Distribution of Dark Matter in Galaxies

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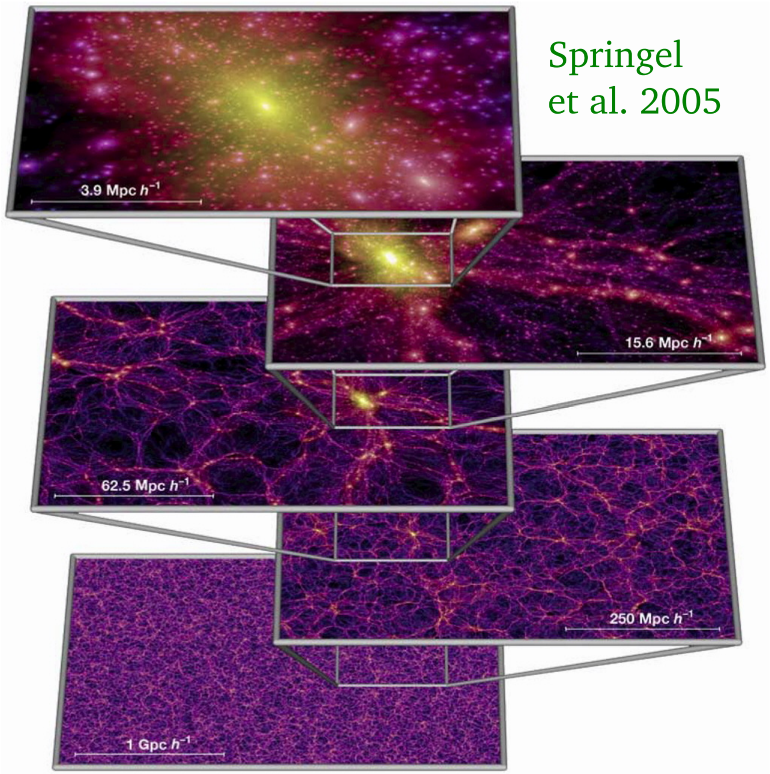
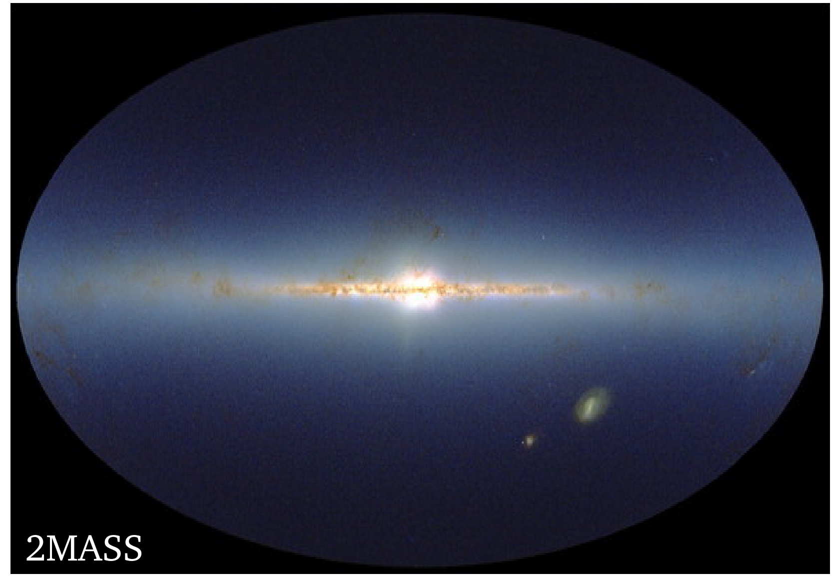


Springel et al. 2005



DM annihilation could produce γ-rays

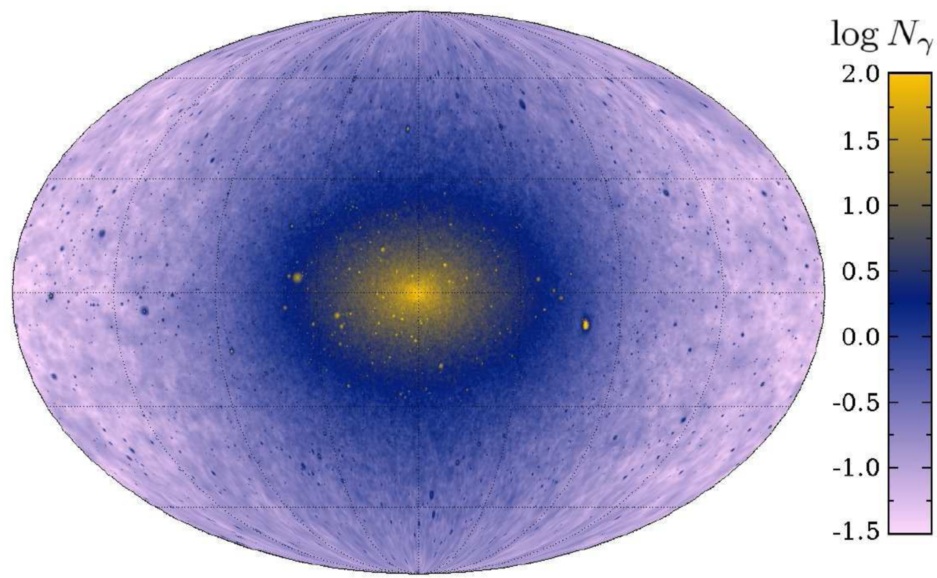


FIGURE 2. Simulated GLAST allsky map of neutralino DM annihilation in the Galactic halo, for a fiducial observer located 8 kpc from the halo center along the intermediate principle axis. We assumed $M_\chi = 46$ GeV, $\langle \sigma v \rangle = 5 \times 10^{-26}$ cm^3 s^{-1}, a pixel size of 9 arcmin, and a 2 year exposure time. The flux from the subhalos has been boosted by a factor of 10 (see text for explanation). Backgrounds and known astrophysical gamma-ray sources have not been included.

Kuhlen et al. 2007

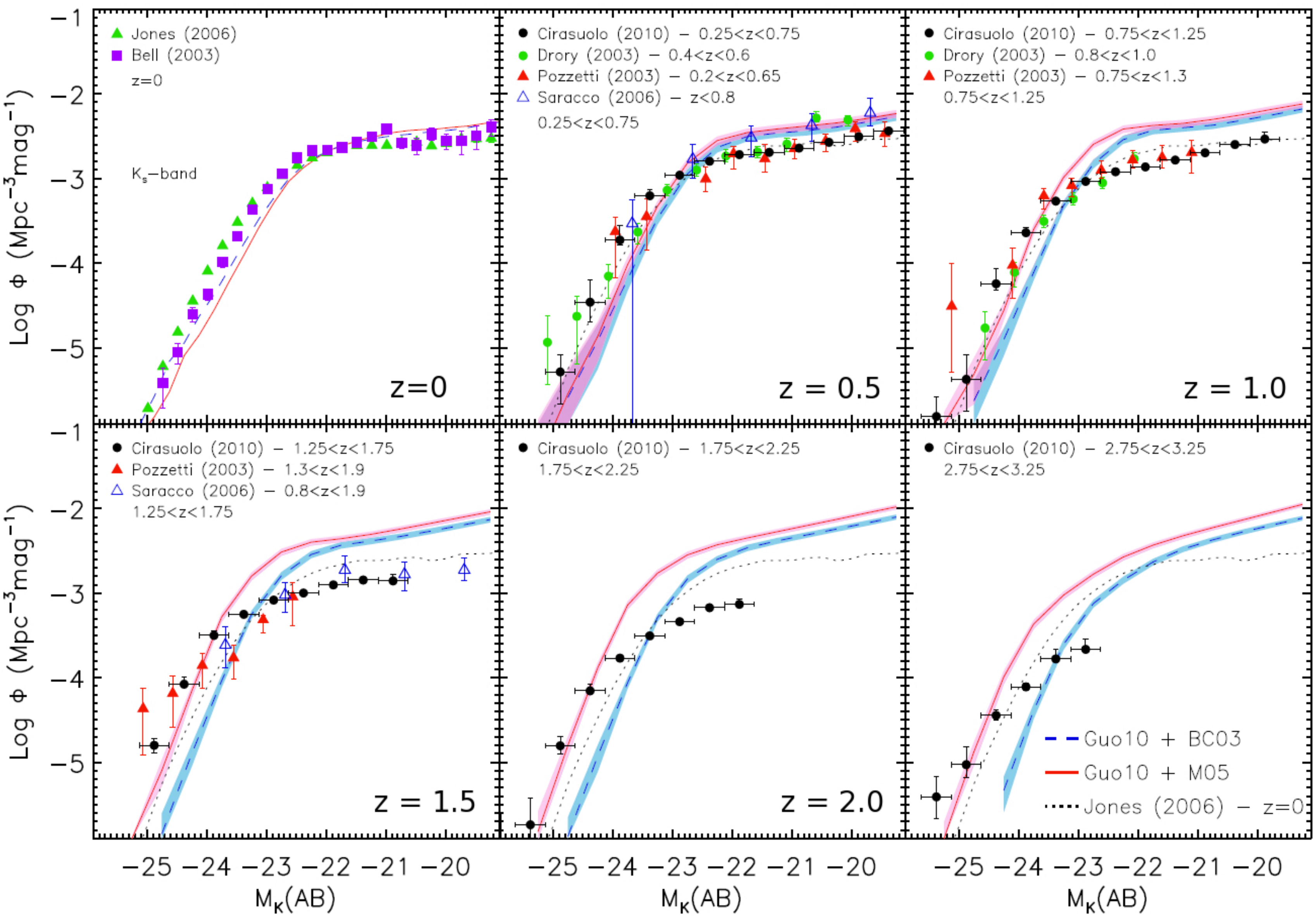
- Dark Matter only simulations,
  e.g. Millenium, Via Lactae, Bolshoi
+ semi-analytic recipes to make
  galaxies

- DM + gas + star formation
+ feedback, etc. e.g. CLUES, Horizon

- also “zoom” simulations
+ simulations with idealized
  initial conditions

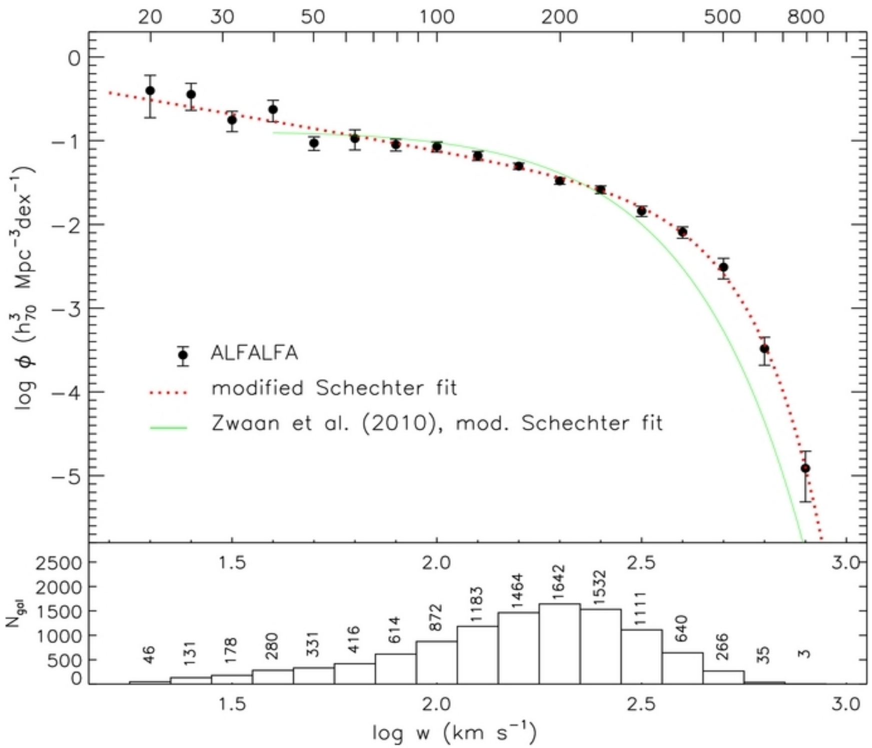
Semi-analytical models

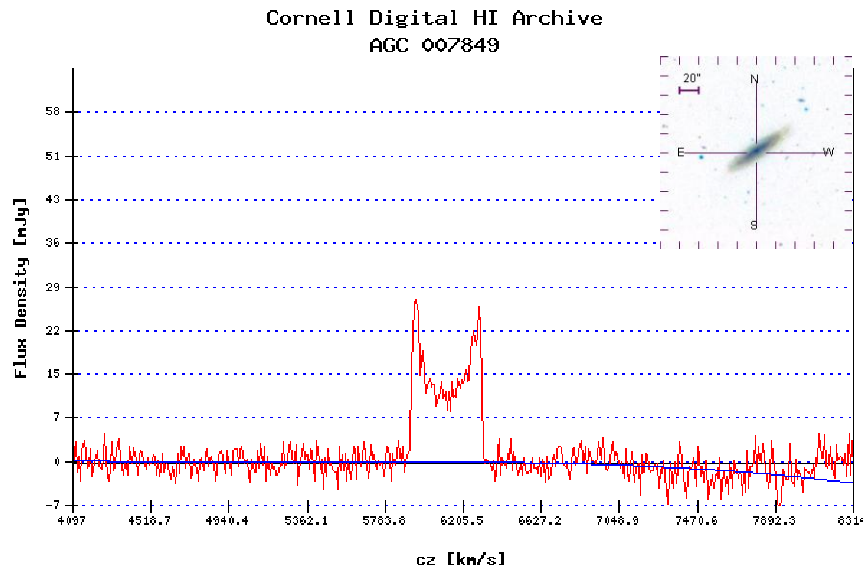
arxiv:1109.3457 Henriques et al.

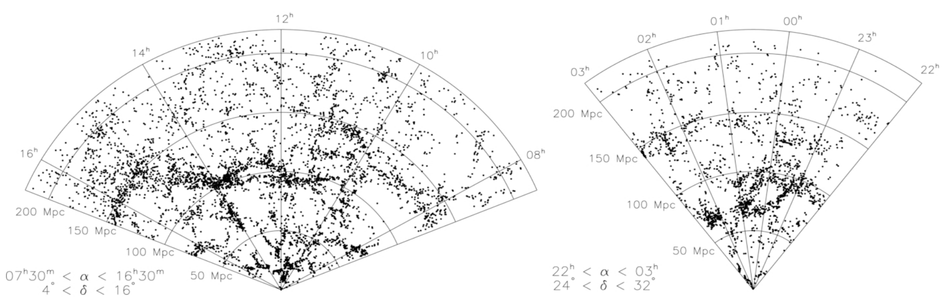


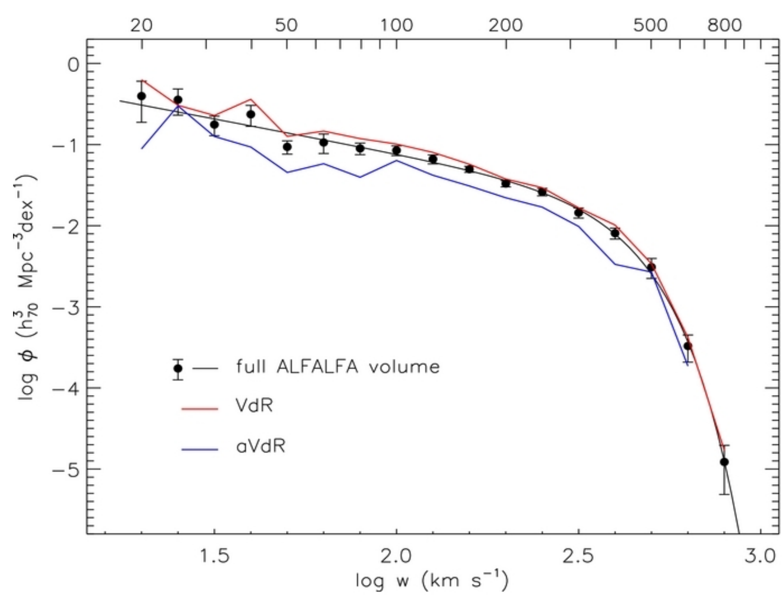
HI velocity width function

arxiv:1106.0710 Papastergis et al.

