Why Baryons Matter: The Central Masses of Dwarf Galaxies

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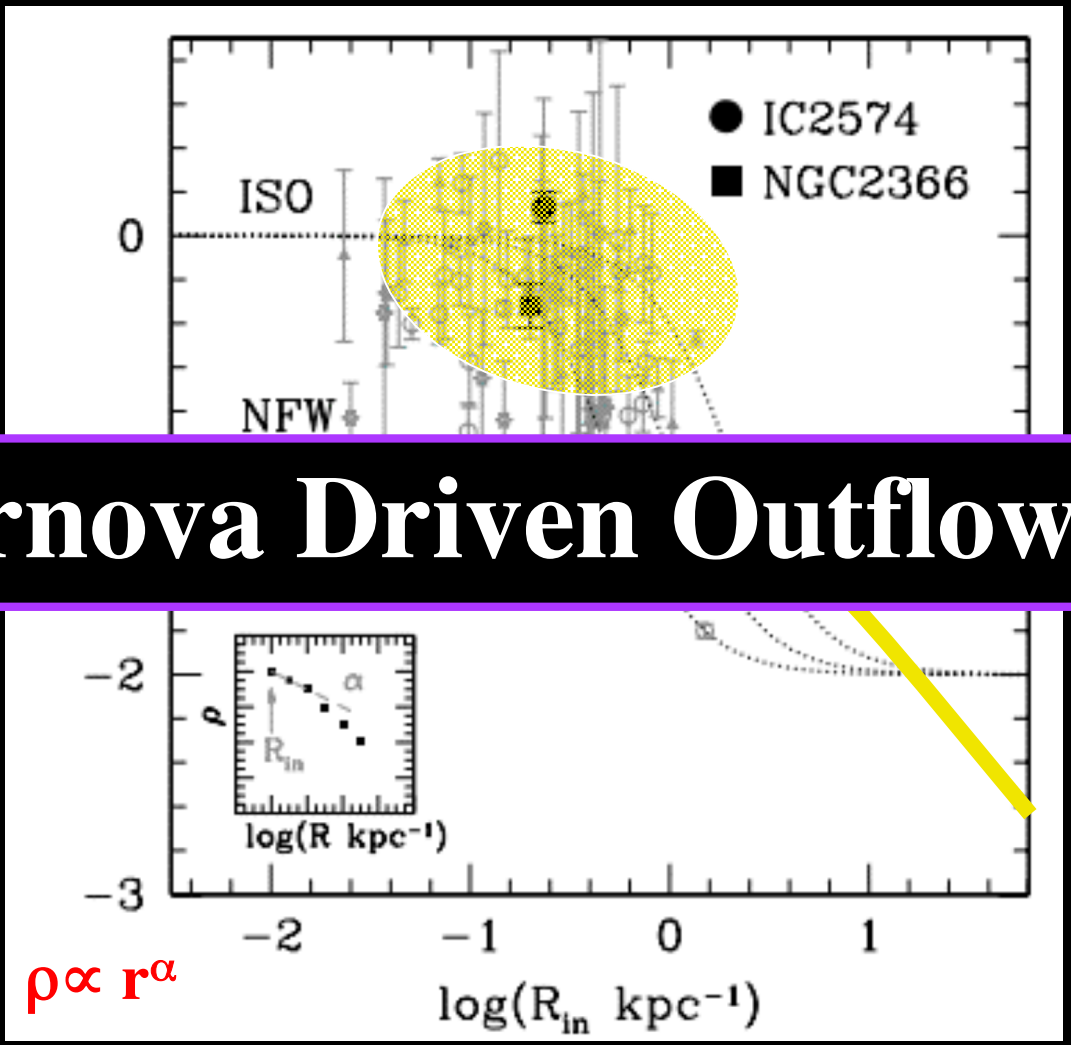
- GASOLINE -

Fornax dSph

I. A challenge to CDM? DM cores

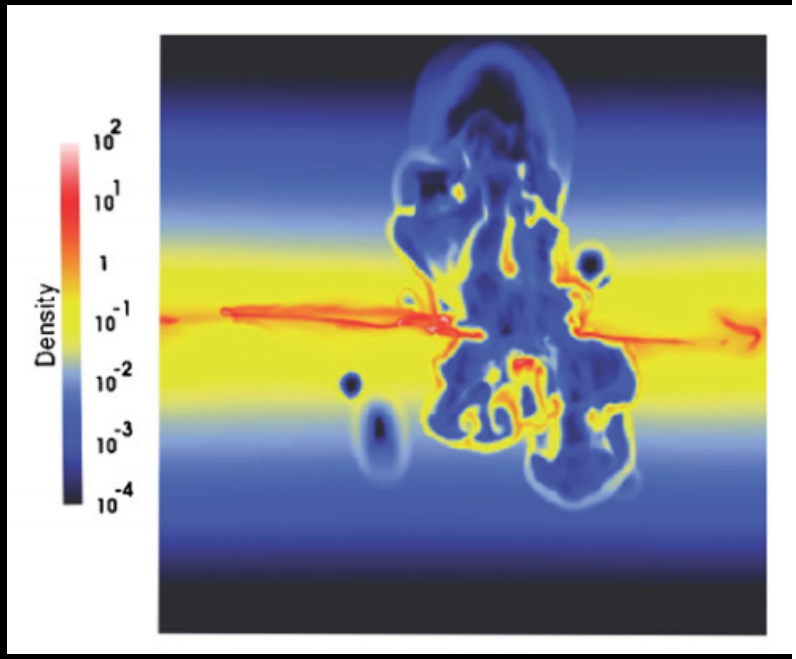


Supernova Driven Outflows?

