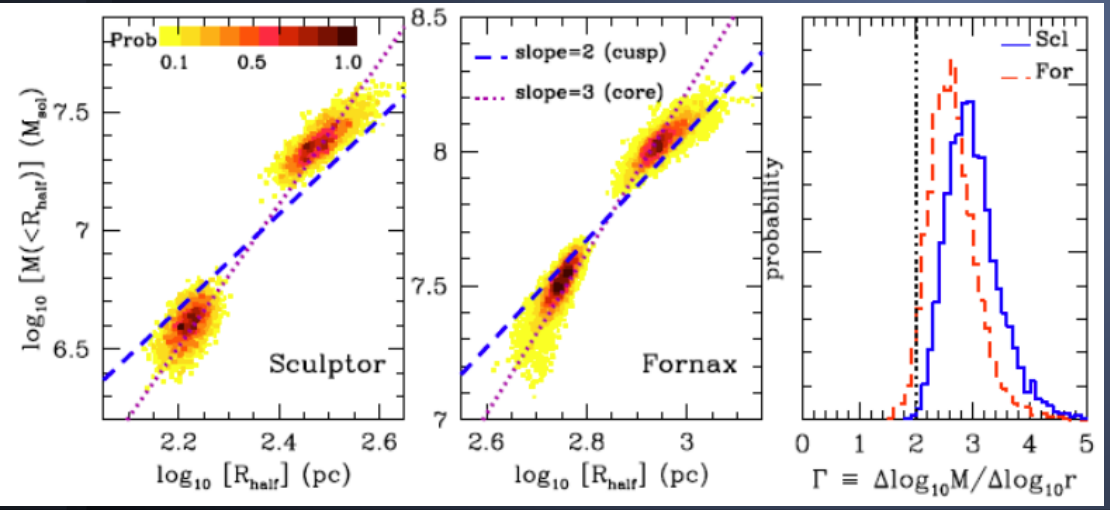


Papastergis et al 2014

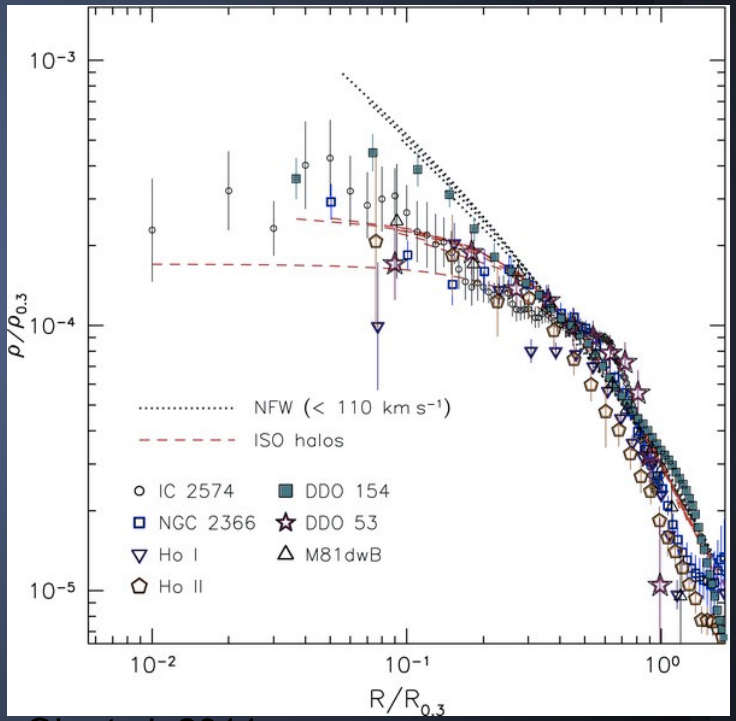
Problem(3): Core vs Cusp

CDM predicts NFW profile

Cores observed in dwarf galaxies



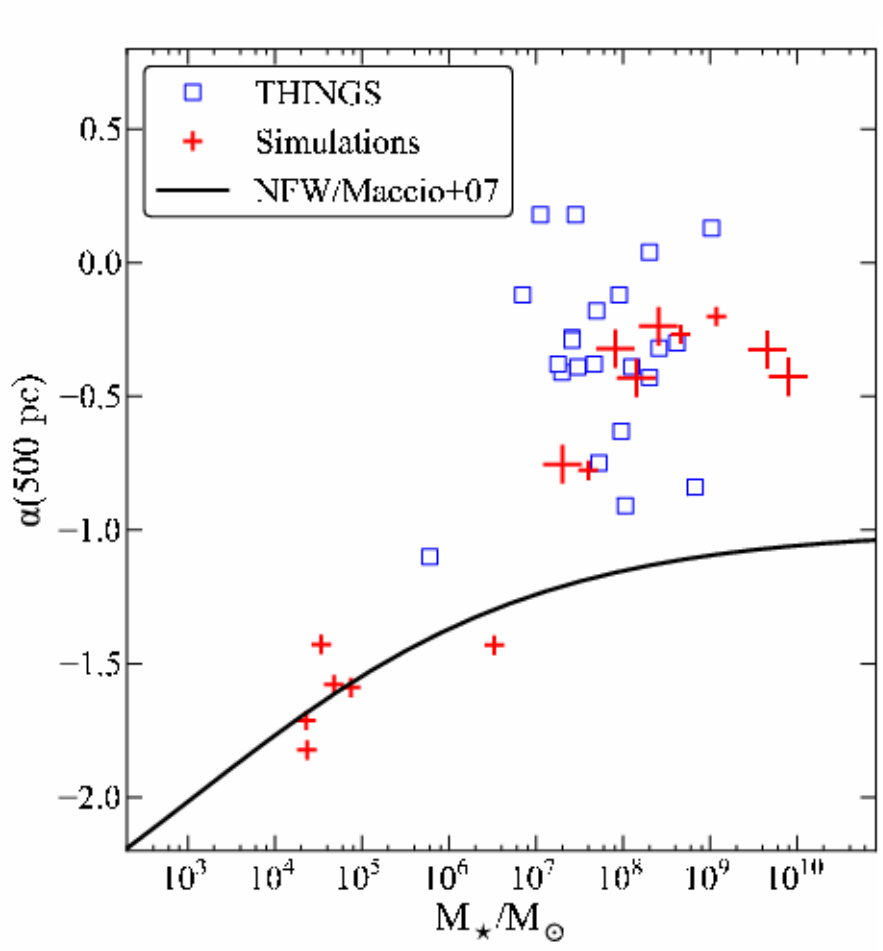
Walker & Penarrubia (ApJ 2011)