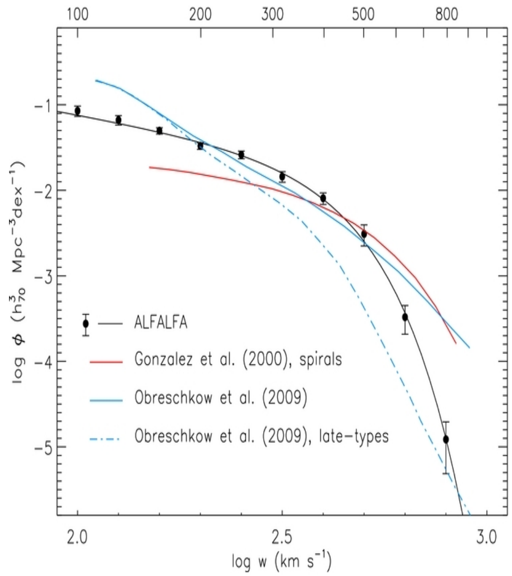


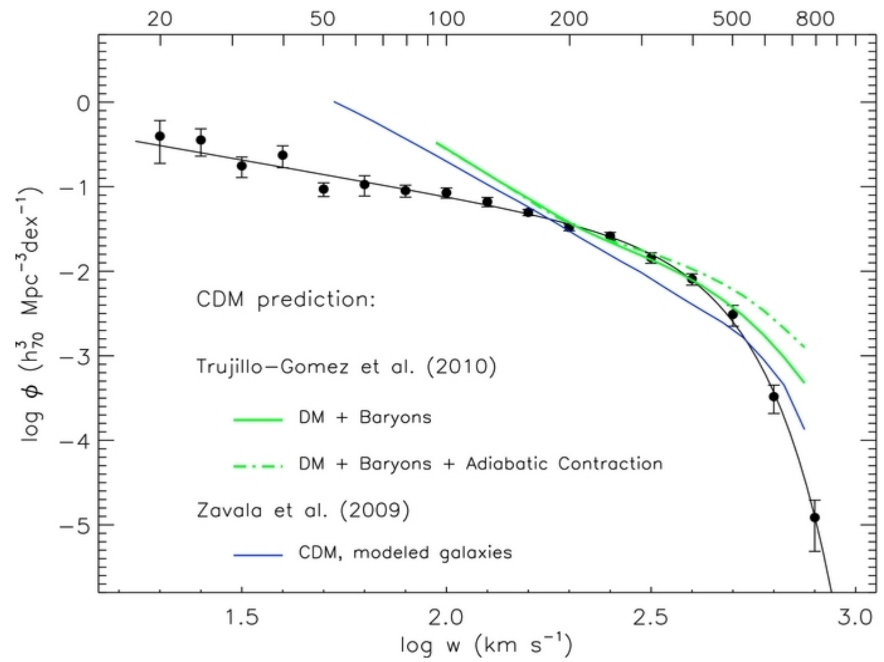


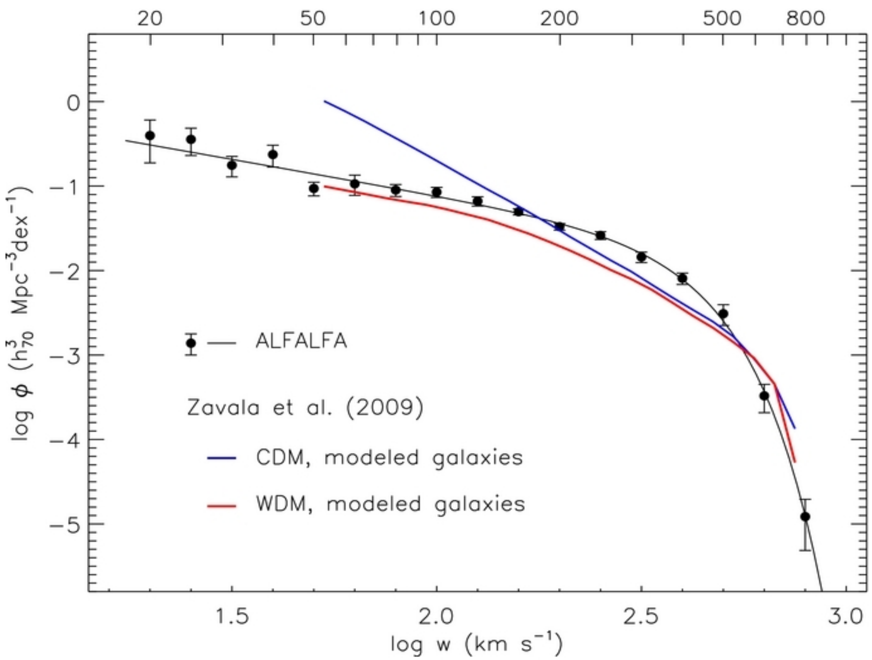




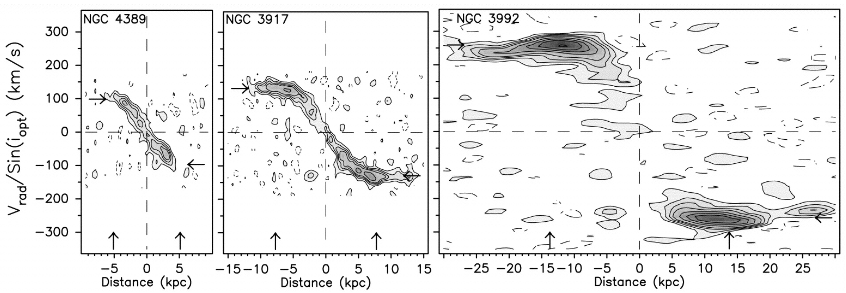
40% of Alfalfa survey







warm DM fits data better, but beware of rising rotation curve effect



Dark Matter in the Galactic Disk

Oort (1932)

From stellar movements we can infer the mass in the solar neighbourhood

dynamics $0.092\ M_\odot\,pc^{-3}$

counted $0.038\ M_\odot\,pc^{-3}$

Table 1. Disc mass model. Holmberg & Flynn (2000)

i	Description	$\rho_i(0)$ ($M_\odot\,pc^{-3}$)	σ_i ($km\,s^{-1}$)	Σ_i ($M_\odot\,pc^{-2}$)	Note
1	H_2	0.021	4.0	3.0	C
2	H I(1)	0.016	7.0	4.0	C
3	H I(2)	0.012	9.0	4.0	C
4	warm gas	0.001	40.0	2.0	C
5	giants	0.0006	17.0	0.4	H
6	$M_V < 2.5$	0.0031	7.5	0.9	H
7	$2.5 < M_V < 3.0$	0.0015	10.5	0.6	H
8	$3.0 < M_V < 4.0$	0.0020	14.0	1.1	H
9	$4.0 < M_V < 5.0$	0.0024	19.5	2.0	H
10	$5.0 < M_V < 8.0$	0.0074	20.0	6.5	H
11	$M_V > 8.0$	0.014	20.0	12.3	X
12	white dwarfs	0.005	20.0	4.4	L
13	brown dwarfs	0.008	20.0	6.2	L
14	stellar halo	0.0001	100.0	0.6	L

Notes. C: component constrained by column density.
H: component constrained by local density using *Hipparcos*.
L: component constrained by local density using star counts.
X: component constrained by column density using *HST* star counts.

TABLE 34.

Mean masses and total mass of the stars in a unit of volume.

$M_{vis.}$	Limiting distance	Average mass	*n*	Total mass
B stars		4·:		·0016:
< +1·5	20 ps	4·09	10	12
+1·5 to +3·5	10	1·87	7	22
3·5 » 5·5	10	1·34	22	74
5·5 » 7·5	10	1·09	27	79
7·5 » 9·5	6·7	·86	5	72
9·5 » 11·5	6·7	·42	14	55
+11·5 » +13·5	5·0	·22:	6	·0049:
All <+13·5				·0378

Dark disk ??

No Moni Bidin et al. arxiv/1011.1289

Yes, if... Garbari et al.arxiv/1011.6339

If mass follows light, then … - no, NGC 3115 Oort 1940, - yes, M31 Schwarzschild 1954

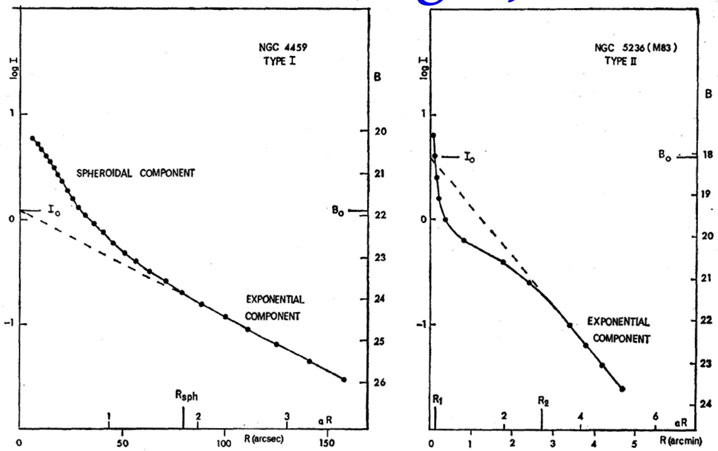
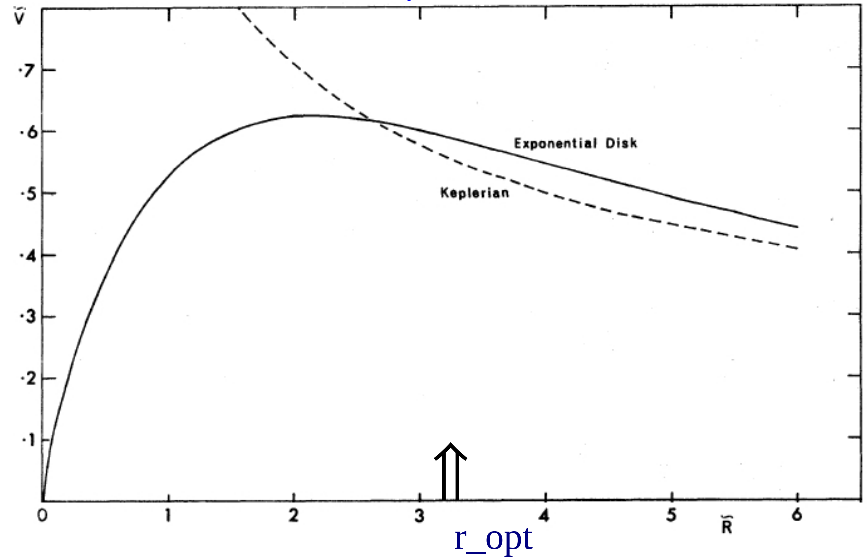


FIG. 1.—Radial luminosity distributions for NGC 4459 and M83. I is the surface brightness. Ordinates are log I and I in B-mag per square second of arc. R is distance from the nucleus along the major axis; the dimensionless radius αR is also shown. I_0, B_0 are the surface-brightness scale for the exponential disk, uncorrected for inclination and galactic absorption. R_1, R_2, and R_{sph} are defined in § III. *Filled circles*, observed points.



Freeman 1970

De Jong 1996

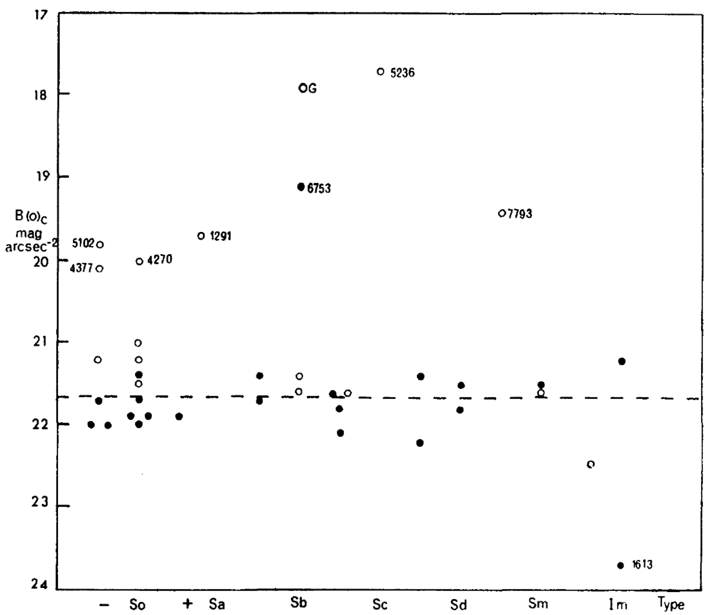
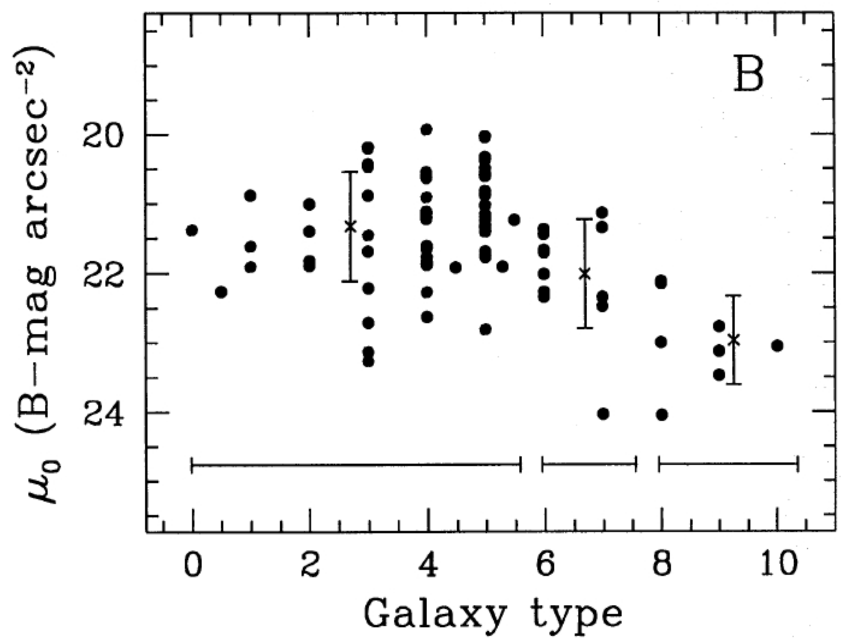