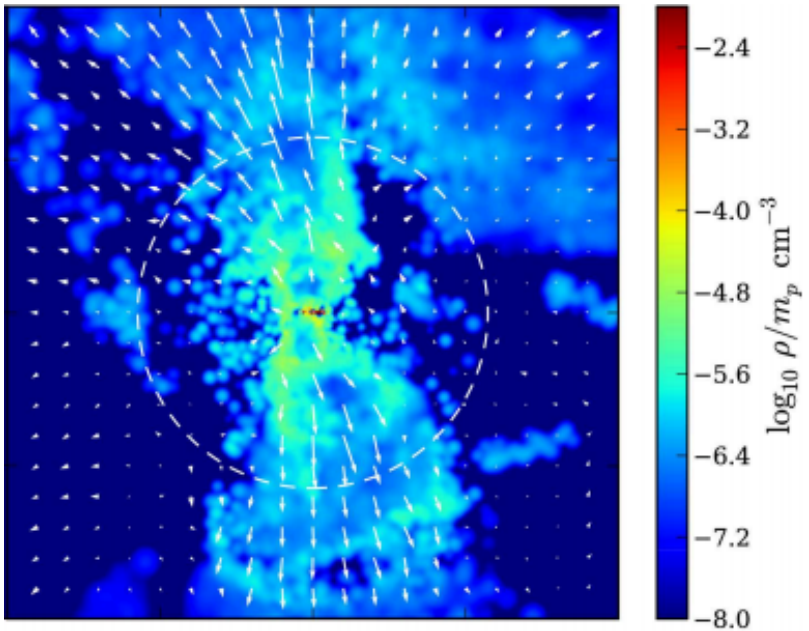
Oh et al. (2011)

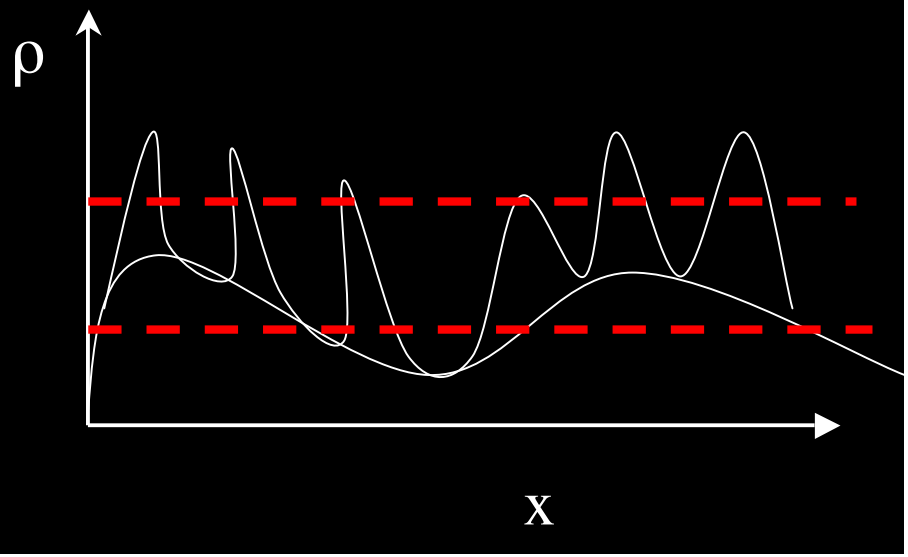
Resolving hi-density SF regions

Ceverino & Klypin (2009)



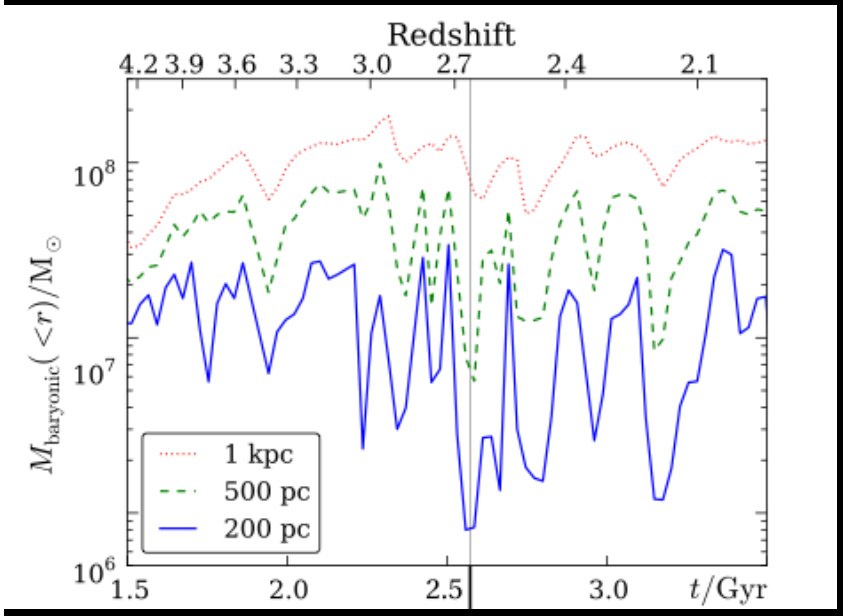
Brook et al. (2011)