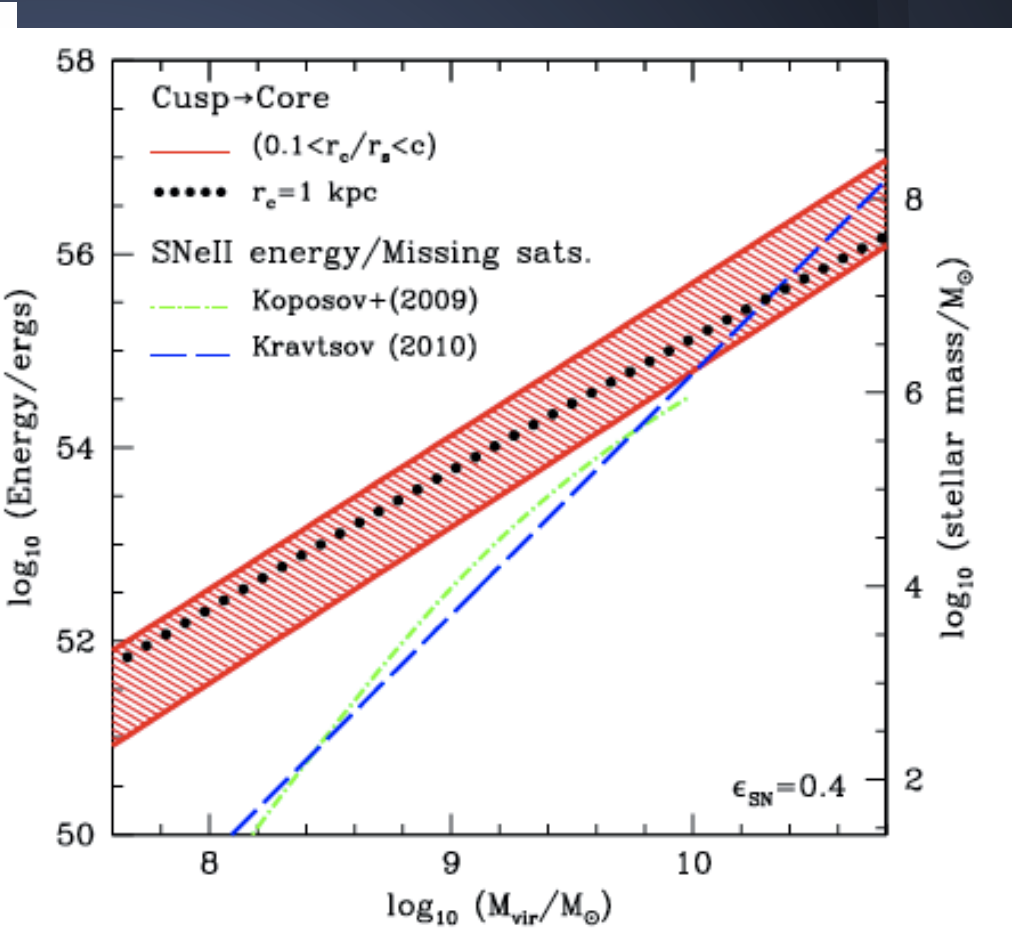
Oh et al. 2011

Solution(1): Supernova Feedback

- Supernovae eject baryonic material, leaving some halos empty, and the change to the potential can turn cusps into cores
- BUT Peñarrubia et al. 2012, Garrison-Kimmel et al. 2013 claim supernovae cannot provide enough energy
- BUT^2 Amorisco et al. 2014 claim they can (at least for Fornax and Sculptor)



