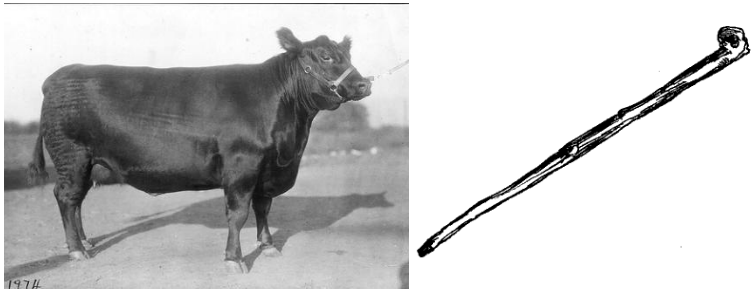
Problems with structure formation

Peebles & Nusser (2010)



Journal club (organised by als)

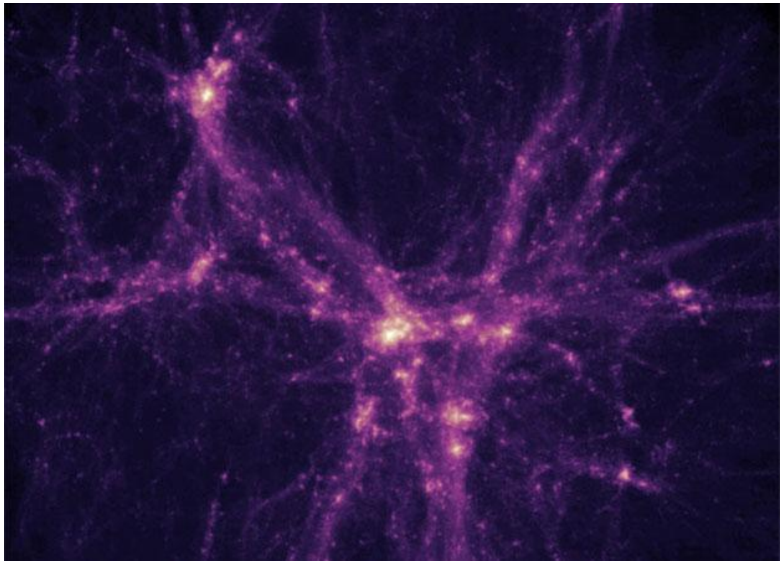
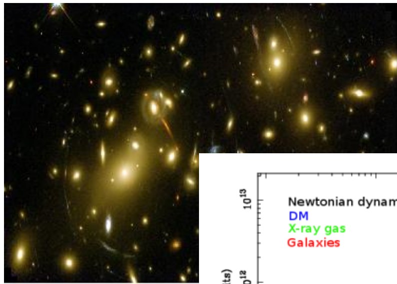
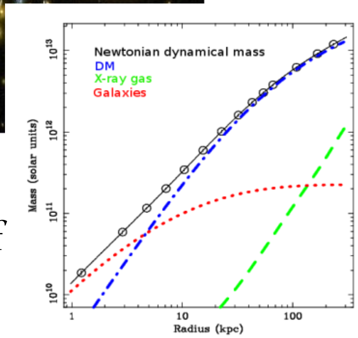


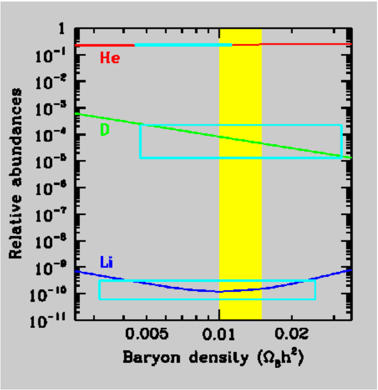
Figure 3: The pseudobulge disk galaxy NGC 4274 [20].