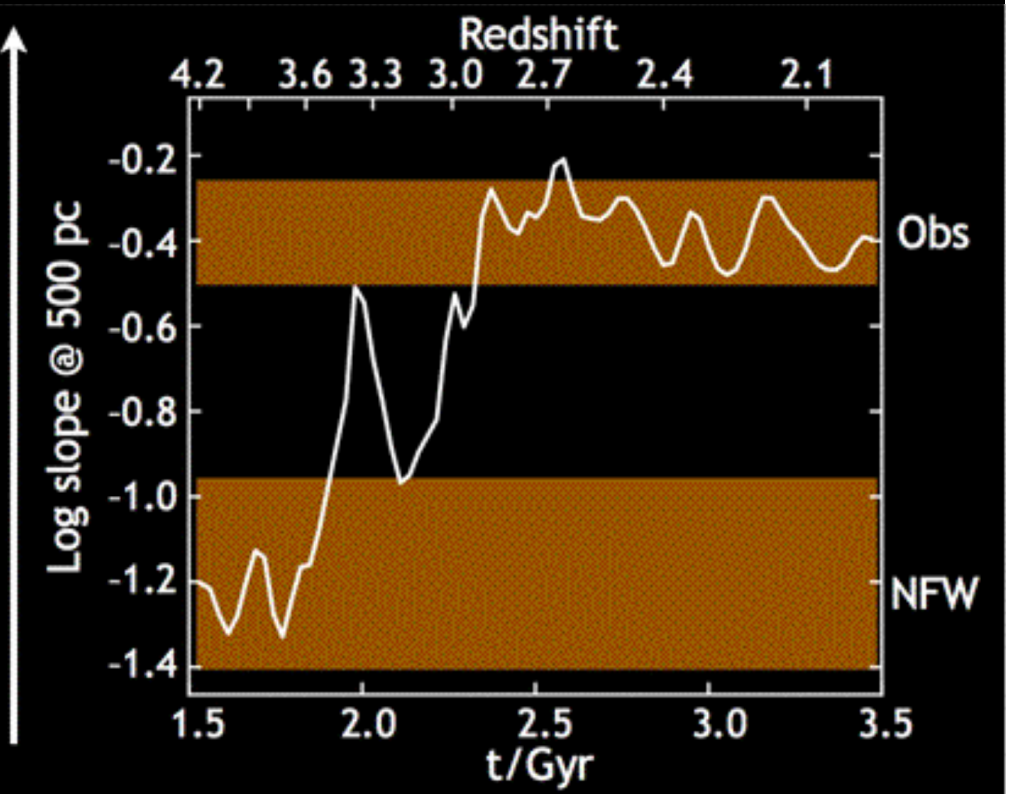


Cusp/Core Problem

Star formation must be episodic

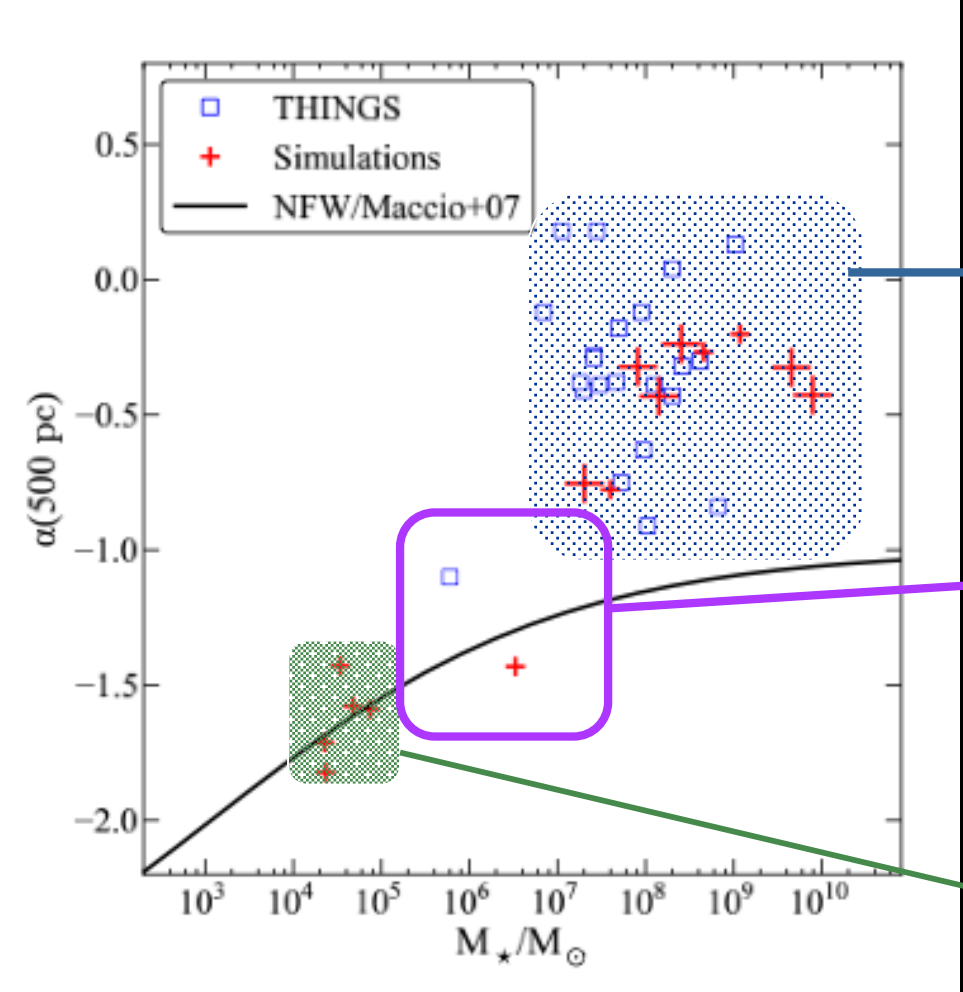


Pontzen & Governato (2012)



See also: Dekel & Silk (1986)
Navarro et al (1996)
Read & Gilmore (2005)
Mashchenko et al. (2008),
Teyssier et al. (2012) + …