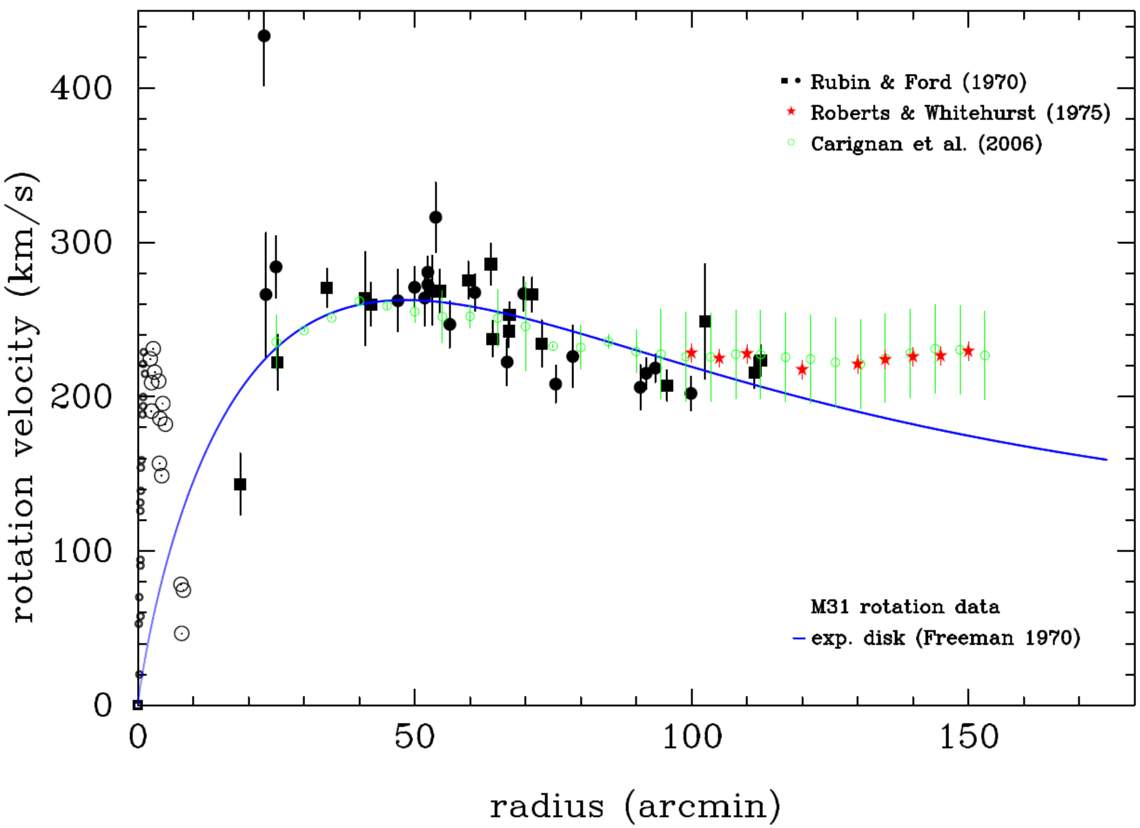
FIG. 5.—Intrinsic distance-independent blue-light luminosity scale $B(0)_c$ for the exponential disks of thirty-six galaxies against their morphological type. Broken line at $B(0)_c = 21.65$ is the mean for twenty-eight galaxies. NGC numbers are shown for the other eight. G denotes an estimate for the Galaxy. *Filled circles*, Type I luminosity profile; *open circles*, Type II luminosity profile (see Fig. 1).



Freeman 1970, appendix

For NGC 300 and M33, the 21-cm data give turnover points near the photometric outer edges of these systems. These data have relatively low spatial resolution; if they are correct, then there must be in these galaxies additional matter which is undetected, either optically or at 21 cm. Its mass must be at least as large as the mass of the detected galaxy, and its distribution must be quite different.

M31 – Need for dark matter based on radio data



Local Group 'timing' argument

Kahn & Woltjer 1959

M31 approaches MW with speed 125 km/s

M31 and MW orbit around center of mass

M* ≥ 1.8 10**12 M⊙

likely intergalactic gas (high T, low ρ)

Haloes necessary for disc stability ??

Ostriker & Peebles (1973) :

Cold disks cannot 'survive': they are prone to a bar instability

If a spherical halo is added, the model is more stable

For our Galaxy, this implies a halo mass interior to the disk which is about equal to the disk mass

Thus the halo mass exterior to the disk may be extremely large

(this was based on simulations with 500 mass points, as well as some analytic calculations)

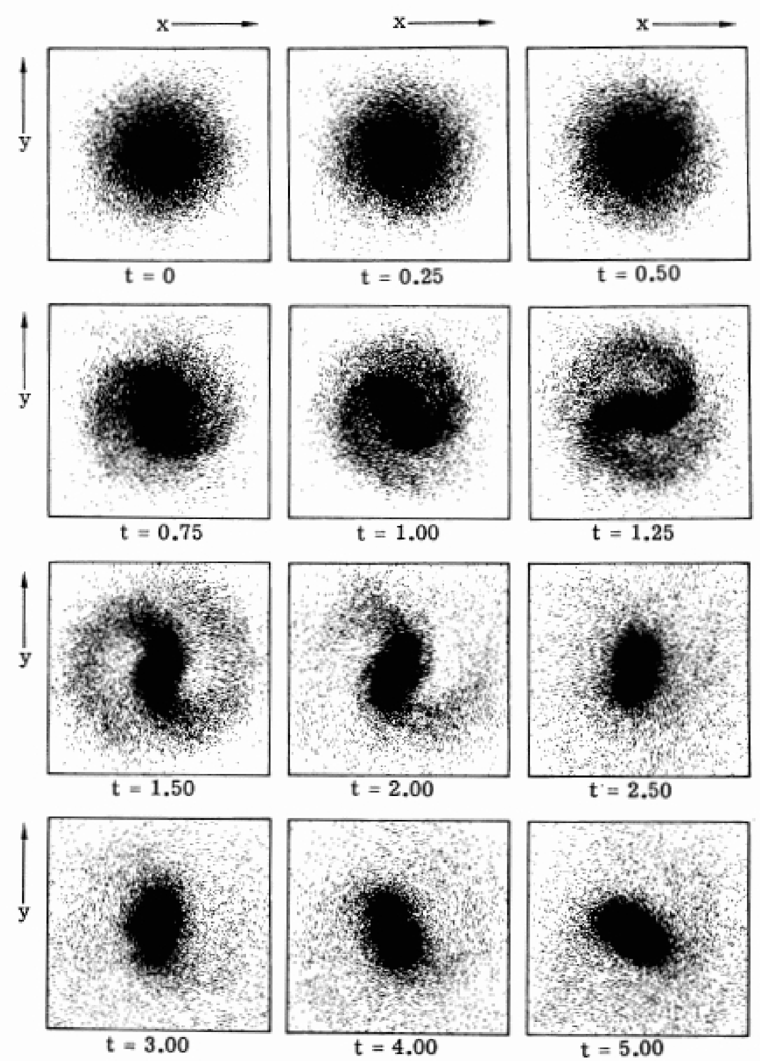


Fig. 9. Evolution of a disk of stars with an initially exponential mass distribution.

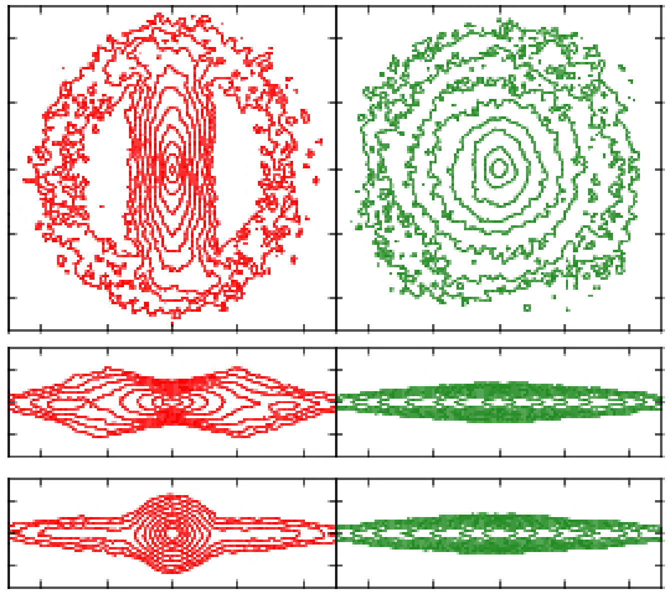
Hohl (1971)

Haloes should be adequately modelled

Live halo

Halo can receive angular momentum

Strong bar develops

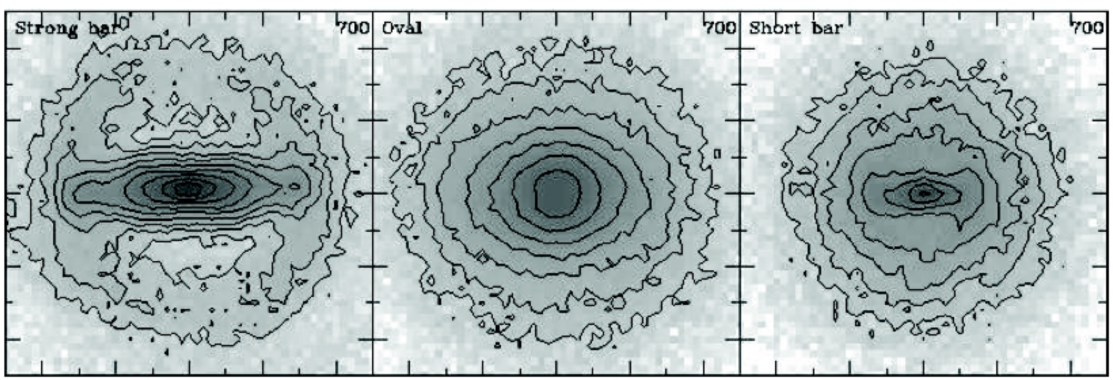


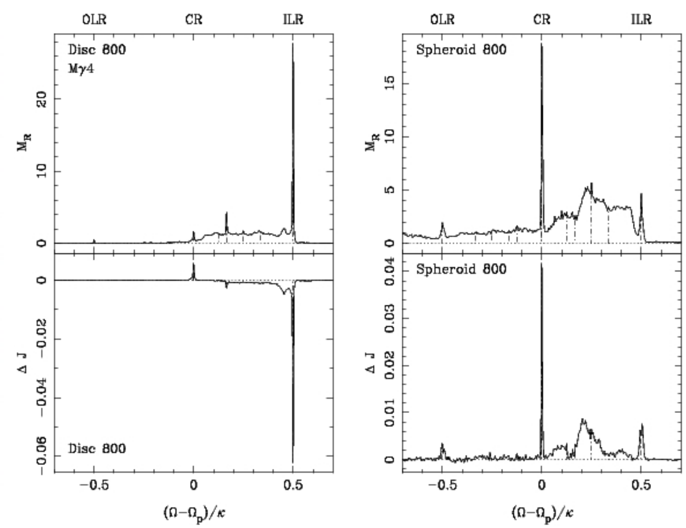
Rigid halo = fixed potential

Halo can not receive angular momentum

No bar develops

Athanassoula 2002, 2003





Considerable amount of angular momentum is exchanged

Little angular momentum exchanged

Responsive halo

Hot outer disc

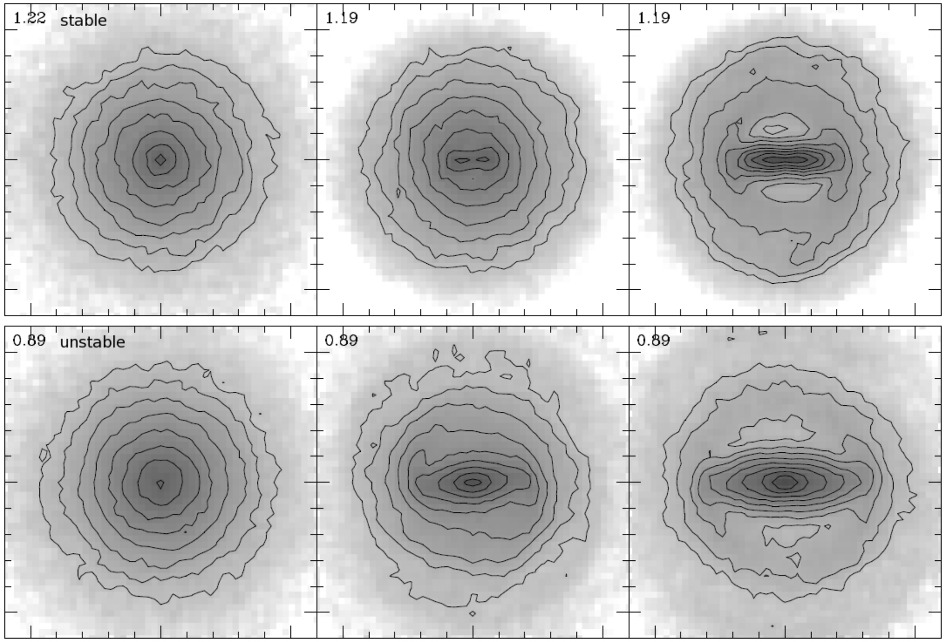
Hot halo

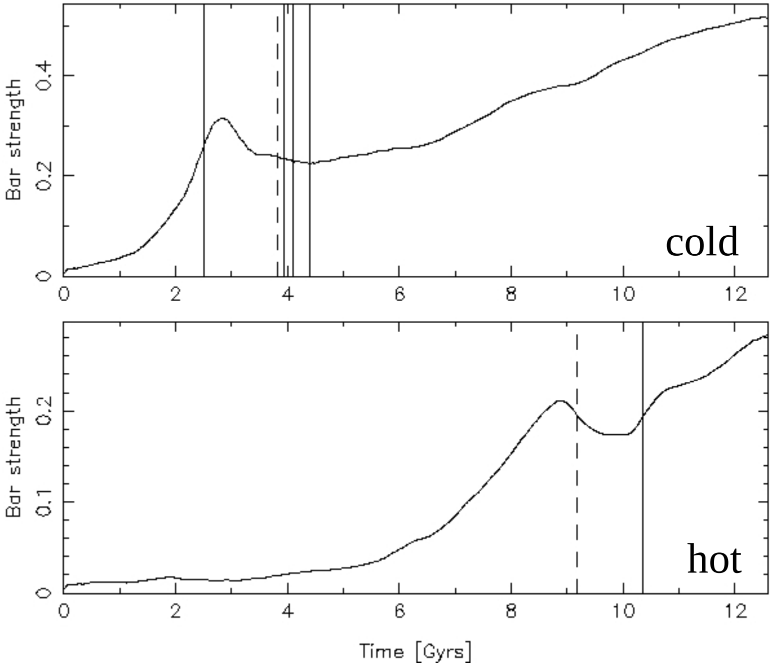
Semi-analytic theory of galaxy formation

Efstathiou, Lake & Negroponte 1982
Mo, Mao & White 1998

$$\frac{V_{\rm max}}{(G\, m_{\rm disk}/r_{\rm disk})^{1/2}} \lesssim 1.1$$

Bower et al. 2006 : if unstable, then form elliptical
De Lucia & Blaizot 2007 : if unstable, then form spheroid instantaneously
Athanassoula 2008 : no! bulge forms when bar buckles





A NUMERICAL STUDY OF THE STABILITY OF FLATTENED GALAXIES: OR, CAN COLD GALAXIES SURVIVE?*

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ABSTRACT

Models with added spherical (halo) component are more stable. It appears that halo-to-disk mass ratios of 1 to 2½, and an initial value of $t \simeq 0.14 \pm 0.03$, are required for stability. If our

* Supported in part by the National Science Foundation.