Governato et al. 2012



Peñarrubia et al. 2012

Solution(2): Tidal Stripping

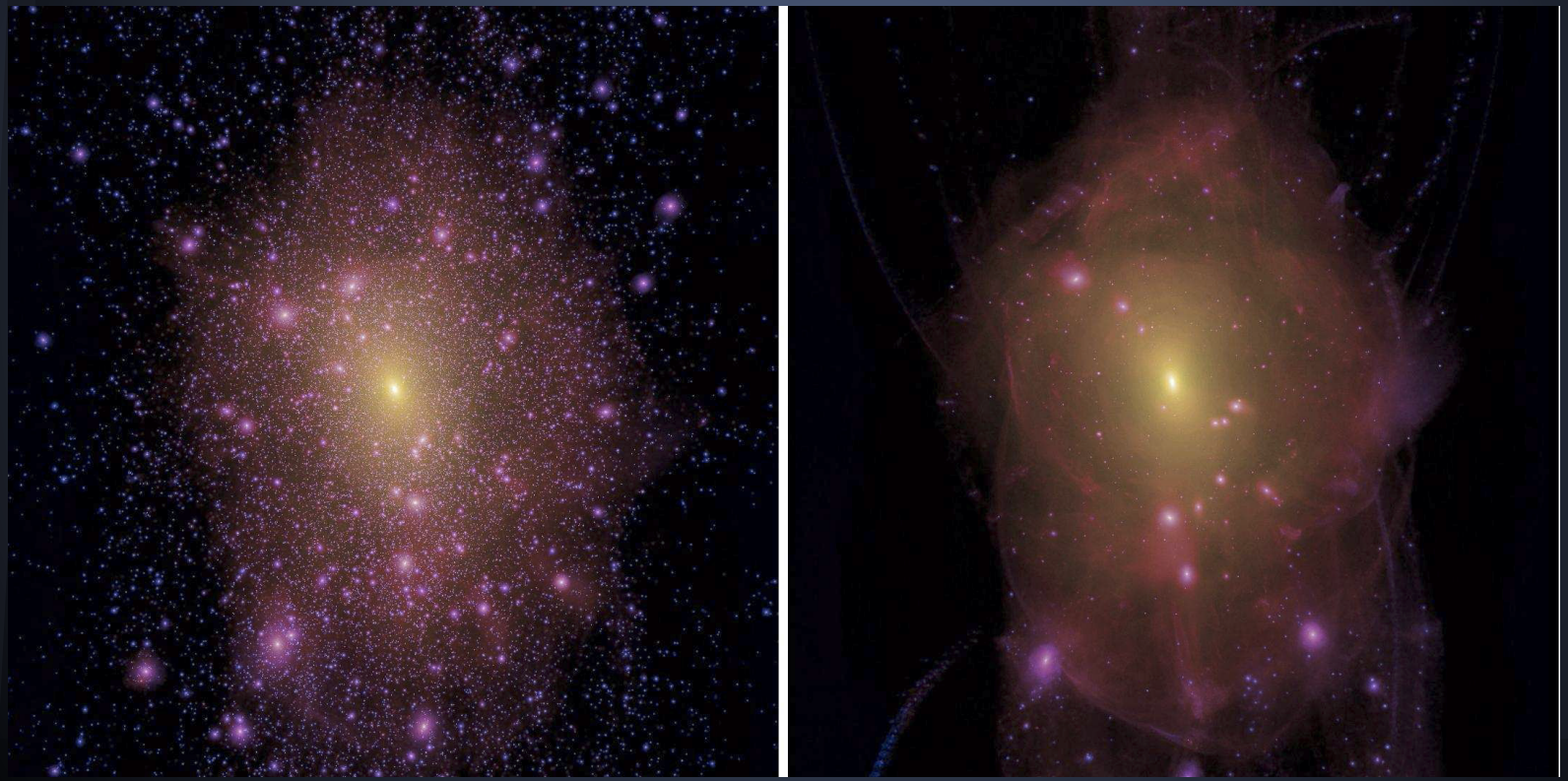
- Tidal stripping -- Satellites fall through host halo and lose their gas, so they don’t form stars
- Problem is that TBTF is also observed in the field for satellites that should never have interacted with larger halos