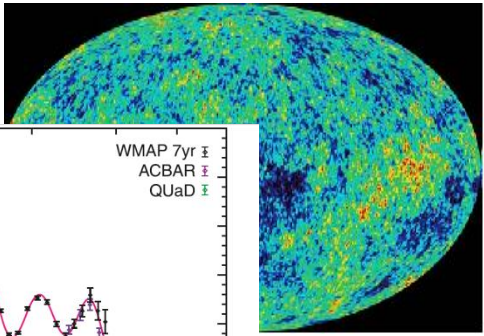
BBN

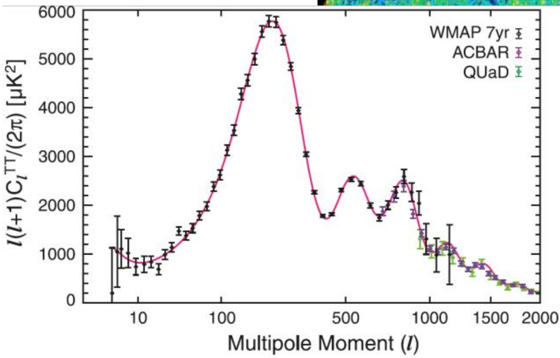




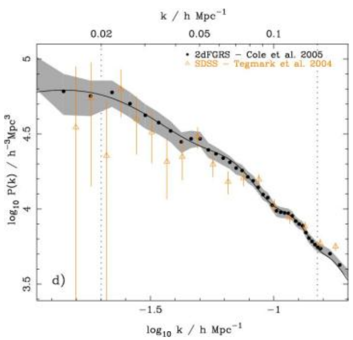
Clusters of galaxies



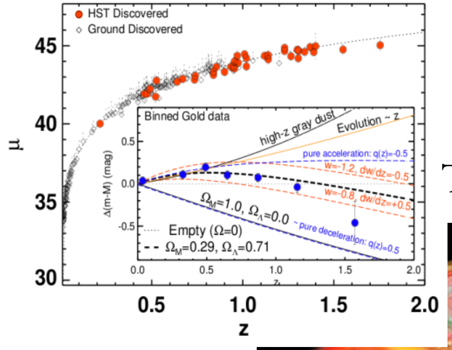




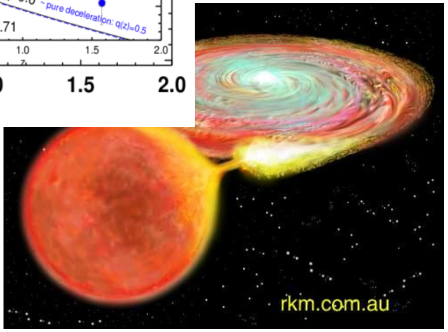
CMB

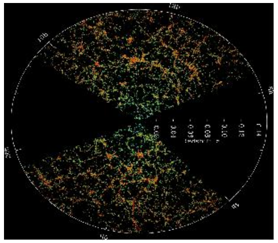


4.5% baryons
21.5% non-baryonic DM
74% dark energy

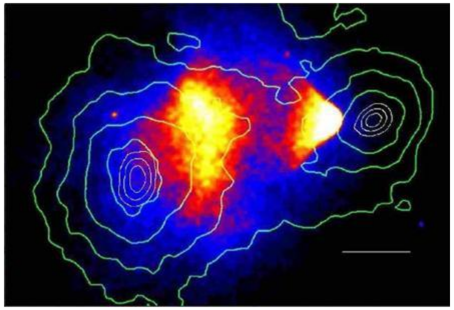


Type 1a SNe





Power spectrum
Of galaxies. Large scale
Structure formation

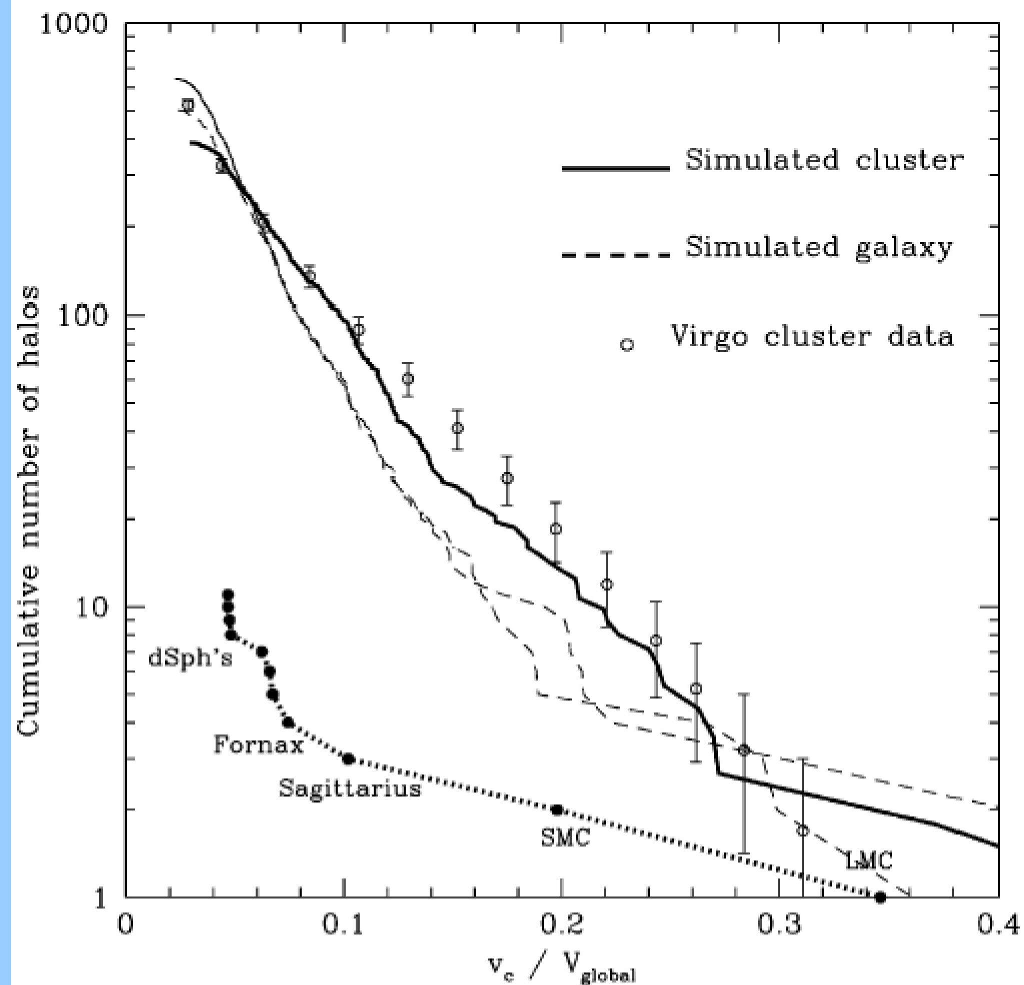


Missing satellite problem

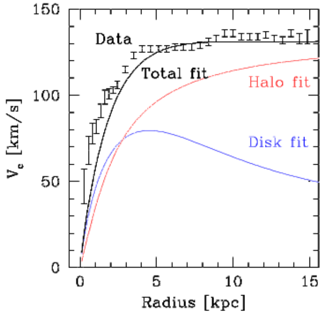
• The number of subhalos exceeds the number of MW satellites by a factor of 100 (Kauffmann et al. 93, Moore et al. 99, Klypin et al. 99)