Dynamic evidence on massive coronas of galaxies

JAAN EINASTO
ANTS KAASIK
ENN SAAR

Nature Vol. 250 July 26 1974 309

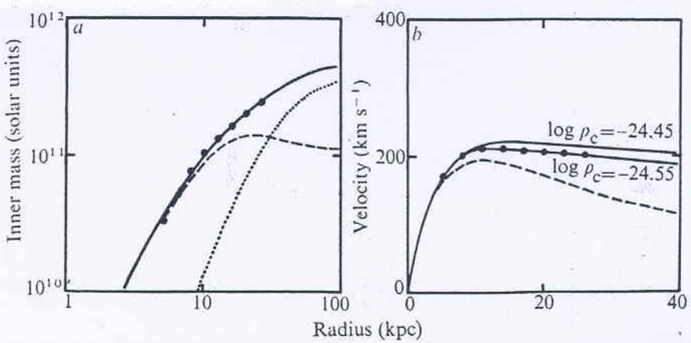


Fig. 1 The distributions of (*a*) the inner mass, $M(R)$, and (*b*) the circular velocity, V_c, in the galaxy IC342. Dots, observed values; dashed lines, model functions for known stellar populations; dotted lines, distributions for the corona; solid lines, total distributions. In Fig. 1*b* two variants of the total velocity distribution are given to demonstrate its dependence on the central density of the corona.

five galaxies (Table 1)

Rejecting the possibility of large systematic deviations from the circular velocity in the outer regions of galaxies, we conclude that galaxies contain a previously unrecognised, massive population.

Ostriker et al. (1974)

Received 1974 May 28; revised 1974 July 15

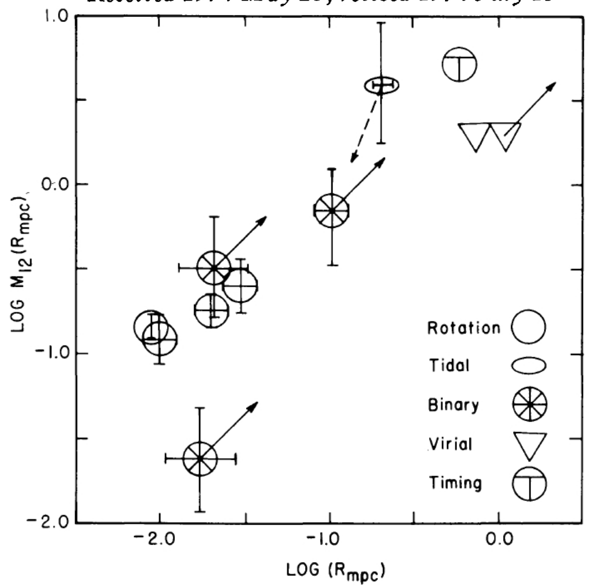
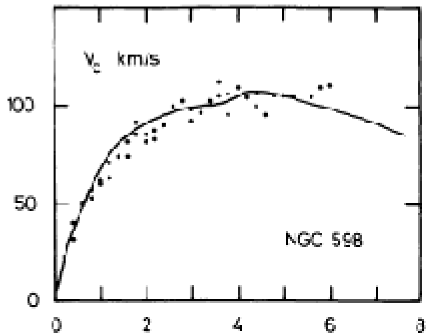
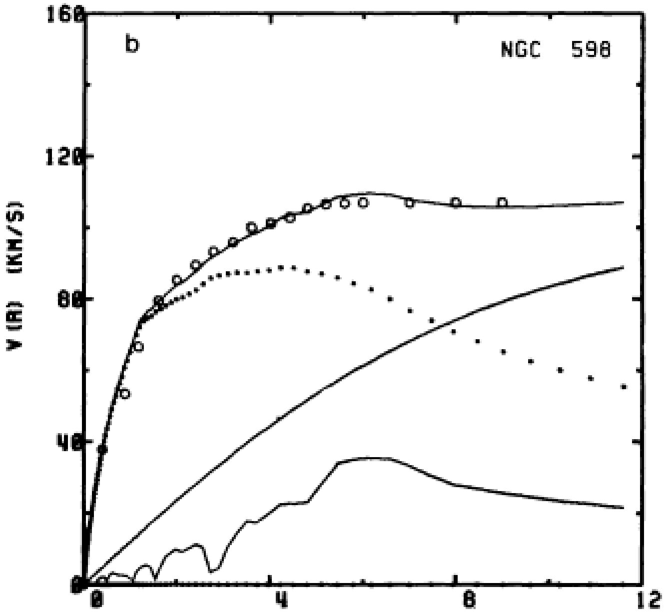


FIG. 1.—Mass (unit 10^{12} $M_\odot$) of local giant spiral galaxies within a distance (R/1 Mpc) of their centers, as determined by various methods.

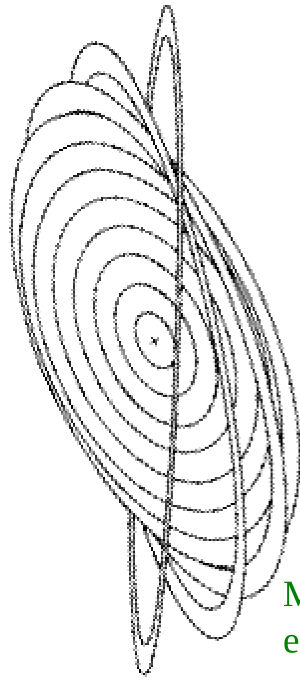
The warp in M33



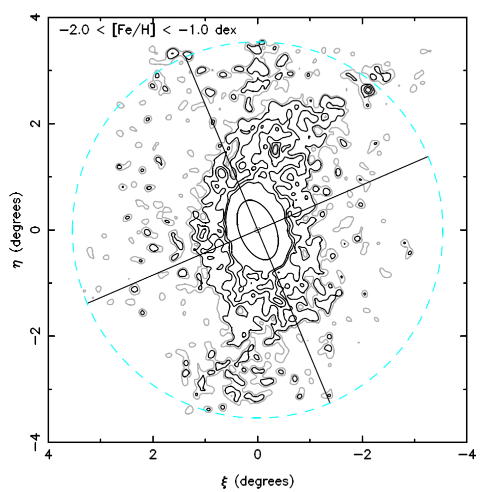


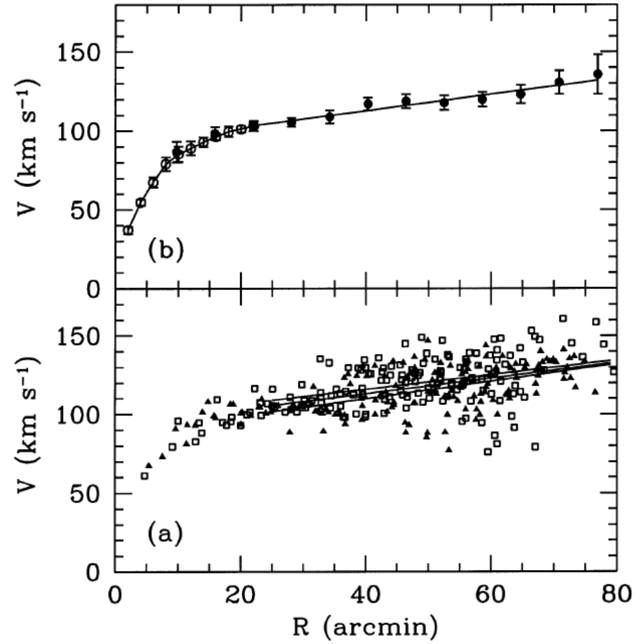
Kalnajs (1983)
Athanassoula et al. (1987)

Rogstad et al. (1976)

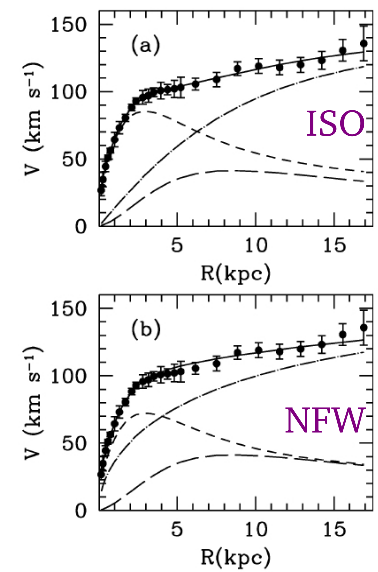


McConnachie
et al. (2010)





Salucci & Corbelli (2004)



HI rotation curves beyond the optical image

Bosma, 1978, 1981a,b

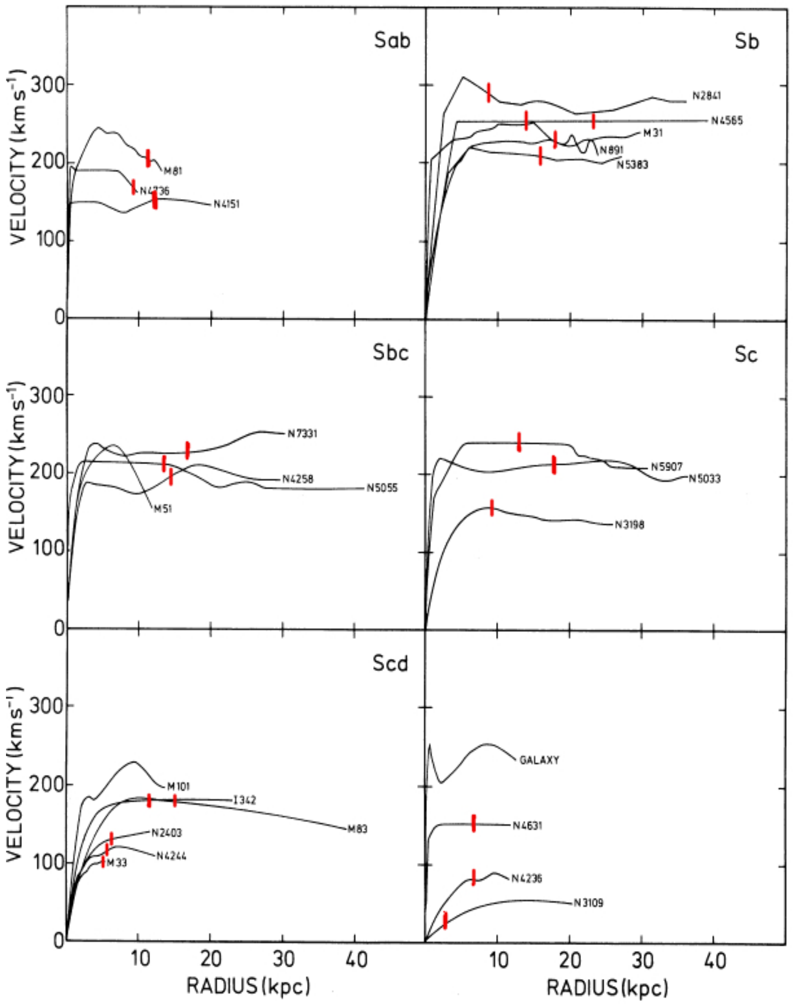
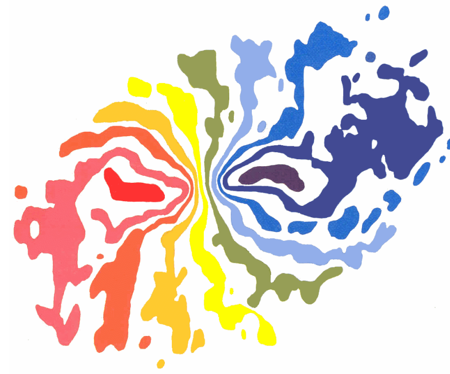
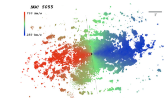
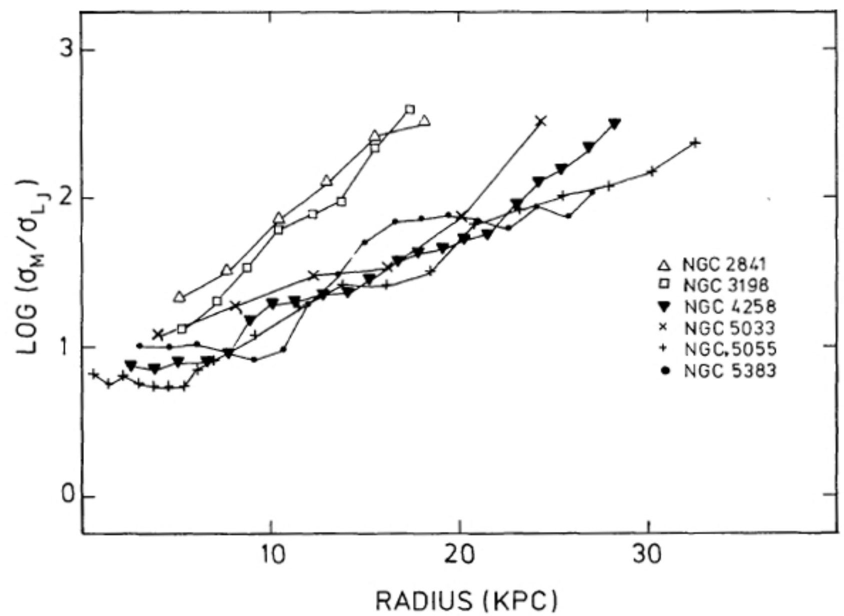


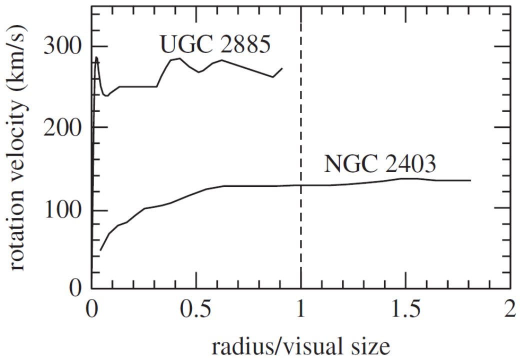
FIG. 3. Rotation curves of 25 galaxies of various Hubble types.