Solution(3): WDM

- Free-streaming suppresses small scale structure
- Much fewer dwarfs → Missing Satellite (✓)
- Reduced central densities → TBTF (✓)
- Solving core-cusp problem requires a DM mass too low to satisfy the Lyman-α forest limit→ Cusp vs Core (X)
- Solving the Missing Satellites and TBTF requires different WDM masses

CDM vs WDM

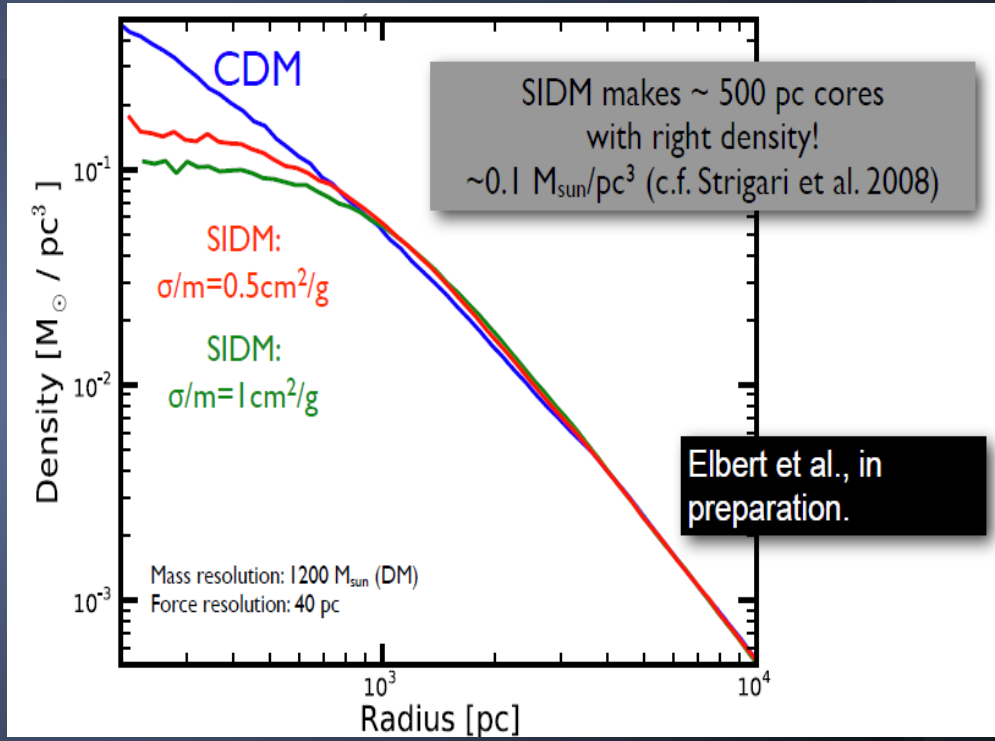
Lovell et al. 2011



Solution(4): SIDM

- Heat transfer makes core → Cusp vs Core (✓)
- DM self-int. → Reduced density → TBTF (✓)
- Big DM self-int. → Maybe MSP (✓)
- Creation of Core + Bullet cluster + Halo Shape