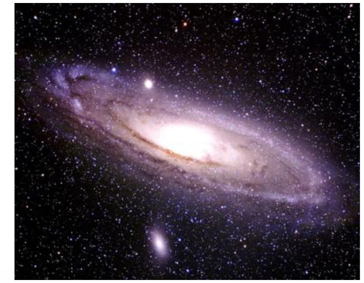
• Velocity dispersion or circular velocity was used as measure of subhalo mass.

What can be wrong ?
- CDM ?
- Circular velocity as measure of the mass ?
- Incompleteness ?
- Star formation ?

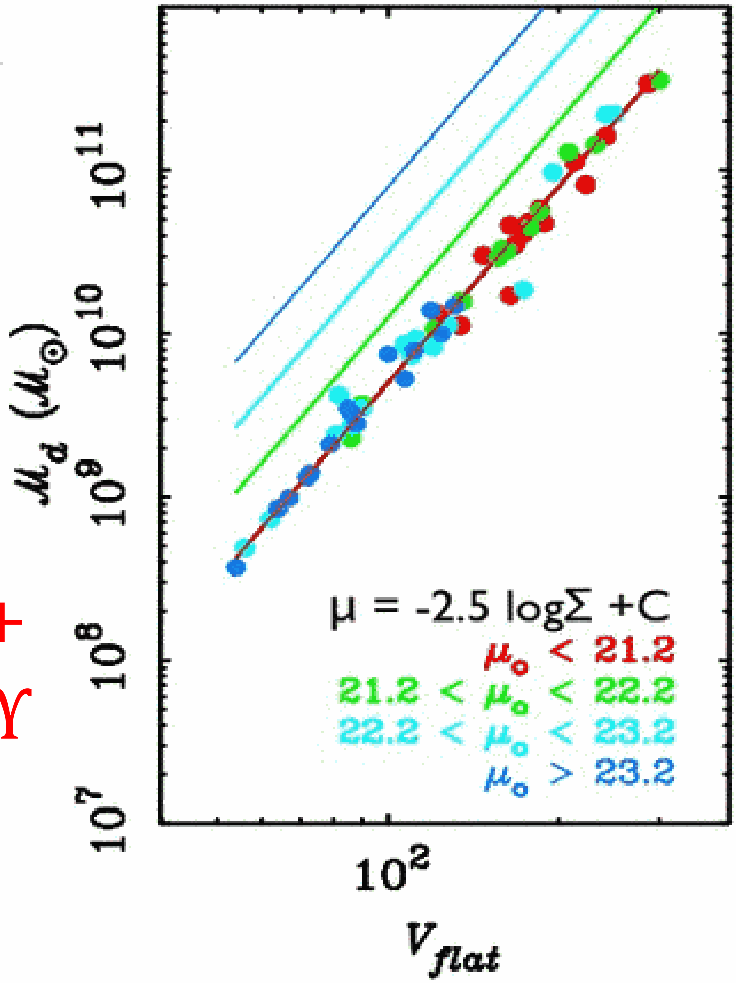


Moore et al.(1999)





TF Relation



<u>Newton says</u>

$V^2 = GM/R.$

Equivalently,

$\Sigma = M/R^2$

$V^4 = G^2 M\Sigma$

Take logs

$M = \Upsilon L_* (+M_g)$

$4\log V = \log L + \log\Sigma\Upsilon$

<u>Therefore</u>

Different Σ *should* mean different TF normalization.