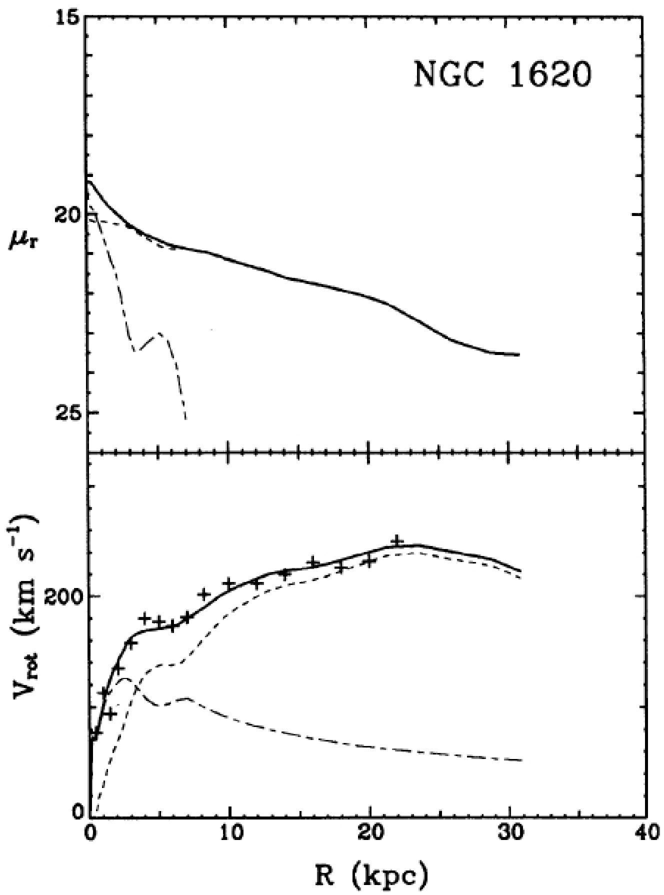
Bosma 1978, Bosma & Van der Kruit 1979

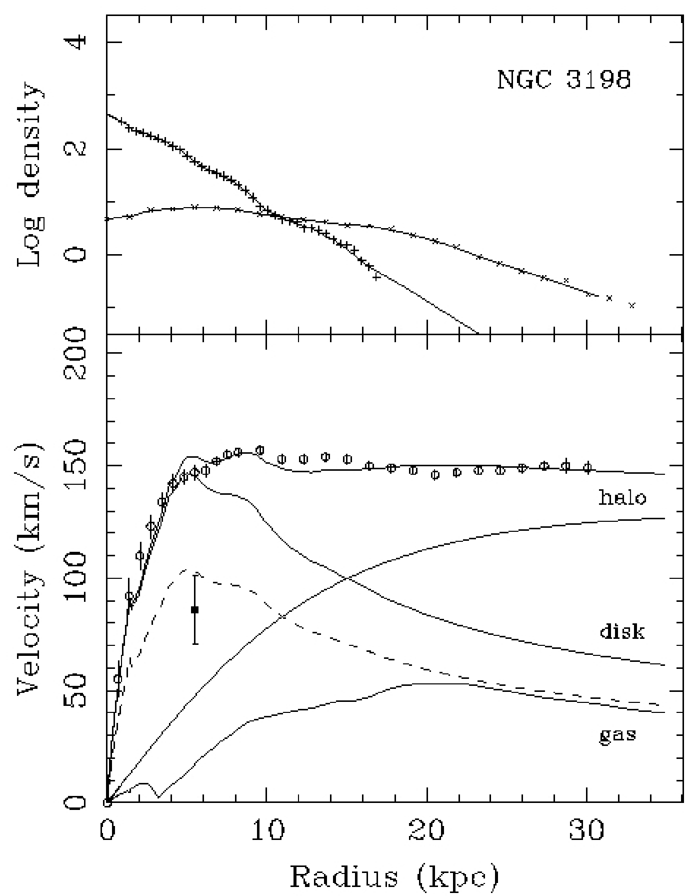


Sanders 2010 book

The last point ... matters

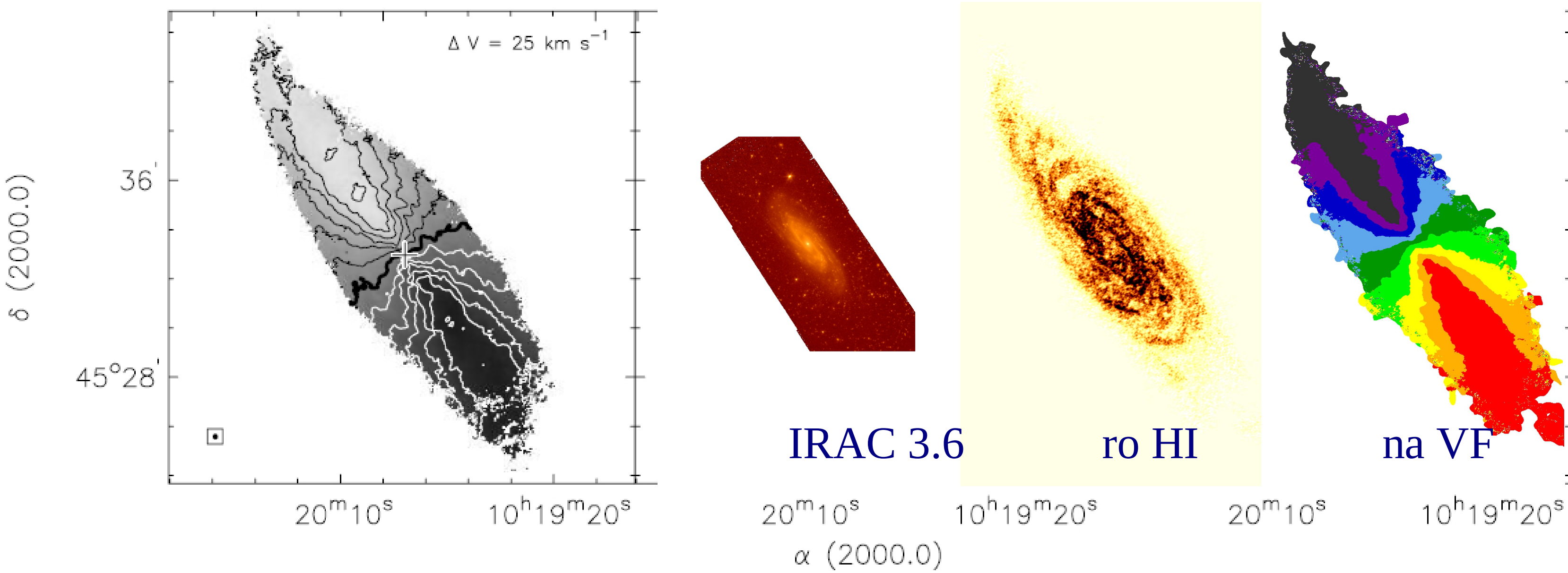
exponential disk peaks at 2.2 scalelength
typically the 'optical size' is 3.2 scalelength
better use HI, since it goes farther out

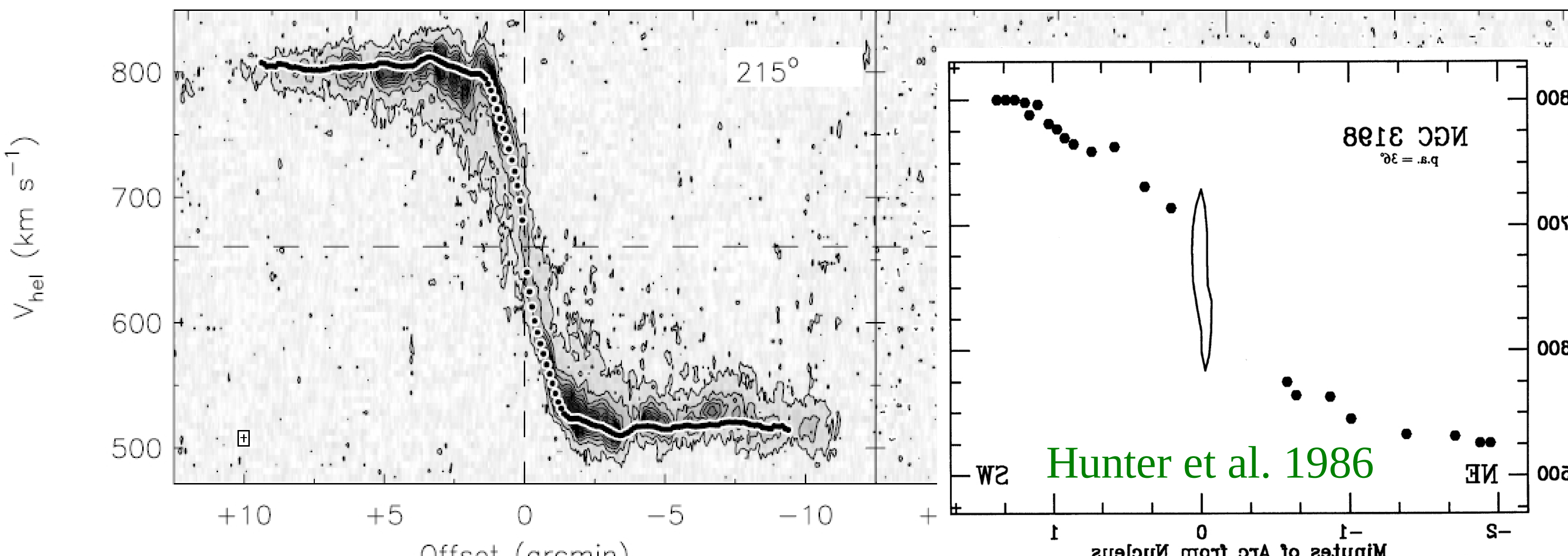




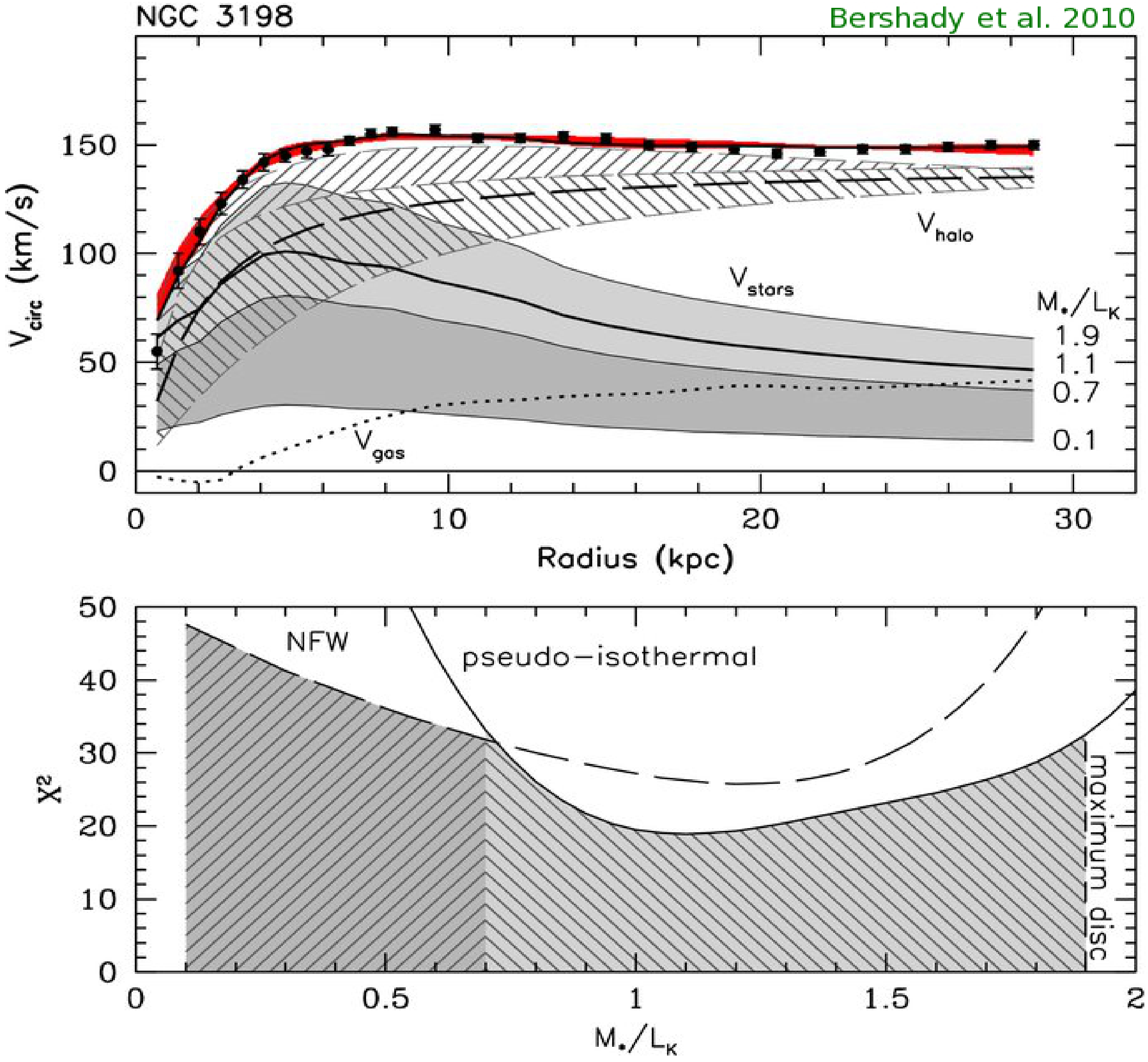
Kalnajs 1983, Kent 1986/7, Athanassoula et al. 1987, Palunas & Williams 2000

NGC3198





De Blok et al. 2008



Degeneracy :

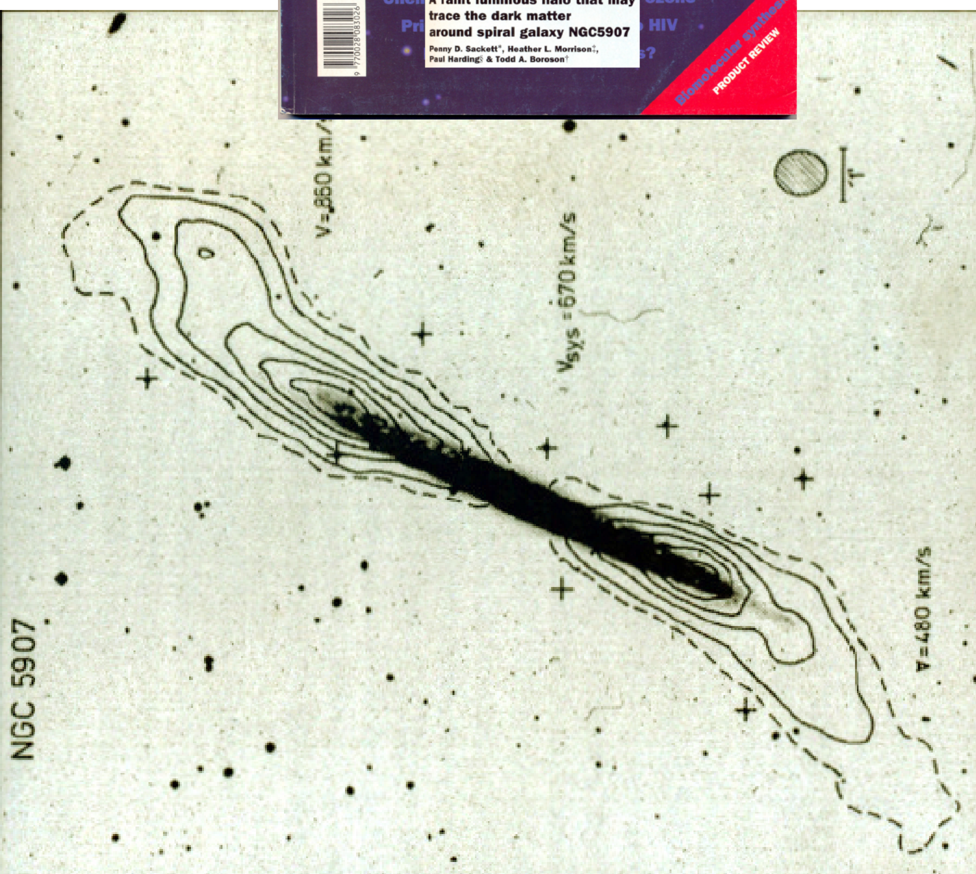
will be discussed later in the talk

various dynamical arguments can be used to estimate whether disks are 'maximum' or not

Moreover, in any blind fitting procedure, the more numerous optical data points should not be given weight equal the outer H I points, to avoid that the fitted model is determined entirely by the optical data. Sanders & Noordermeer, 2007