Cusp/Core Problem



Isolated field Galaxies with $M_* > 10^7$ Msun have shallow DM profiles

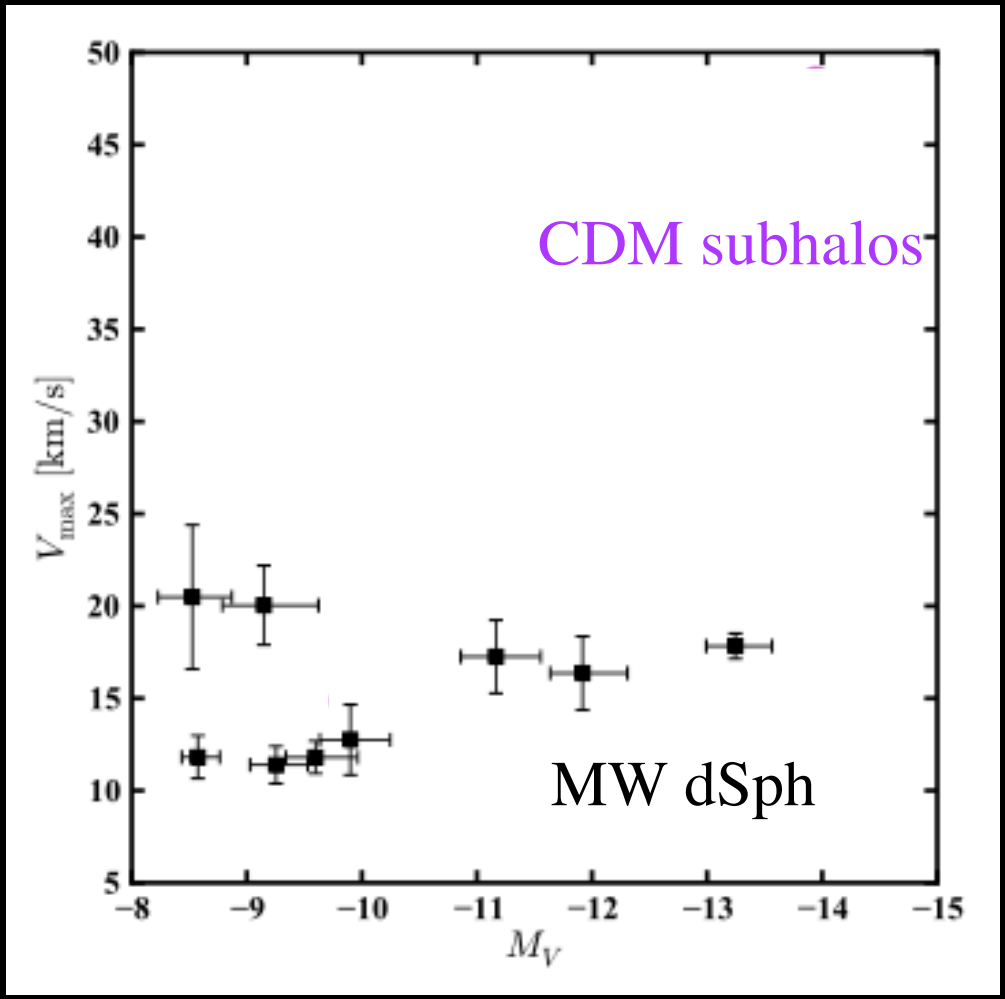
MW classical dSph

Low luminosity field dwarfs have cusps? Cores in central unresolved regions?

Governato, Zolotov, et al. (2012)

II. Another challenge to CDM: Massive Failures

Moore et al. (1999)
Klypin et al. (1999)

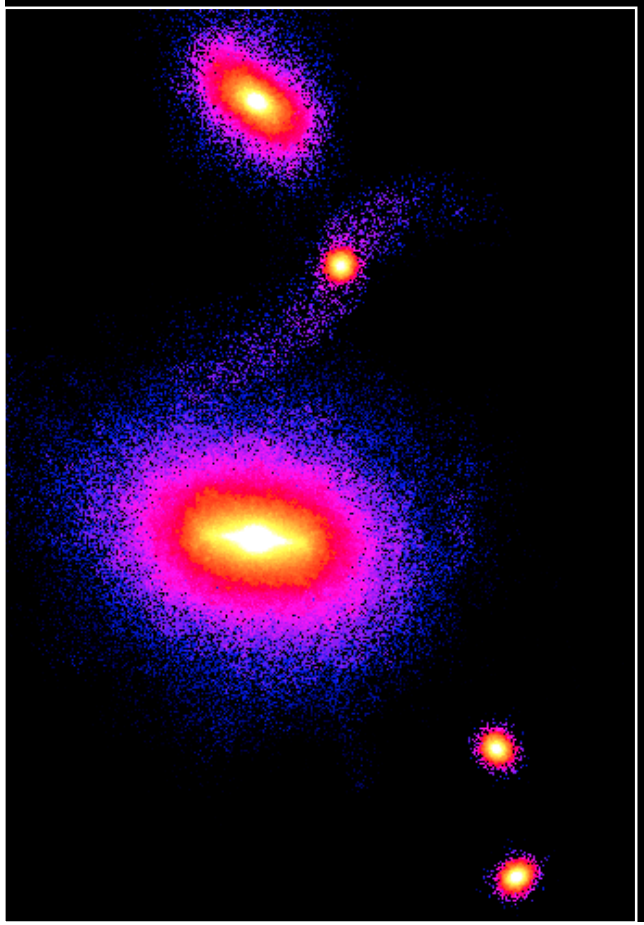


Boylan-Kolchin et al. (2011, 2012)

II. A challenge to CDM: Massive Failures

Two MW-mass galaxies ($M_{vir} \sim 7 - 8 \times 10^{11}$)