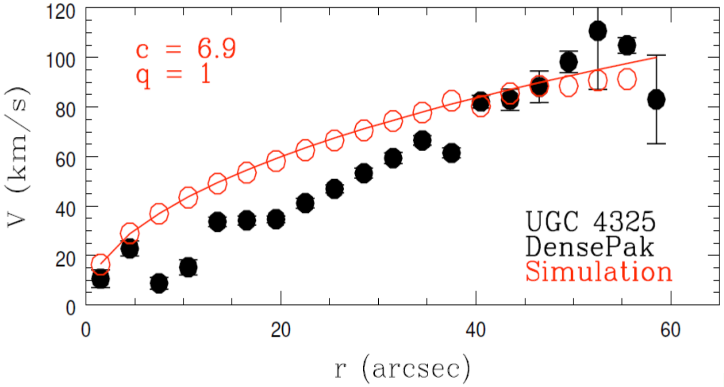
<u>Tully Fisher residuals</u>

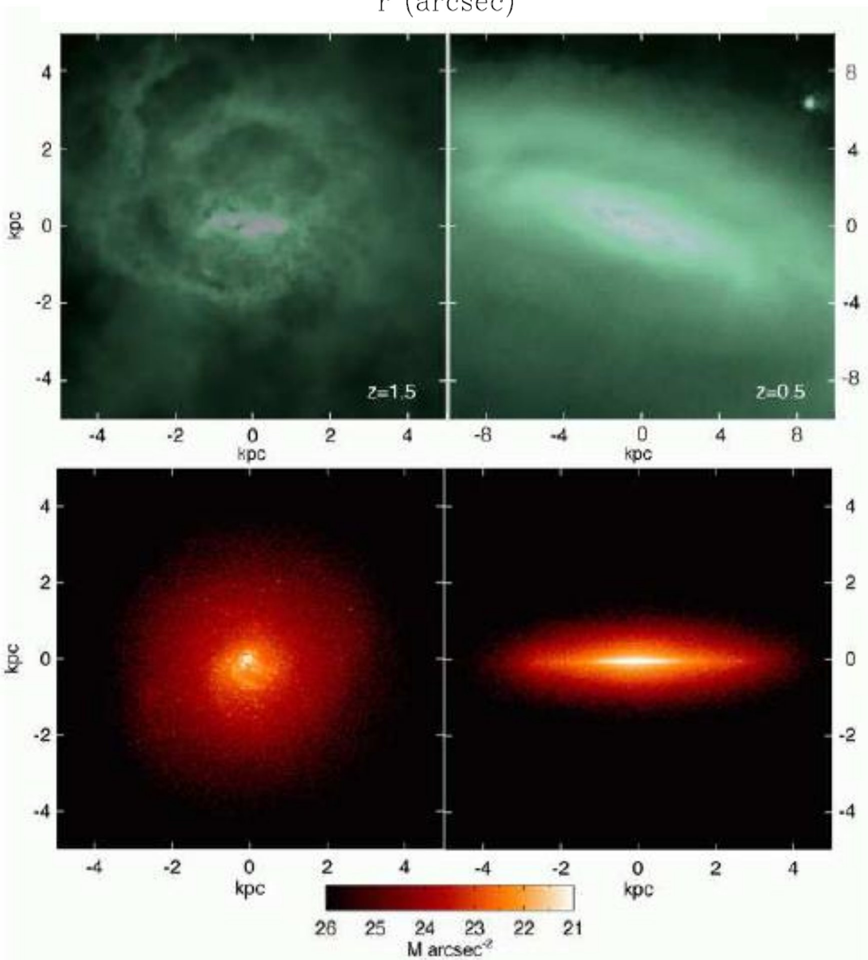
Zwaan et al. (1995)
Sprayberry et al. (1995)
Tully & Verheijen (1997)
McGaugh & de Blok (1998)
Courteau & Rix (1999)
McGaugh (2005)
Pizagno et al. (2005)
Dutton et al. (2006)
Gnedin et al. (2006)