Sackett et al. 1994

Sancisi 1976

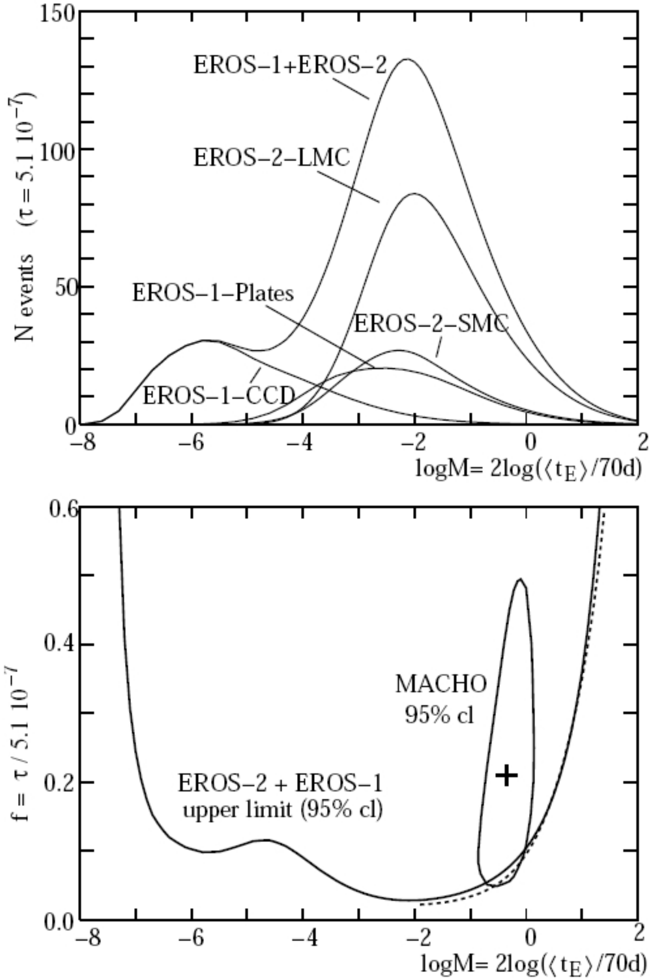


Martinez-Delgado et al. 2008

The nature of galactic dark matter

Microlensing towards LMC/SMC :
- no evidence for much baryonic DM

Microlensing towards bulge :
- not much room for NFW-like profile



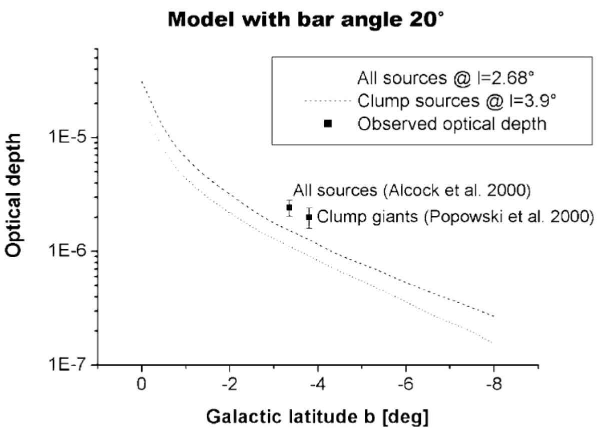


Figure 17. Microlensing optical depth of our reference model at the longitudes of the newly published *MACHO* results, plotted as function of galactic latitude. The observations are indicated in the figure. The upper curve shows the optical depth for clump giant sources, the lower curve for all sources. Both curves are for the galactic longitude of the published observations for the respective group of sources.

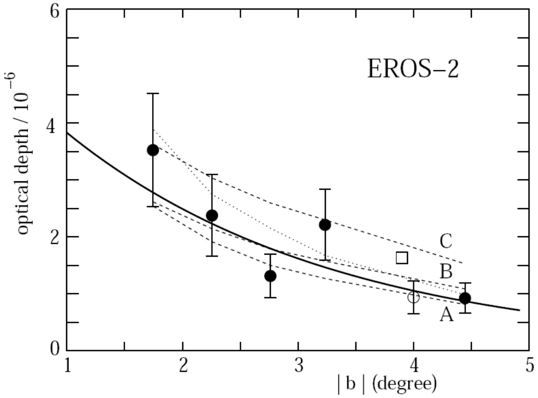
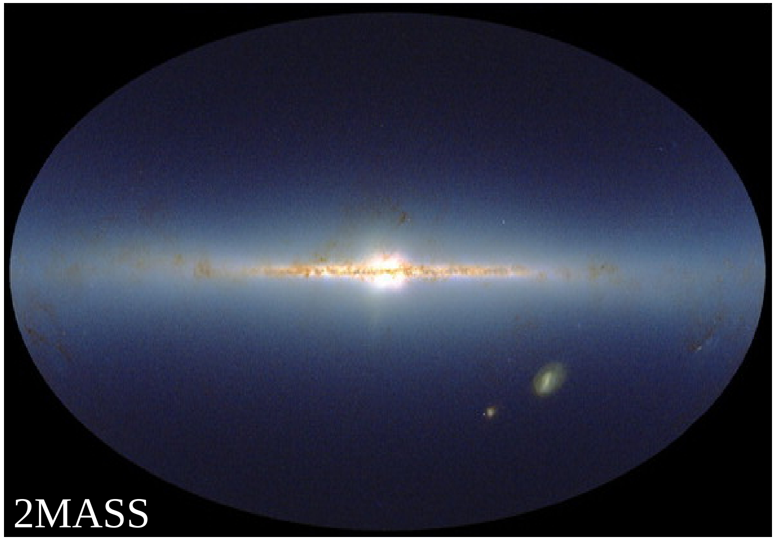


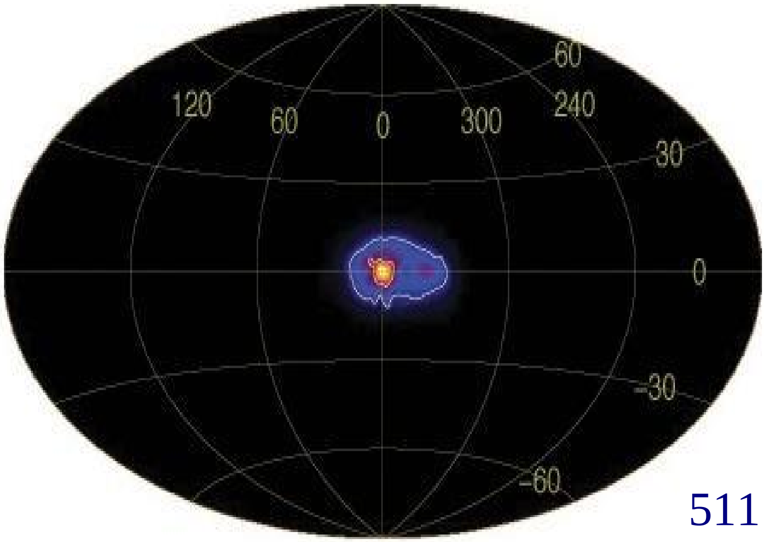
Fig. 15. The top panel shows the EROS-2 measured optical depth as a function of Galactic latitude. The bottom panel shows the optical depth as a function of Galactic longitude for the latitude range 1.4° < |b| < 3.0°. The filled circles are from this work while the open circle in the upper panel is from the first EROS-2 analysis (Afonso et al. 2003b). In the upper panel, the solid line shows the fit (14). In both panels, the dotted lines show the prediction of the model of Bissantz & Gerhard (2002) and the dashed lines, A, B and C, show the predictions of three models used by Evans & Belokurov (2002) as described in Section 7. The open square in the upper panel is the prediction for the Baade Window by Han & Gould (2003).

Tisserand et al. (2006) Bissantz & Gerhard (2002) Hamadache et al. (2006)

Galactic center area complicated ...

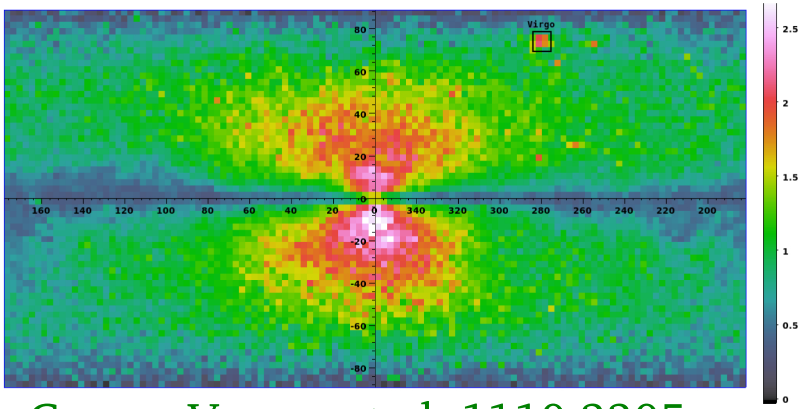
Weidenspointner et al. 2008





511 keV

⇓



Gomez-Vargas et al. 1110.3305

Gao et al. 1107.1916 also argue that clusters are good candidates

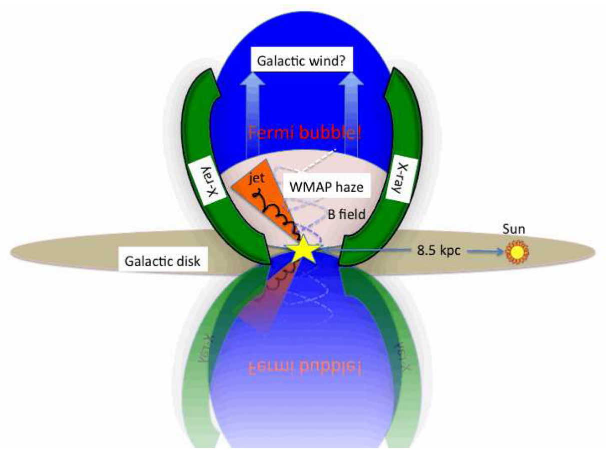
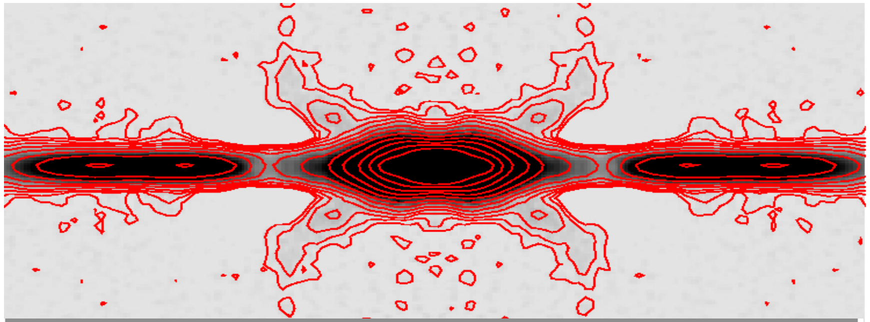


Fig. 27.— A cartoon picture to summarize the observations of the *Fermi* bubble structures. Two blue bubbles symmetric to the Galactic disk indicate the geometry of the gamma-ray bubbles observed by the *Fermi*-LAT. Morphologically, we see corresponding features in *ROSAT* soft X-ray maps, shown as green arcs embracing the bubbles. The *WMAP* haze shares the same edges as the *Fermi* bubbles (the pink egg inside the blue bubbles) with smaller extension in latitude. These related structures may have the same physical origin: past AGN activities or a nuclear starburst in the GC (the yellow star).

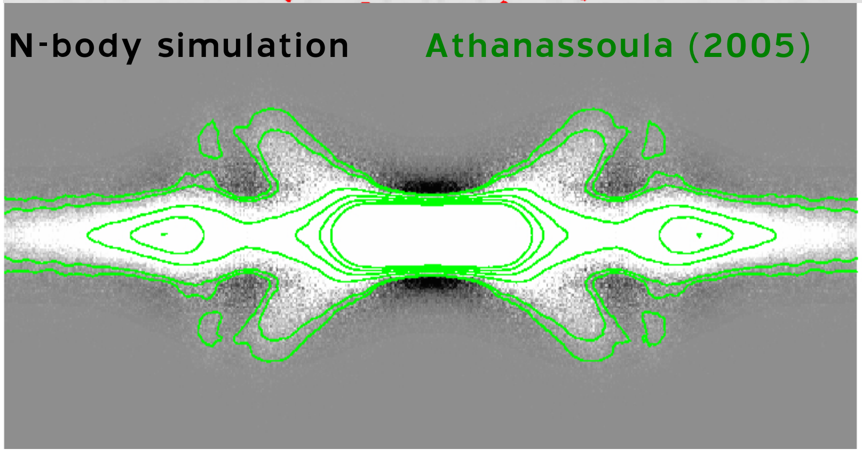
Su, Slatyer & Finkbeiner 2010

Bulge/bar systems in NGC 4710 and the Milky Way

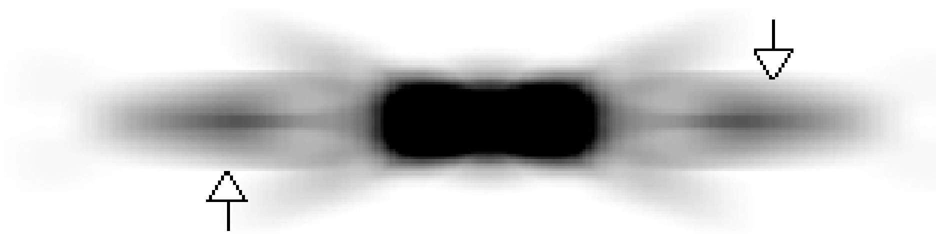
N4710 unsharp masked Aronica et al. (2003)



N-body simulation Athanassoula (2005)

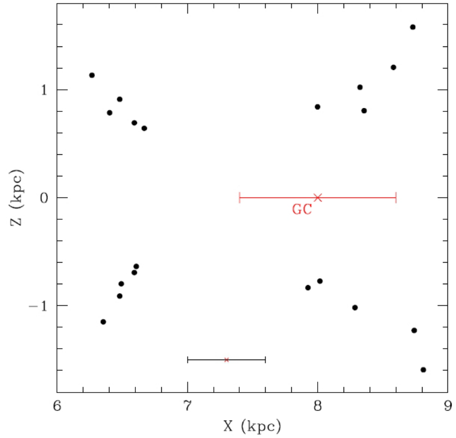


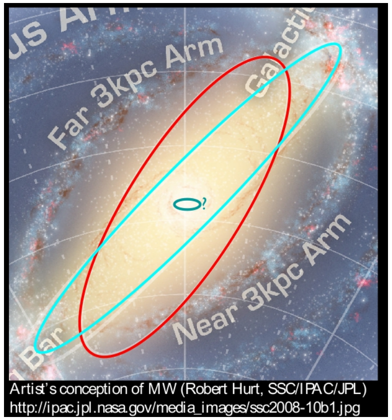
3-D periodic orbit calculation

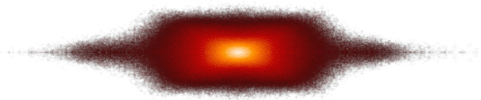


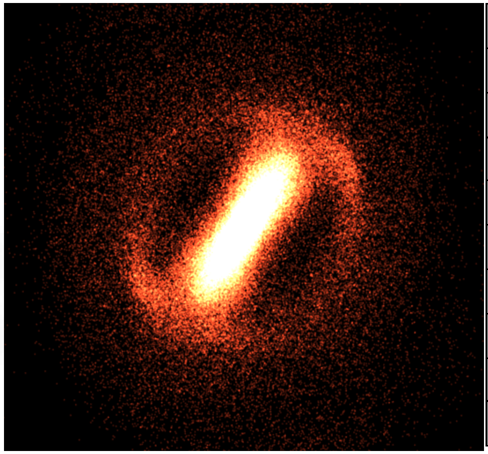
Patsis, Skokos and Athanassoula (2002)