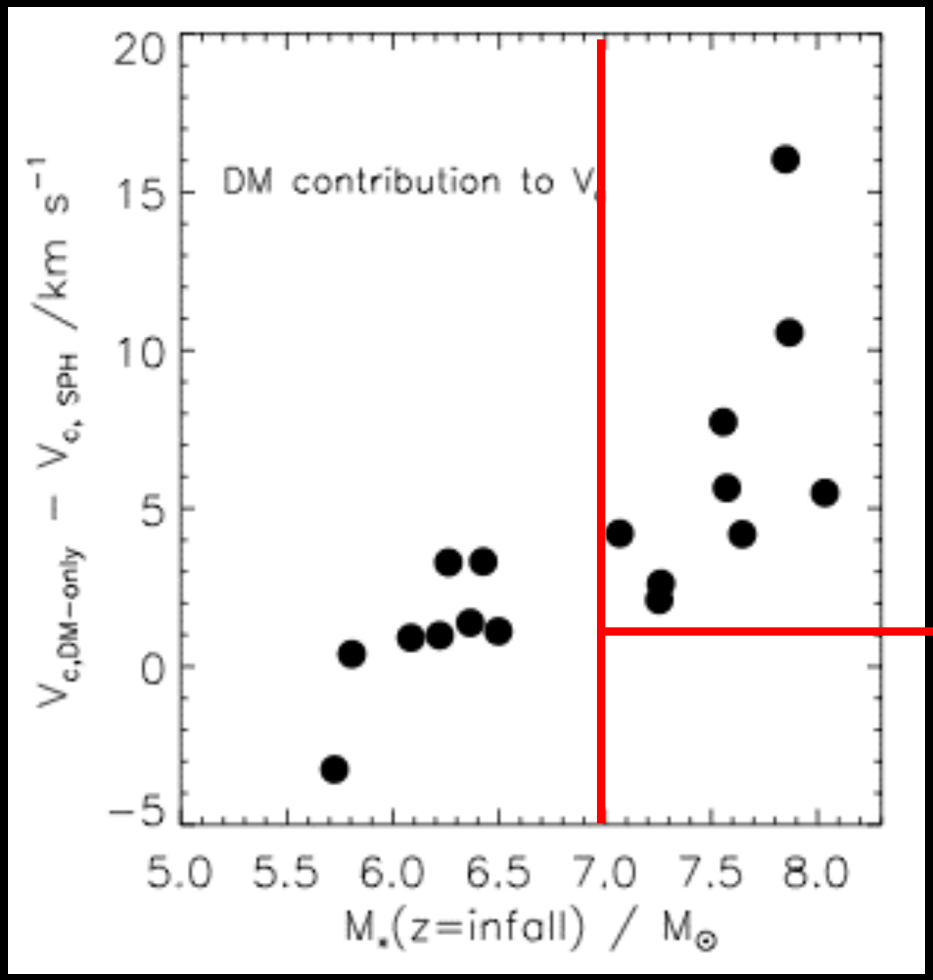
DM-only vs DM + baryons



1. Find all satellites at z=0 in SPH run
2. Match to satellites in DM-only run at hi-z & infall & z=0
3. Compare density& mass at hi-z, at infall, and at z=0 between DM-only and DM+baryon sats

Zolotov, Brooks, et al. (2012)
Brooks & Zolotov (2012)

1st Regime: Before Infall



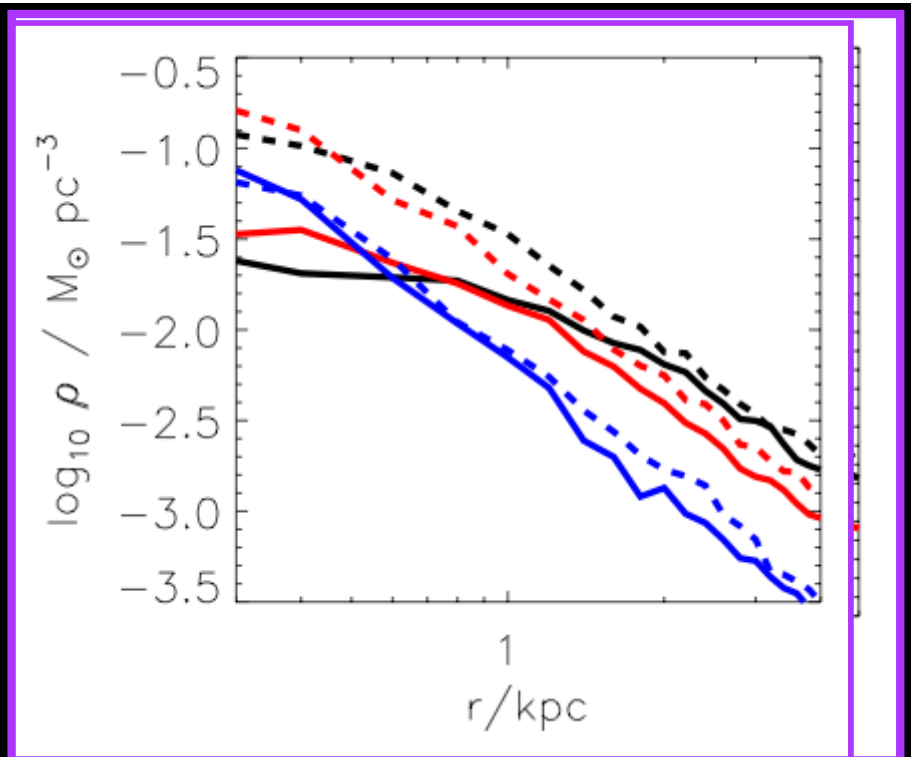
The most luminous satellites experience a reduction of **2 - 16 km/s** in the central DM Vc due to SNe feedback

Zolotov et al. (2012)

Before Infall: SNe Feedback

Weisz et al. (2012) - Dwarfs with $M_* < 10^7 M_\odot$ are consistent with bursty SFHs