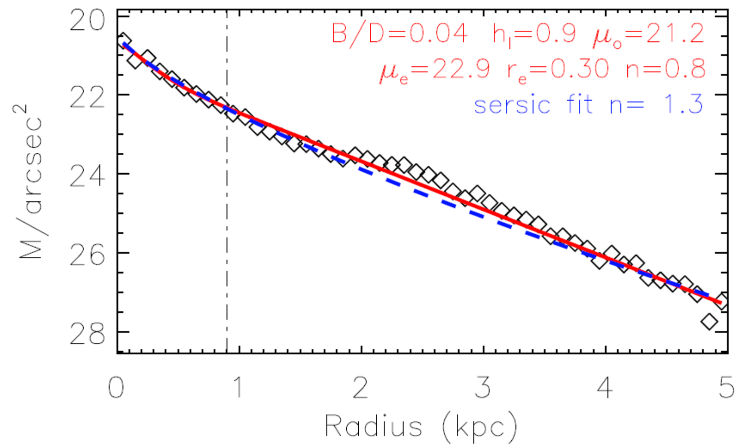
Cusp/core problem

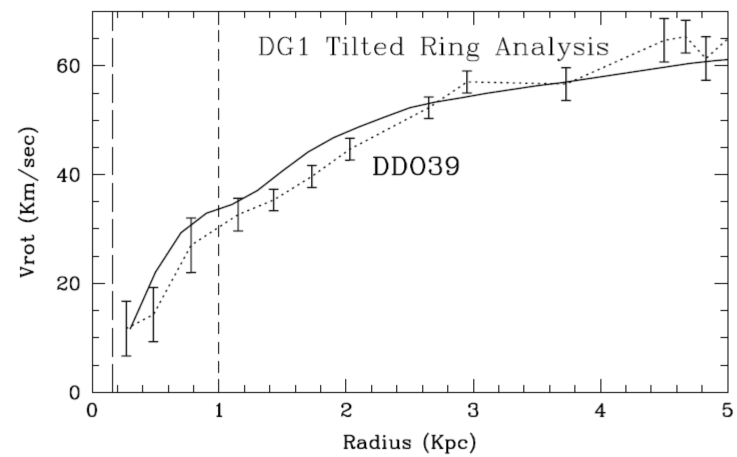
ρ (near centre)=constant

ρ (near centre)=1/r



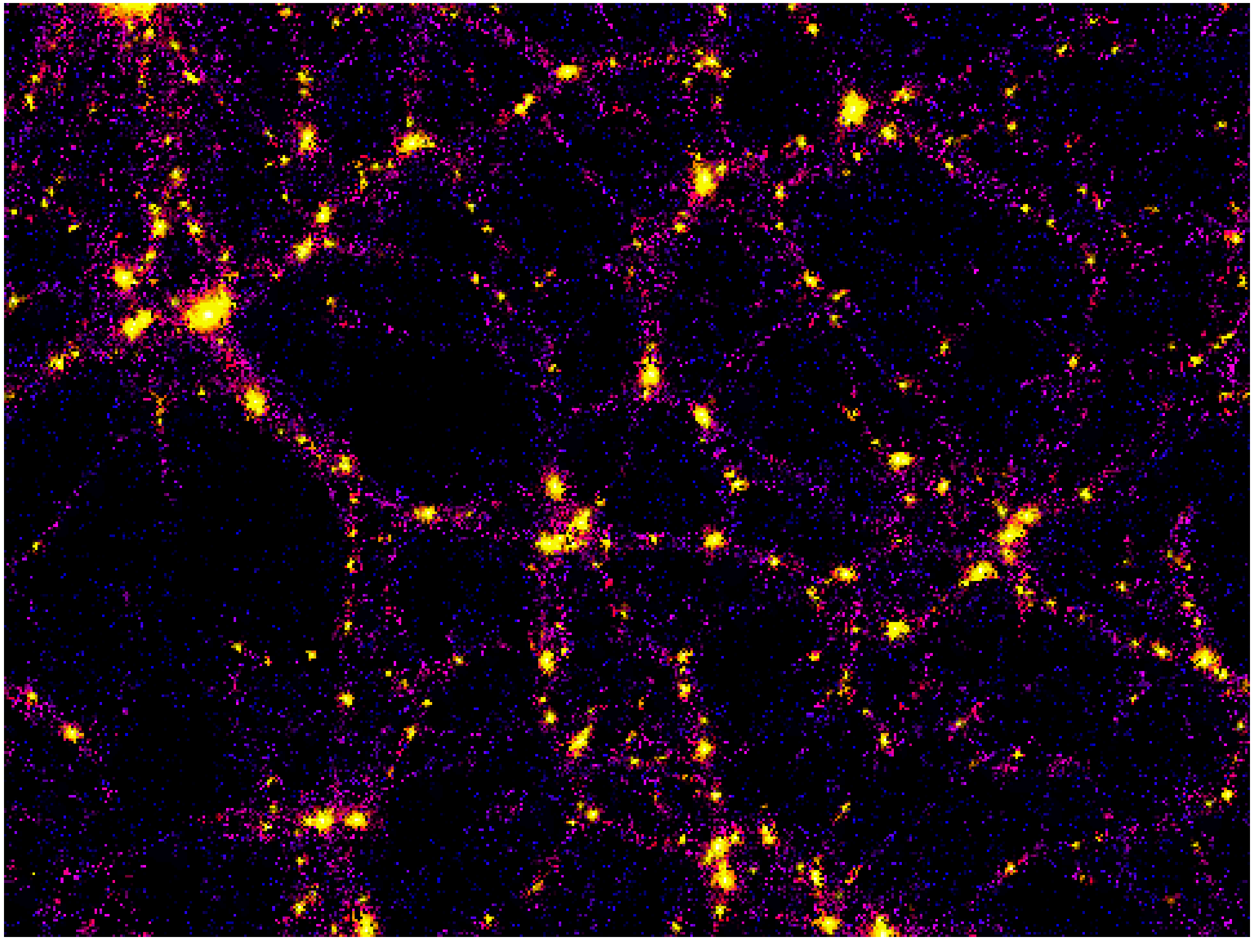






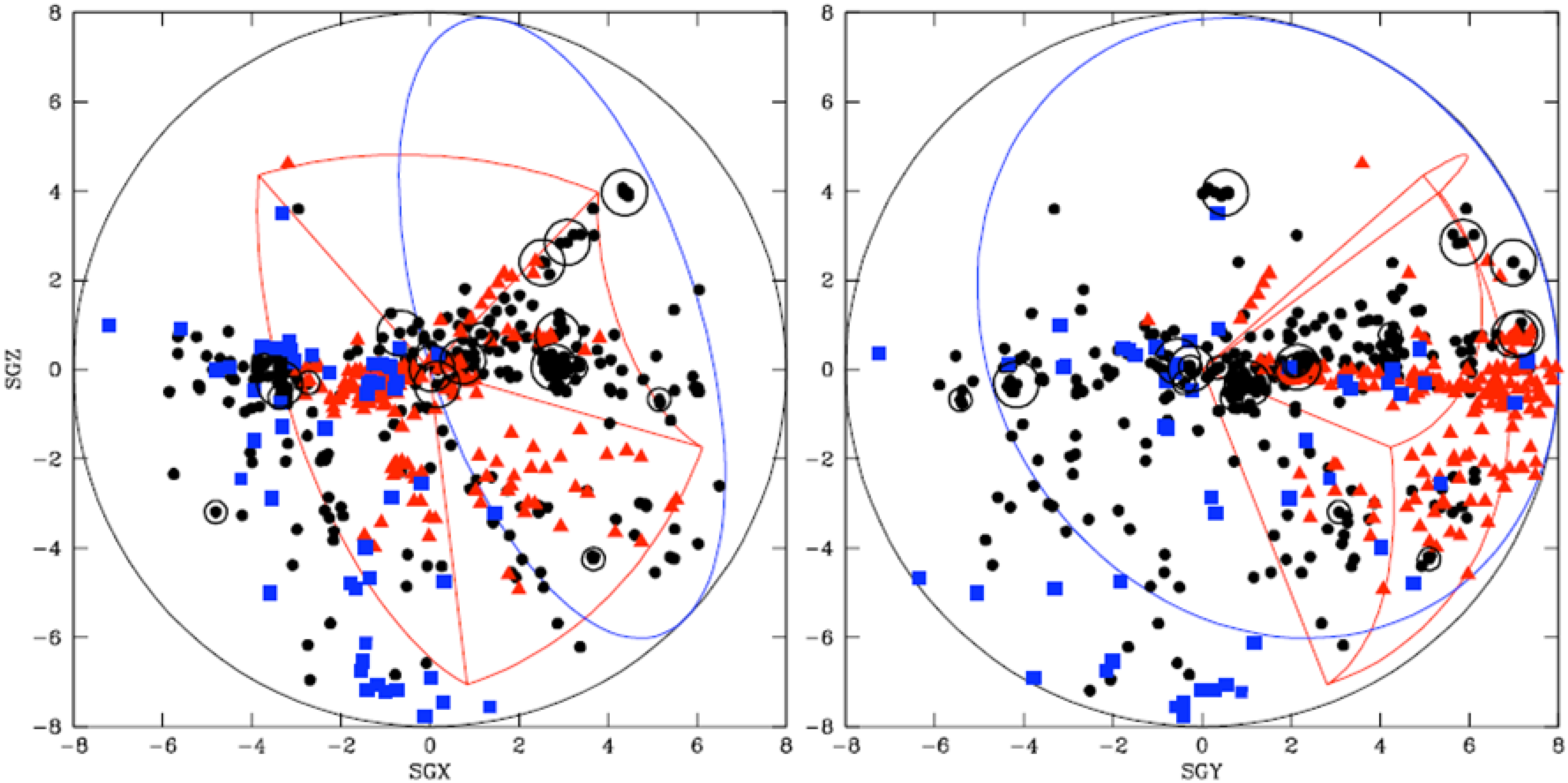
Governato et al. (2009), Nature

ΛCDM predicts hierarchical formation of a cosmic web of structures



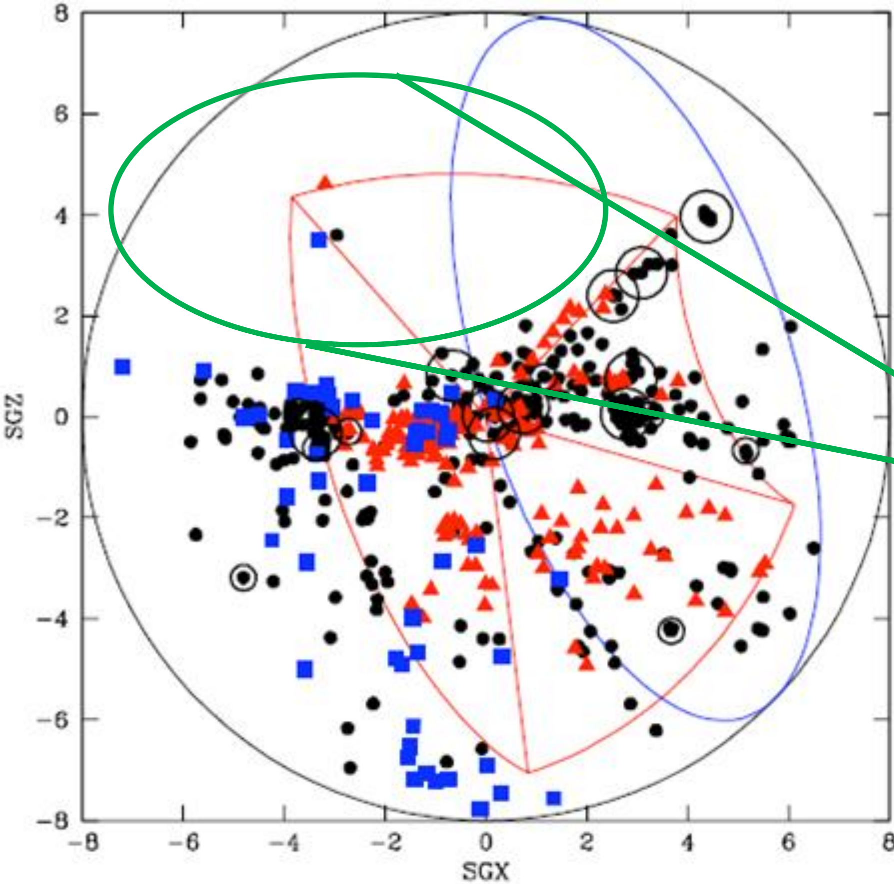
We can compare this with the distribution of nearby galaxies.

The 562 galaxies at $1<D<8$Mpc in the supergalactic coords of de Vaucoulers.



SGZ=0 resembles the cosmic web, but there is a problem with the relative distribution of bright and faint galaxies.

Only 3 galaxies in the Local Void.



PARKES HIPASS survey detected H-I in

No H-I in perhaps SDSS distance is wrong?

Numerical Sims predict the number density of small DM halos in a void is 10% the global mean.

The **Local Void** occupies 1/3 of Vol 1<D<8Mpc.

If environment has no effect on prob that a DM halo is luminous with stars (or 21cm) then

562 (N of gals <8Mpc) x 1/10 -> 57 (gals per unit vol) x 1/3 ->

expected gals in LV: $\bar{x} = 19$

$$\boldsymbol{\sigma^2 = 19 \rightarrow P(x=3 \text{ gals in LV})} \approx \frac{1}{\sqrt{2\pi\sigma^2}} \times \exp\left[-\frac{(\bar{x}-x)^2}{2\sigma^2}\right] \approx 10^{-4} \approx 0$$

Predicted number of LV gals must not be confused with the missing satellite problem.
The number of LV gals is scaled from the counts of nearby gals.