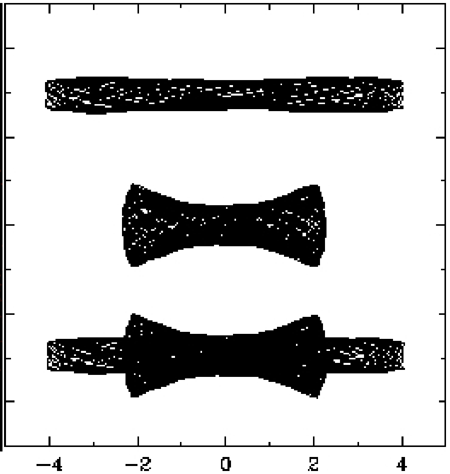
McWilliam & Zoccali 2010



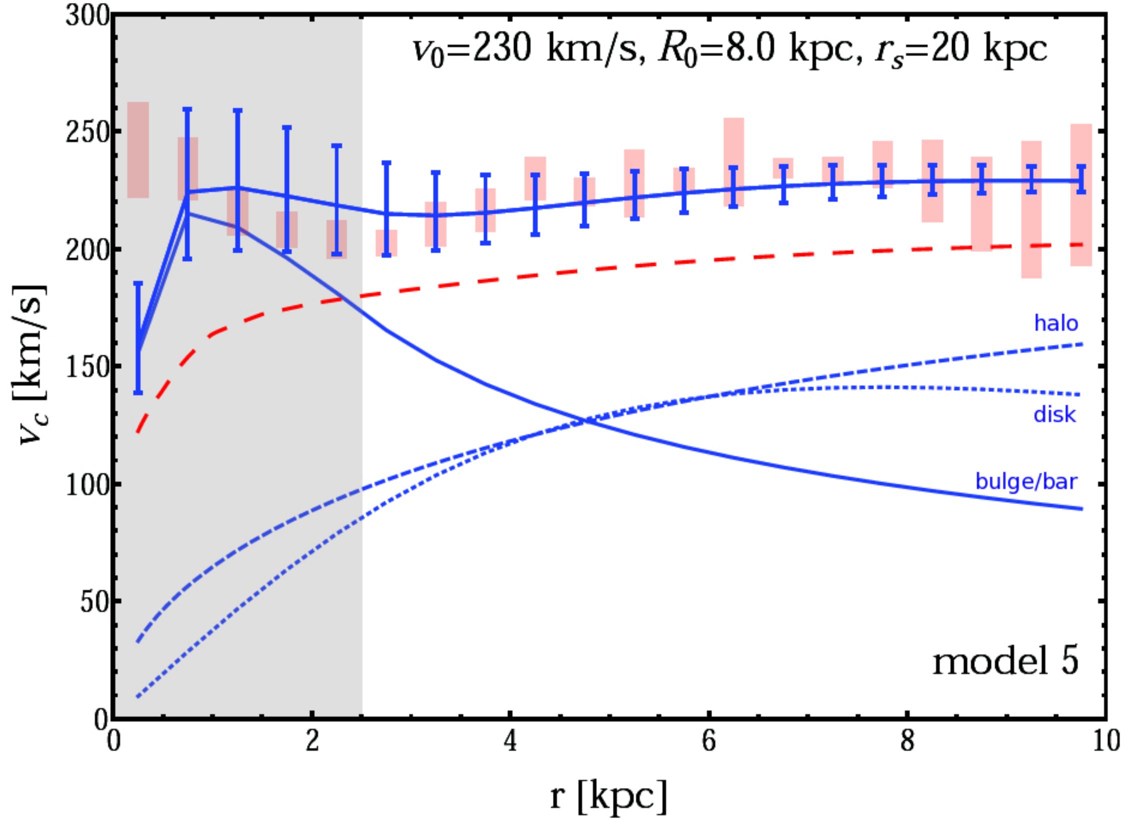








Iocco et al. - 1107.5810



Probing the Galaxy's bars

Gardner & Flynn
arxiv:1002.0551

Parameter	Value	Unit
Galactic Bar		
Angle	25	$^\circ$
Dimensions	3.5:1.4:1.0	kpc
Mass	10	10^9 $M_\odot$
Pattern Speed	55.9	km s^{-1} kpc^{-1}
Local standard of rest	239	km s^{-1}
OLR	1.87	
Long Bar		
Angle	43	$^\circ$
Dimensions	3.9:0.6:0.1	kpc
Mass	6	10^9 $M_\odot$
Pattern Speed	54.9	km s^{-1} kpc^{-1}
Local standard of rest	235	km s^{-1}
OLR	1.87	

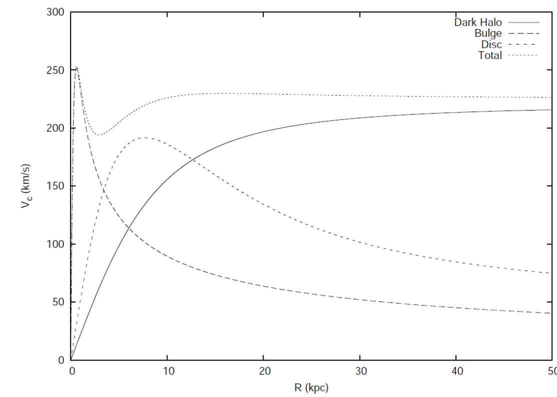
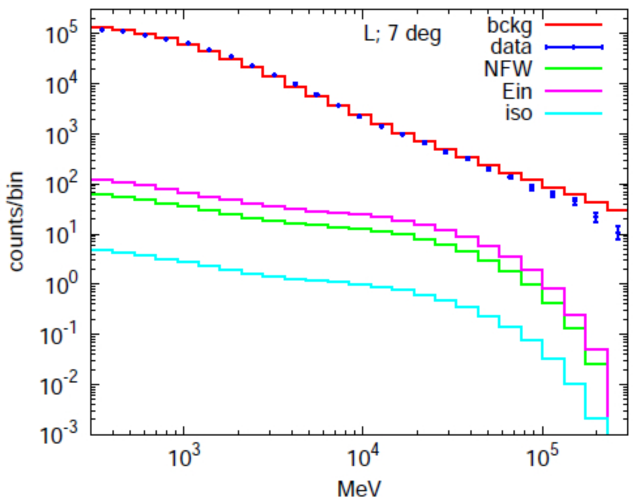


Figure 3. Rotation curve for the model Milky Way (dotted), and the different contributions of the disc (dashed), bulge (long dashed), and dark halo (solid).

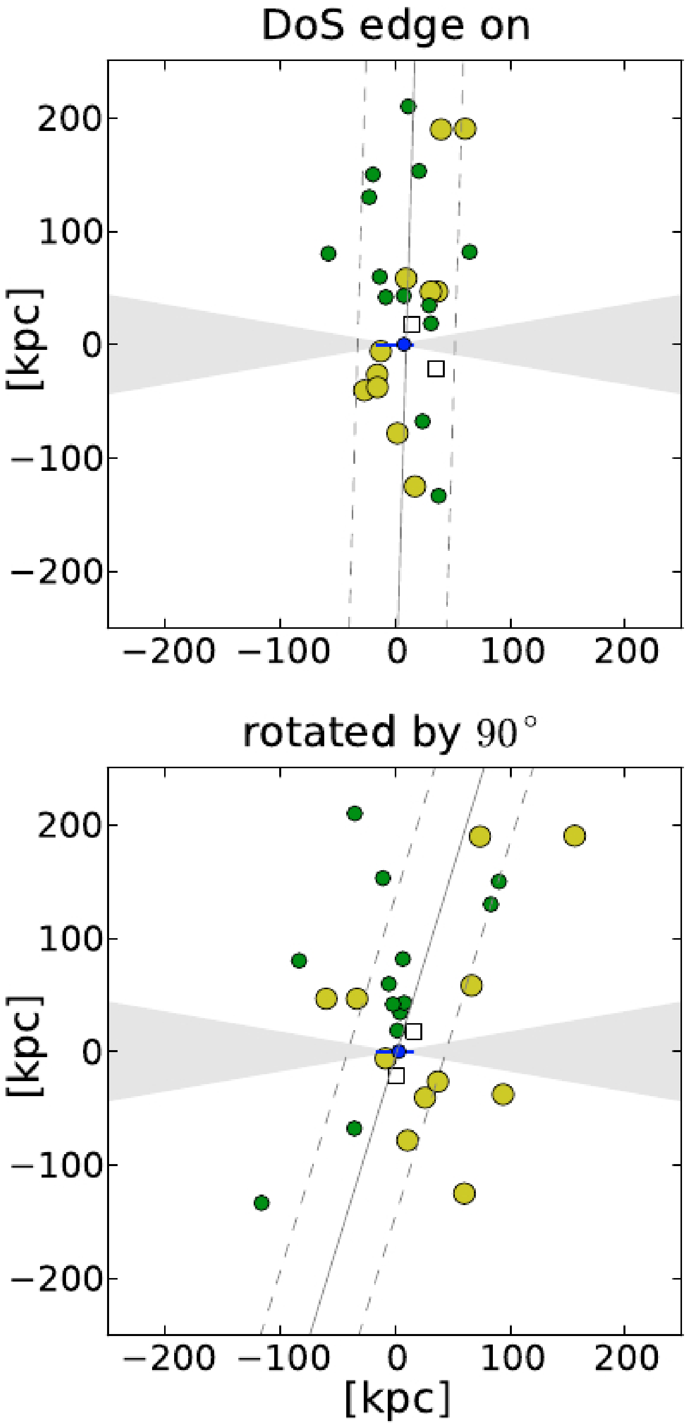


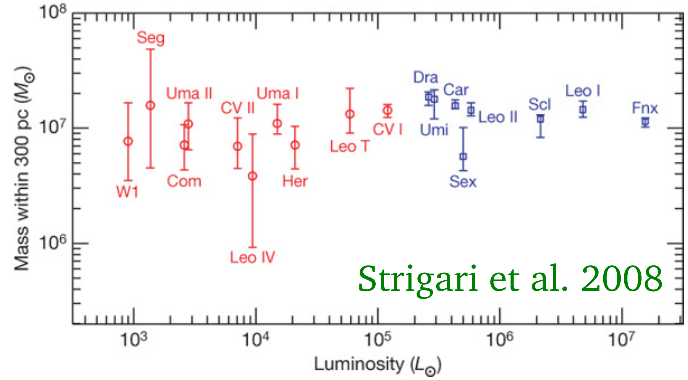
Ellis et al.
1106.0768

$$\rho_{\rm NFW}(r) = \rho_s \frac{r_s}{r}\left(1+\frac{r}{r_s}\right)^{-2}, \qquad r_s = 20\ \text{kpc}$$

$$\rho_{\rm Ein}(r) = \rho_s \exp\left[-\frac{2}{\alpha}\left(\left(\frac{r}{r_s}\right)^{\alpha}-1\right)\right], \quad \alpha = 0.17$$

$$\rho_{\rm iso}(r) = \frac{\rho_s}{1+(r/r_s')^2}, \qquad r_s' = 5\ \text{kpc}$$





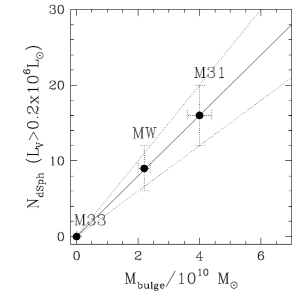
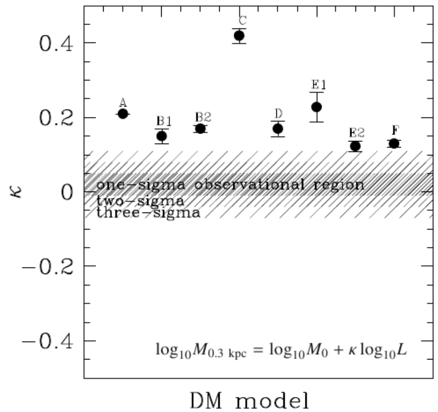


Fig. 3. The number of dSph and dE satellite galaxies more luminous than $0.2 \times 10^6\ L_\odot$ is plotted versus the bulge mass of the host galaxy (MW: Zhao 1996, M 31: Kent 1989, M 33: Gebhardt et al. 2001). Only satellites within a distance of 270 kpc of the MW and M 31 are used. The solid line (slope = 4.03) is Eq. (17). The upper (slope = 5.03) and the lower (slope = 3.03) dotted lines illustrate the relative uncertainty assumed in the Monte Carlo experiment (see Sect. 4).



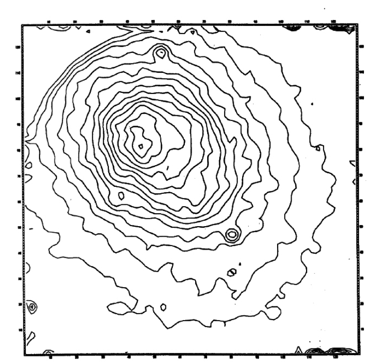


FIG. 4. Isophotes of equal stellar density of field 1 reveal that the structure of Fornax, near the center, is not symmetric.

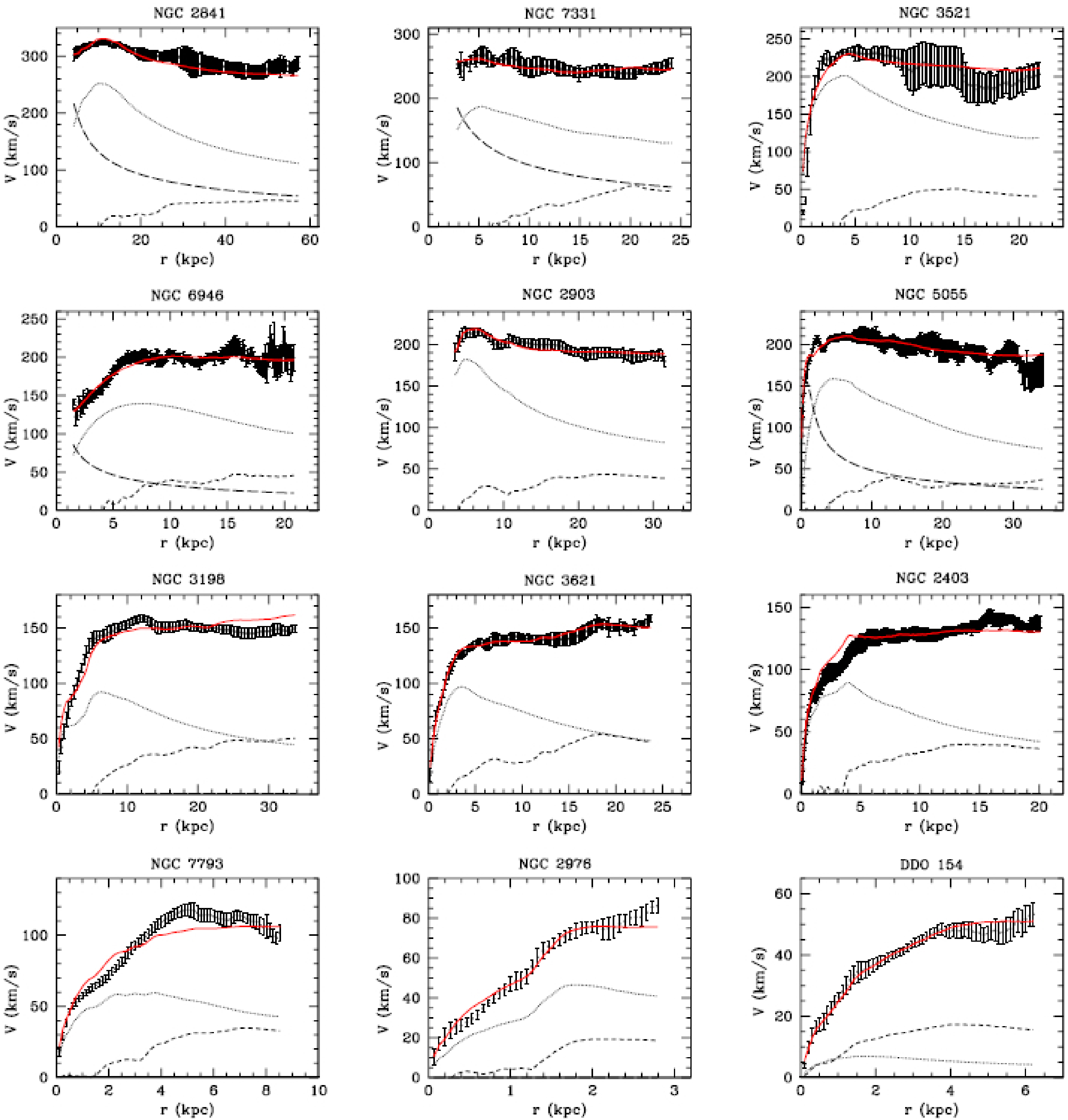
Fornax dSph
Demers et al. 94

Satellite problem also not so clear

Kroupa et al. A&A 523, A32, 2010

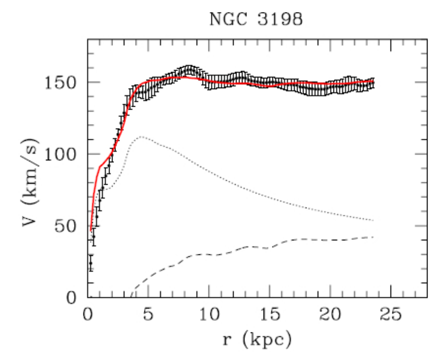
ΛCDM predicts many more than observed
a disk of satellites ?
some are not symmetric – tidal effect?