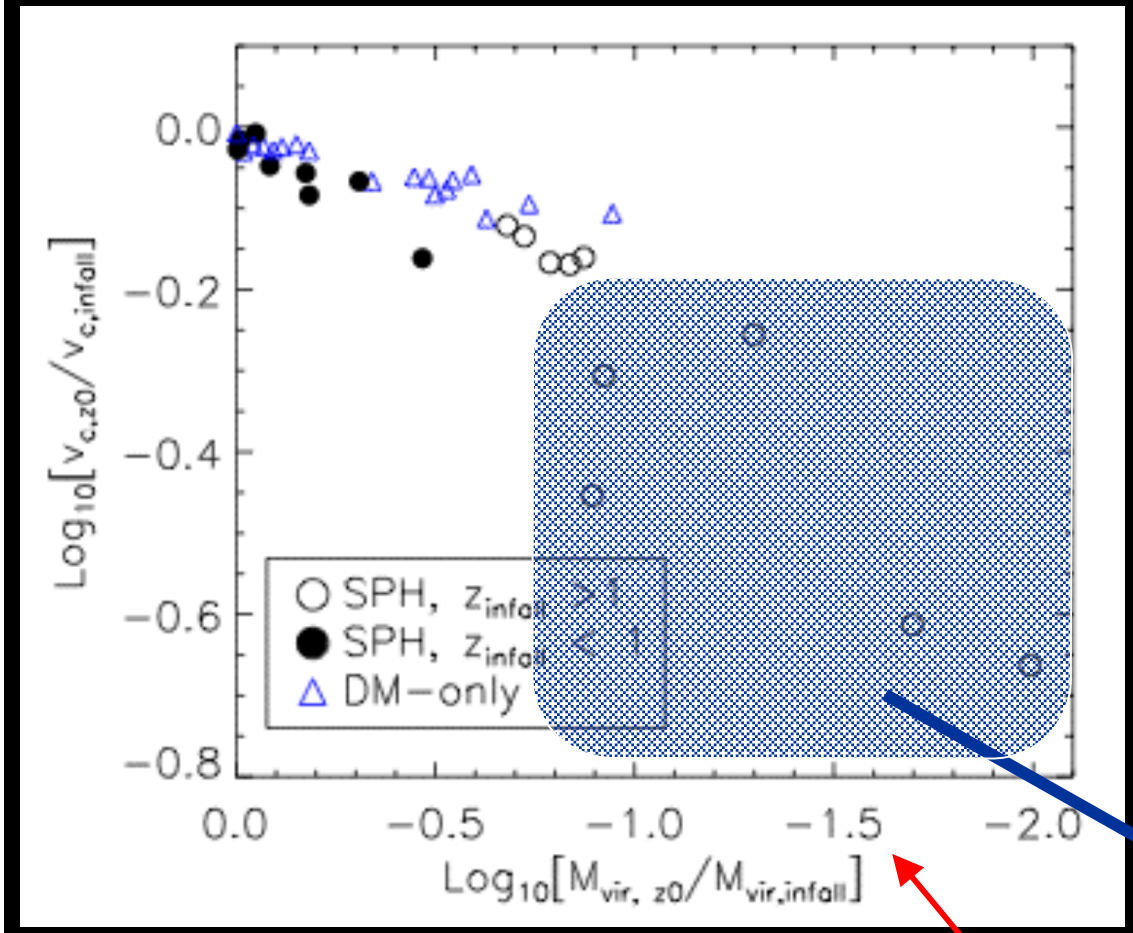
Zolotov et al. (2012)



DM-only

DM+baryons

2nd Regime: After Infall



Only SPH satellites lose more than 90% of initial mass -> some satellites lose stars as well

Only SPH satellites undergo a reduction of more than 40 % in central Vc

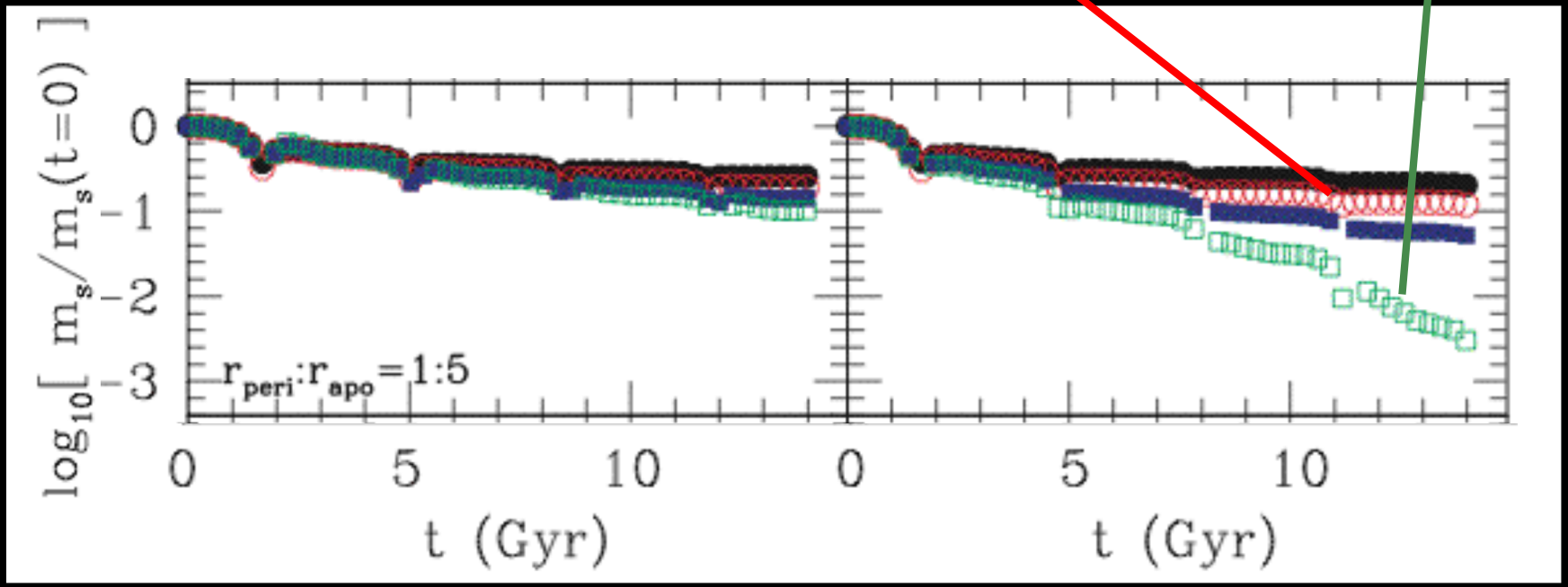
Due to baryonic disk+ DM density profile