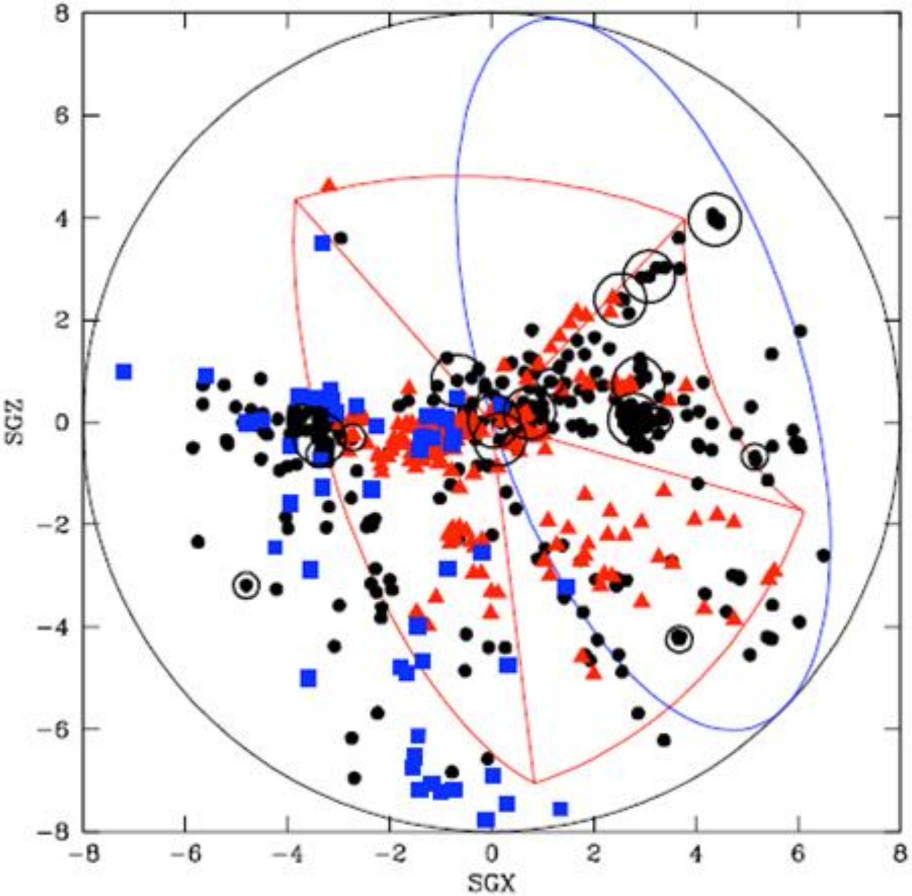
Possible error is that there are many more LV gals to be discovered, although unlikely.
Still, future surveys will be very interesting.

2nd error, may exacerbate problem. We have assumed so far that a DM halo of given mass has the
Same chance of being noticed, regardless of where it is. However, more isolated gals contain HI in
Clouds , or at greater isolation – disks. And, it is difficult to find a hydrogen disk w/o stars.
DISKS FORM STARS.

Star formation is over for the dSPhs near the MW. Ram pressure has presumably stripped all
The gas.

So the tranquil environ in voids offers the best chance for fragile gal disks to survive, meaning
We expect more than 19.

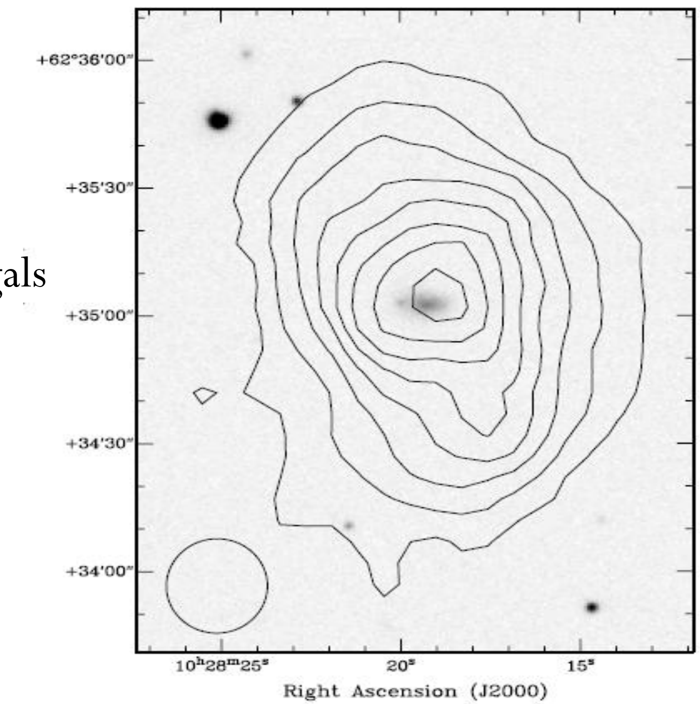
Perhaps the LV is atypical, or perhaps we are learning that we need growth of structure that
Is faster than standard cosmology, more completely emptying voids.