  → 0.1 $cm^2/g < \sigma/m < 1\ cm^2/g$

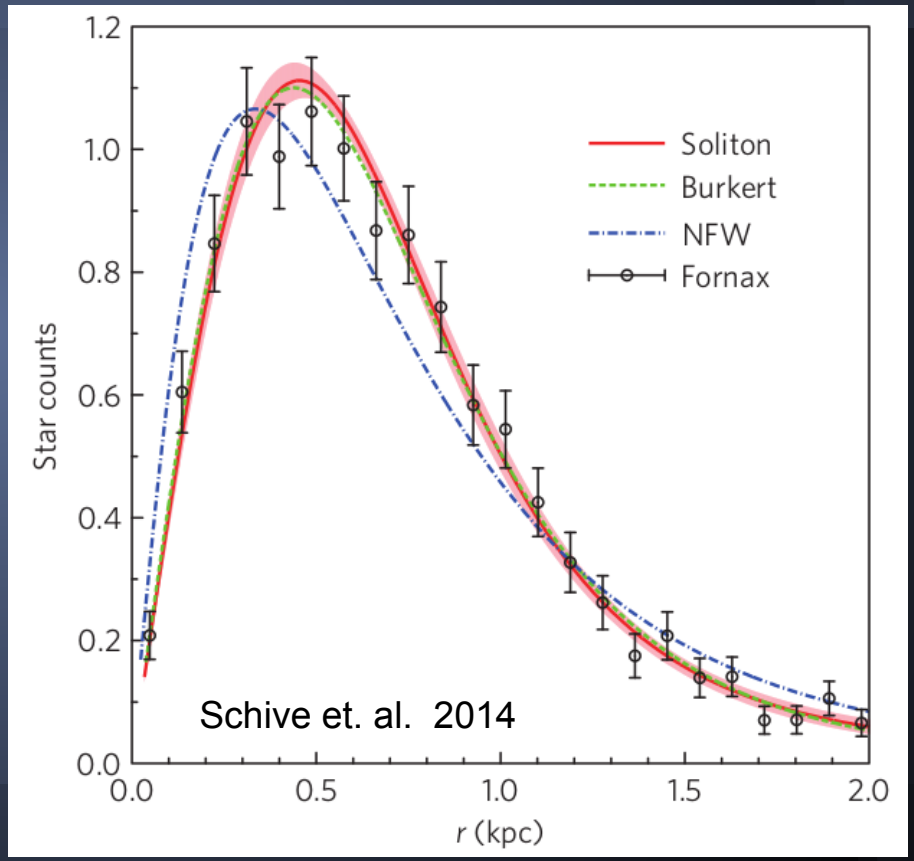


Solution(5): φDM/Fuzzy DM

- Soliton profiles fit better stellar distributions including dSph.

  → No cusp/core problem

- TBTF not well studied, but wave properties suppress small scale structure, while leaving the large scales indistinguishable from CDM.



Search for small DM halos to test WDM

- WDM and φDM predict suppression of small DM halos, but a precise measurement of the shape of the power spectrum around the suppression starting scale should distinguish one from another (Silk et al. 2014)
- Use lensing to find amplitude and slope of DM halo mass function (Vegetti et al. 2012)
- Use spiral arms (Chakrabarti & Blitz 2009) and tidal streams (Carlberg & Grillmair 2013) to look for disruptions caused by small DM halos

Testing Baryons as the Solution

- Look at correlations
- For SNe: Compare core radius vs SNe number, stellar mass, or star formation history
- Tidal Stripping: Compare core size and central density with environment (eg. projected distance to host galaxy)
- But if these correlations aren’t seen, it won’t rule out baryons as part of the solution

Thank You

supernova →