Bound mass fraction

Zolotov et al. (2012)

2nd Regime: After Infall

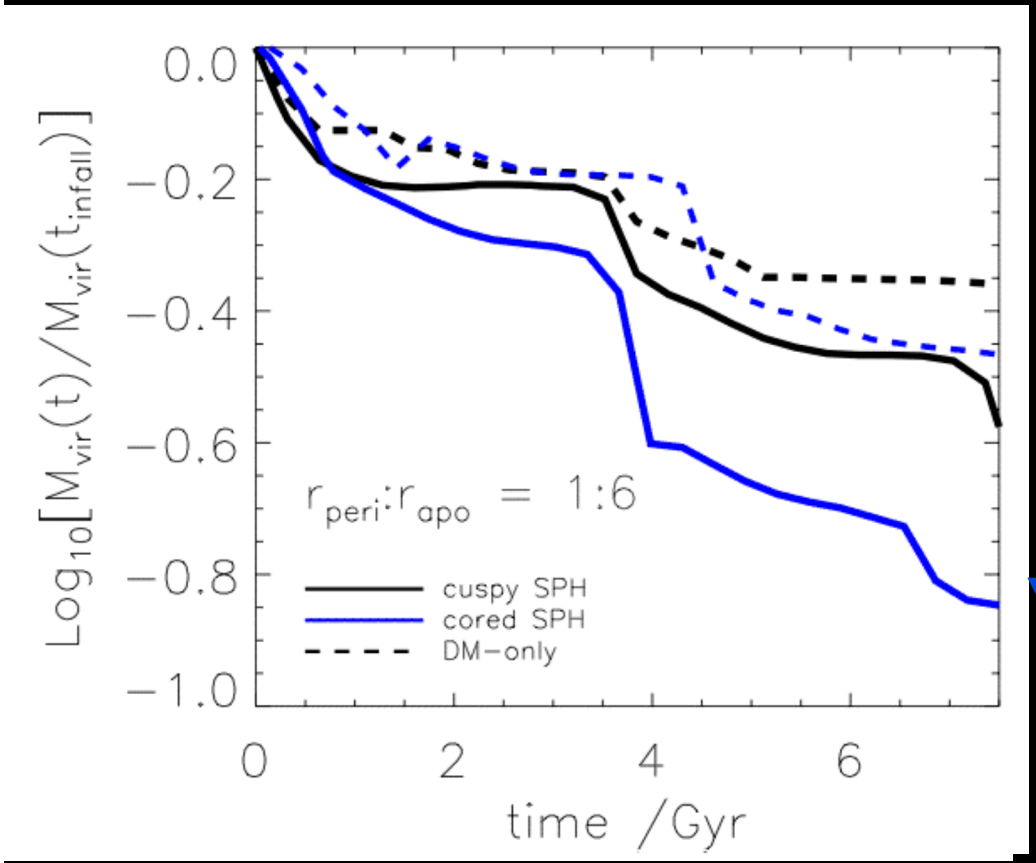
Penarrubia et al. (2010)



- Disk presence results in more mass loss at each pericentric passage for all satellites
- This effect is even stronger for cored satellites