5% of gals

73% of gals

Huge rotationally supported disk of H-I
With a tiny stellar disk in low density region



M51, M101, NGC6946
SGZ = 2.4 , 2.8 , 4 Mpc

○ are the 10 most luminous gals (1 is NGC6946)
○ are the next 10 most luminous gals

The ● inside the ○ are the satellite gals.
$L_1 = 2 \times L_{10} = 6 \times L_{20}$. The rest are much lower ($10^5 L_{592}$)

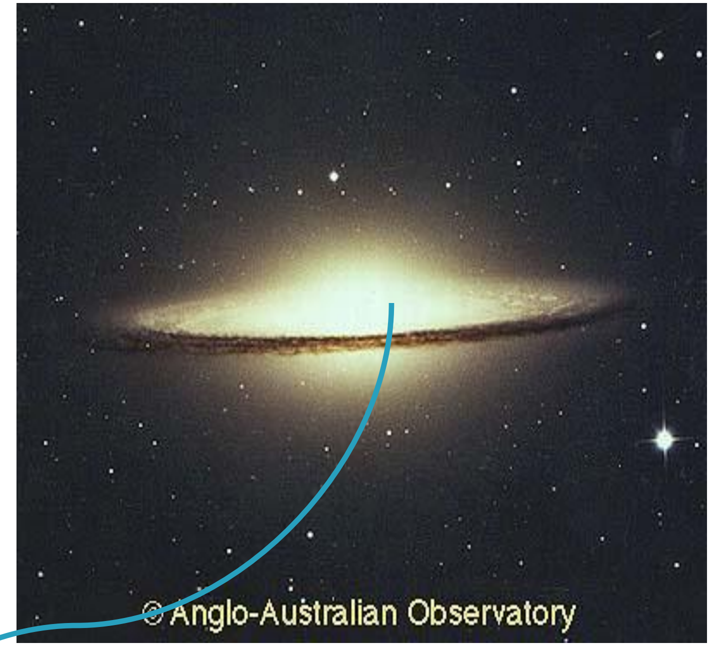
Problem is that 3/10 of the ○ are in uncrowded regions above the local sheet.

If galaxy luminosities are assigned randomly: the prob 1/10 ○ is SGZ>2Mpc is $1 - (0.95)^{10}$ -> 40%.

For 3/10: $\frac{10!}{7!3!}(0.95)^7(0.05)^3 = 1\%$

Problems with pseudobulges

Figure 3: The pseudobulge disk galaxy NGC 4274 [20].



Kormendy & Fisher said half of the 20 large nearby galaxies have their stars in a thicker disk even at the centre.

Supported by rotation, not random motions like

Accounting for pseudobulges is tough for CDM.

The bulge is a natural outcome of CDM galaxy formation. Hi-res sims always produce healthy bulges and small disks.

Multiple mergers disrupt the circular motions of stars that formed in an early disk.

PsBs cannot have accreted much debris, or there would be a bulge.

Milky Way must have evolved in isolation z<3.

Is it even possible to form a bulgeless galaxy?

Galaxies as island Universes

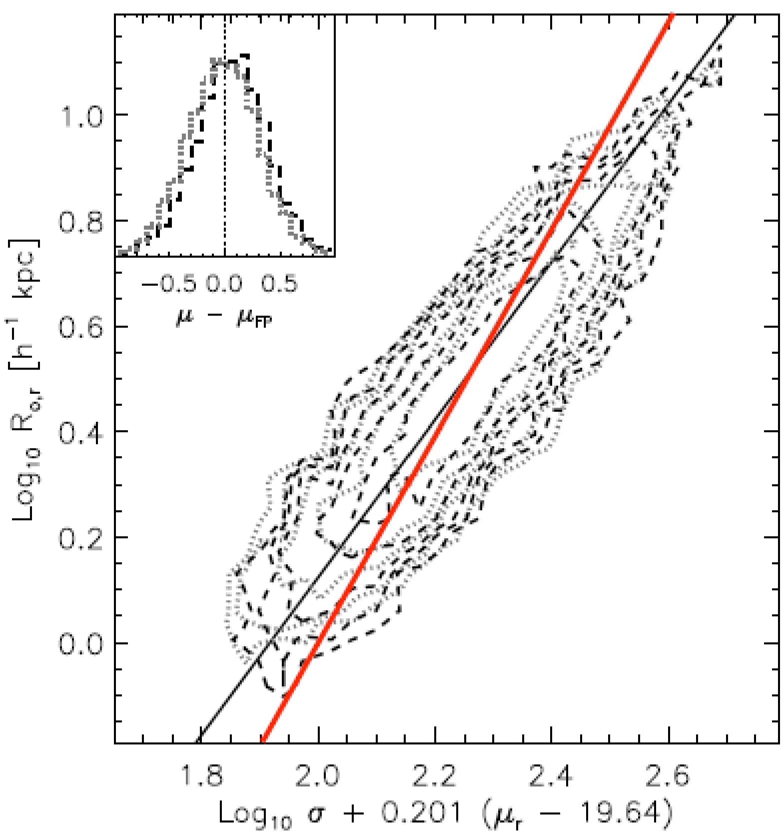
Correlations among early types (Es, S0s, dEs).

Different contours for gals that are isolated and in dense environs measured by the SDSS.

There is a significant difference, but it is remarkably small.

The standard picture of hierarchical galaxy formation depends on multiple mergers.

This fig suggests mergers are unimportant since two spirals merging to produce an elliptical would need to pre-arrange for their colours to match.



Conclusions

Need more rapid structure formation to:

empty voids.
make galaxies present there large.
build galaxies before merging is important.

Possible solutions:

5th force gravity. Non gravitational interaction between dark matter particles that has strength of the same order.

MOND ☺