After Infall: Tidal stripping

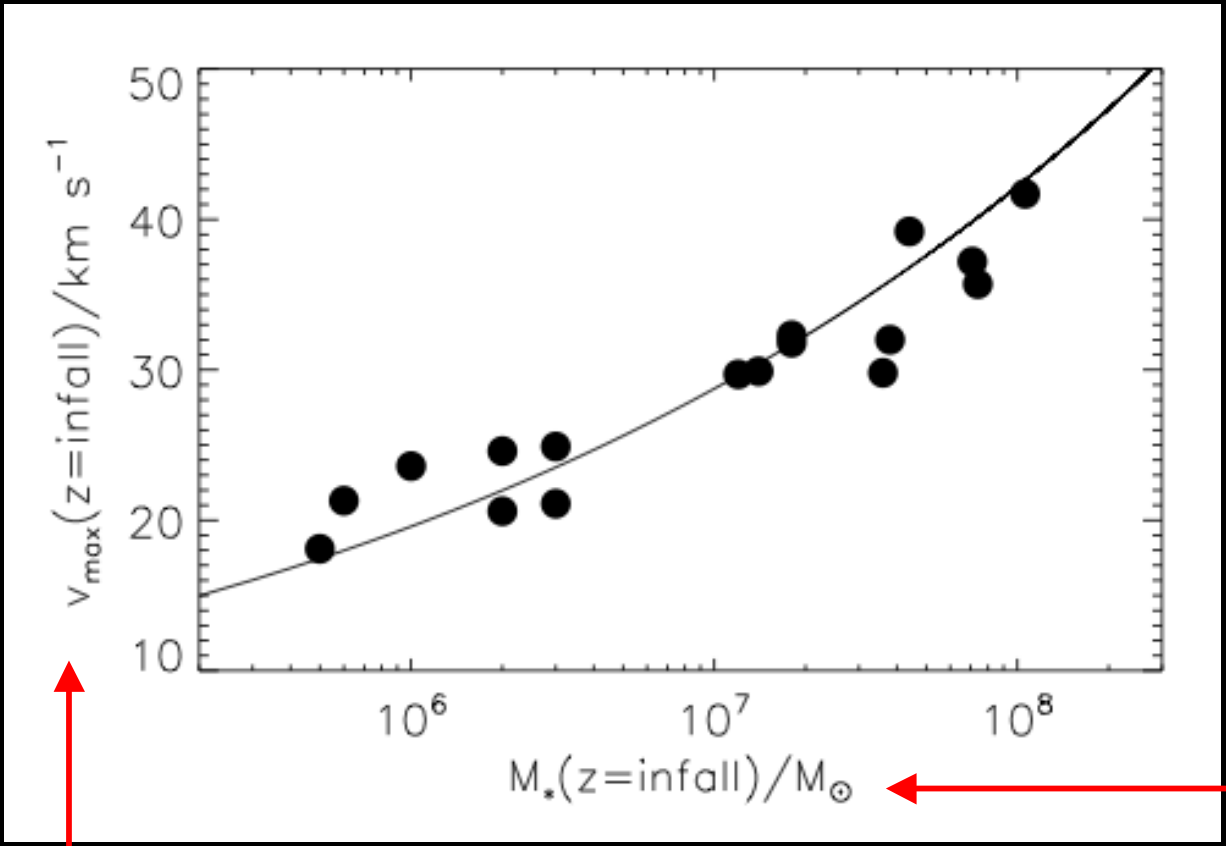
Satellite with DM ~~cusp~~ core



Disk effect:
DM +baryon sat lost ~ 12% more mass

Disk + core effect:
DM +baryon sat lost ~ 23% more mass

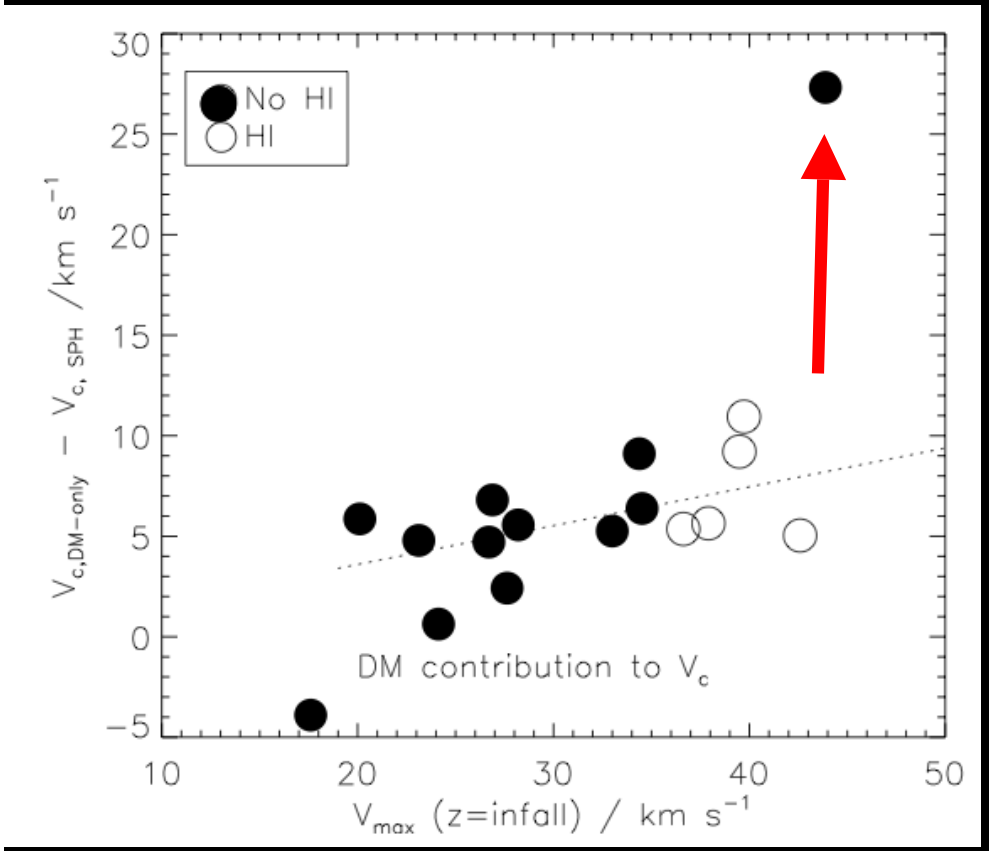
The Big Picture



Most Luminous satellites at infall

Most massive DM subhalos at infall

The Big Picture



- ✓ Abundance matching works
- × The central DM masses at z = 0, however, do not match between satellites with baryons and DM-only satellites
- × There is also gas loss and stellar mass loss in SPH satellites…

Summary

- ✓ Including baryons in cosmological simulations alleviates some of the tension between predictions of CDM model and observations of galaxies
- ✓ Supernova feedback in simulations that resolve high-density SF peaks naturally result in the flattening of DM cores into cusps ($M_* > 10^7$ Msun)
- ✓ This is true for both field galaxies.
- ✓ For satellites, this results in *reduced* DM densities
- ✓ Tides result in more mass loss at pericentric passage for all satellites in simulations with baryons (baryonic disk + DM core in satellites)

Baryons Matter!