http://www.scilogs.eu/en/blog/the-dark-matter-crisis



MOND (Milgrom 1983)
algorithm to fit
rotation curves

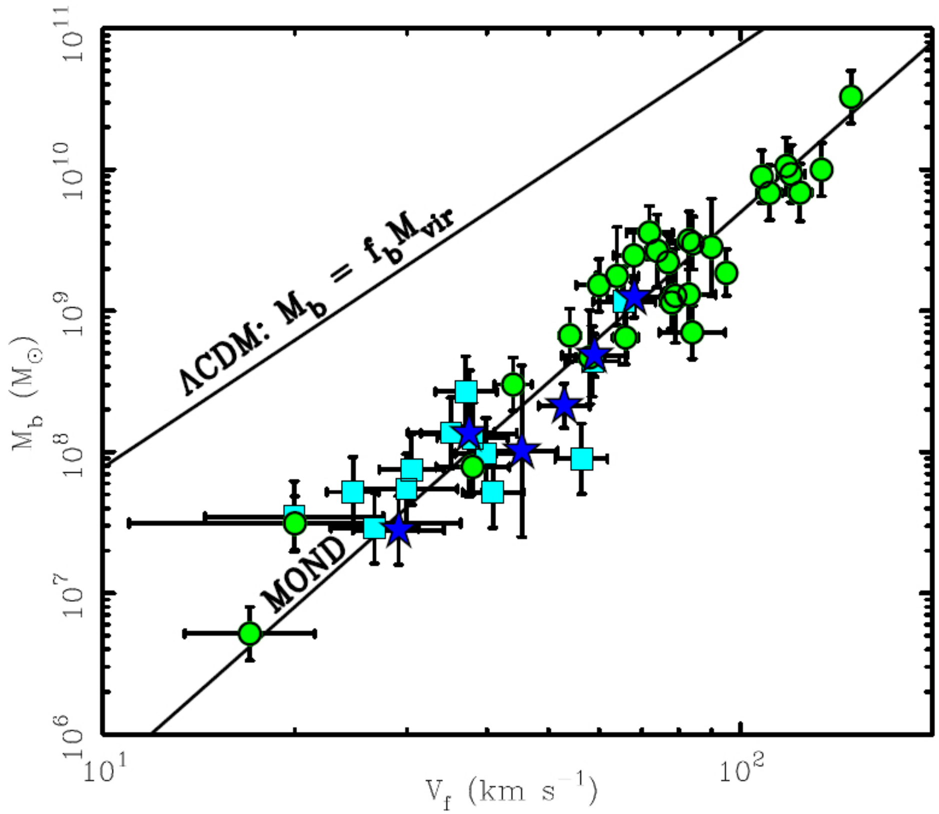
doesn't work well
at larger scales:
11 eV neutrino
as dark matter?



Fit for NGC 3198
with D = 8.6 Mpc
not D = 13.8 Mpc

Gentile et al. 2010

McGaugh 2011



McGaugh & Wolf 2010

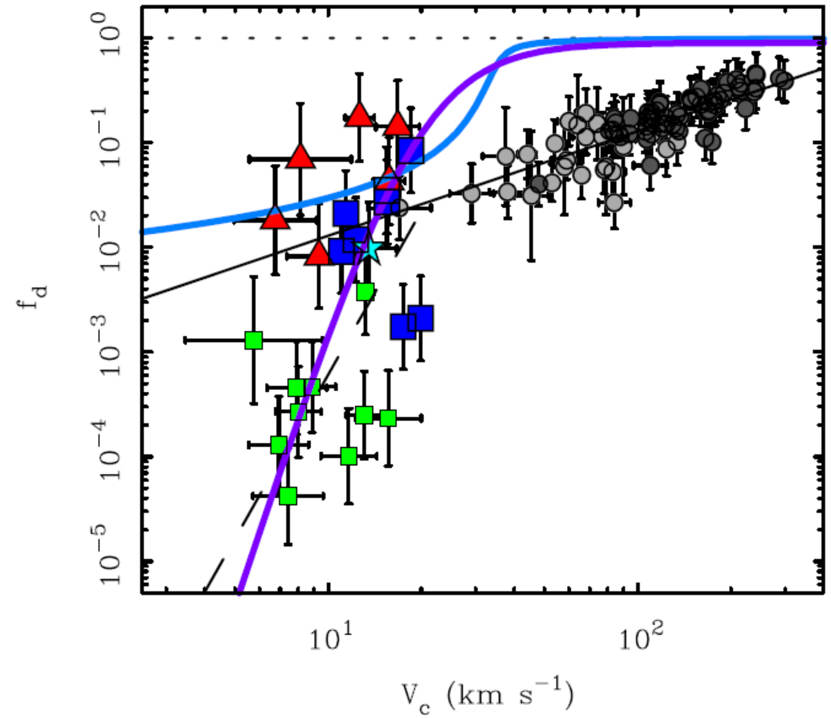
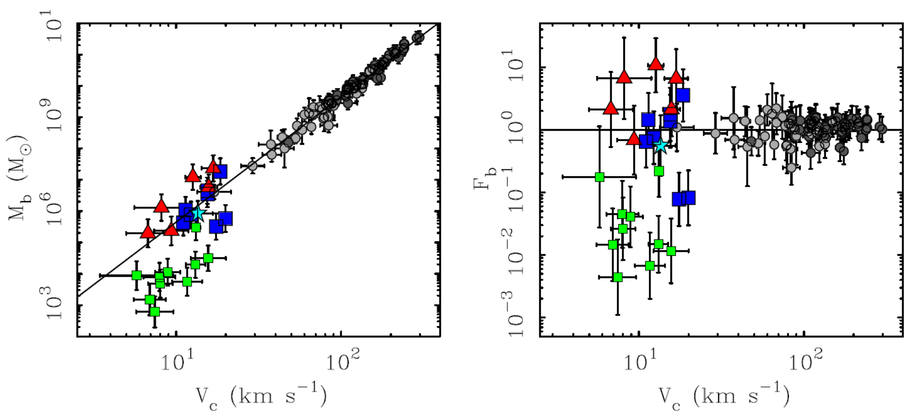
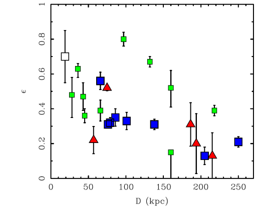


Figure 4. Detected baryon fractions $f_d = M_b/(f_b M_{500})$ (McGaugh et al. 2010) of galaxies (symbols as per Figure 1) fall well below the cosmic baryon fraction f_b (dotted line). The ultrafaint dwarfs appear to follow a steeper relation than the BTFR (thin solid line): the dashed line is the fit from McGaugh et al. (2010) before the M31 data (Kalirai et al. 2010) were available. The heavy solid lines illustrate the expected effects of cosmic reionization (descending line: Crain et al. 2007; Hoeft & Gottloeber 2010, S-shaped line). This alone cannot simultaneously explain both dwarfs and disks.



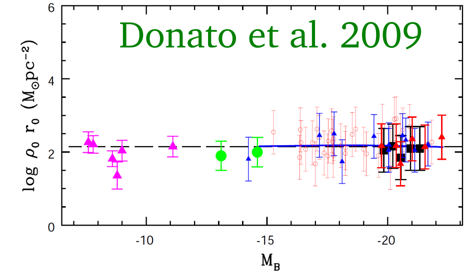
McGaugh & Wolf 2010

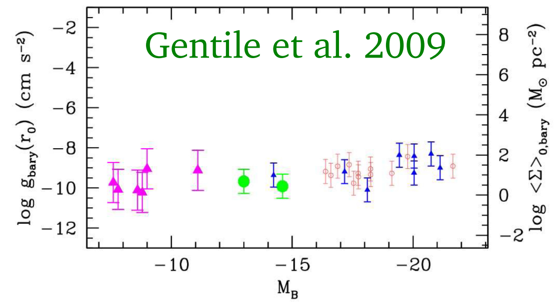
BTF & fine-tuning problem in ΛCDM…
Some environmental influence on dSph likely.



Unease about Dark Matter/Dark Energy model

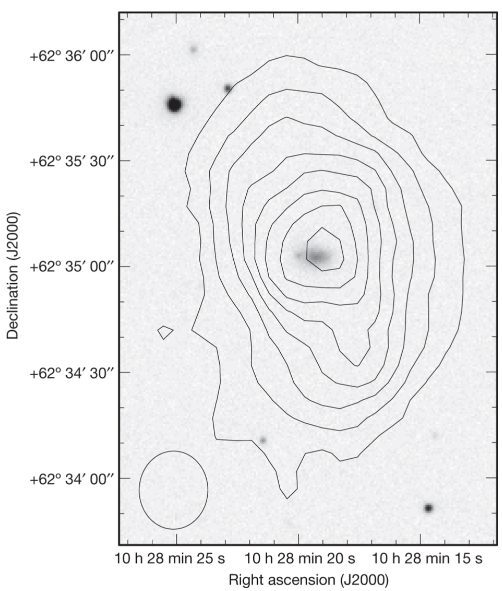
- too much dark stuff
- poor development of alternative theories
- still papers fighting the need for DM for rotation curves
- or pointing out systematics not easily explained by ΛCDM
- CDM too cold ??





More rapid structure formation

Peebles & Nusser 2010



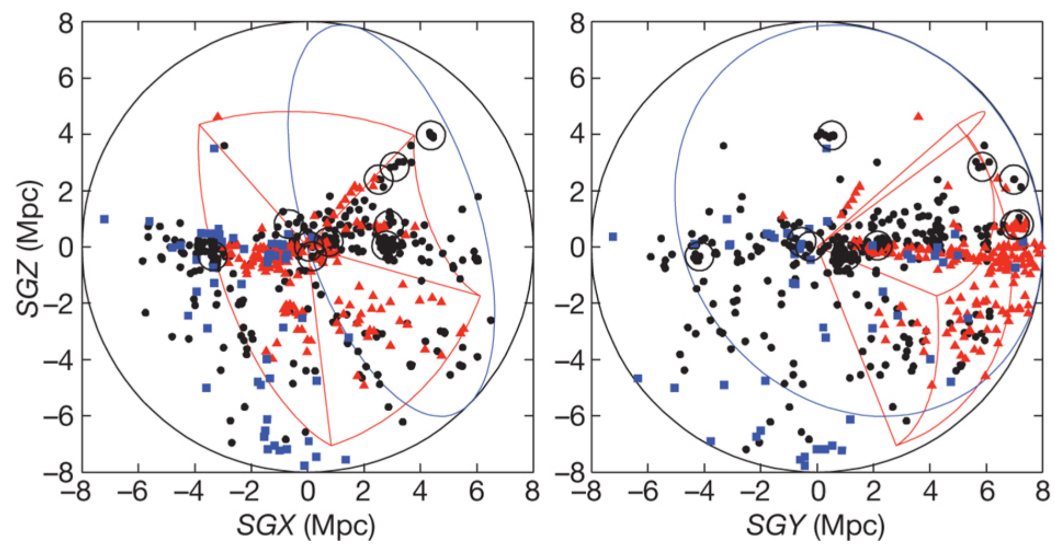


Figure 1: Galaxies at radial distances 1 < *D* < 8 Mpc from the centre of the Local Group of galaxies.

Concluding remarks (first part):

- Galaxies are the 'testbed' for ΛCDM 'theory'
- Galaxies have systematics not easily explained yet
- Theories are not very predictive:
    - pb. with standard model (neutrino mass)
    - the 'scenario' is constantly updated
- Better to seek out the discrepancies and explore them
- New ideas should be encouraged

NGC 3198 Van Albada & Sancisi 1986

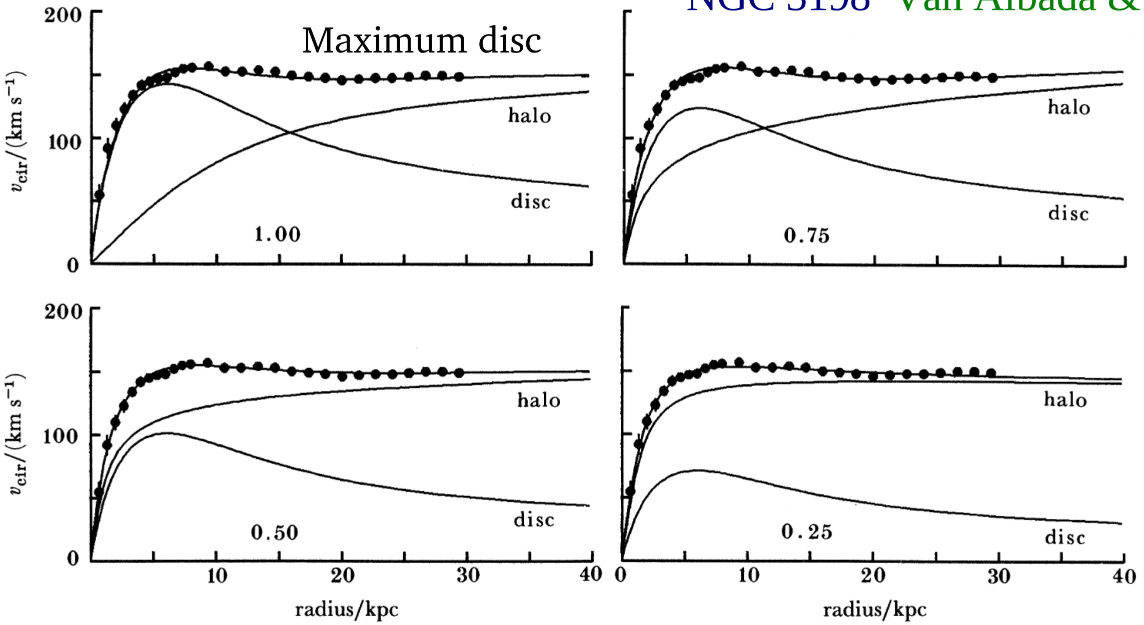


FIGURE 5. Fits of exponential disc and halo to the observed rotation curve (dots) for NGC 3198 (see van Albada *et al.* 1985). Disc models with maximum mass (upper left) and also with masses 0.75, 0.50 and 0.25 times the maximum mass are shown. Constraints on the amount of luminous matter discussed in §3 indicate that the halo contribution in the lower two panels is too large.

Disc-Halo degeneracy

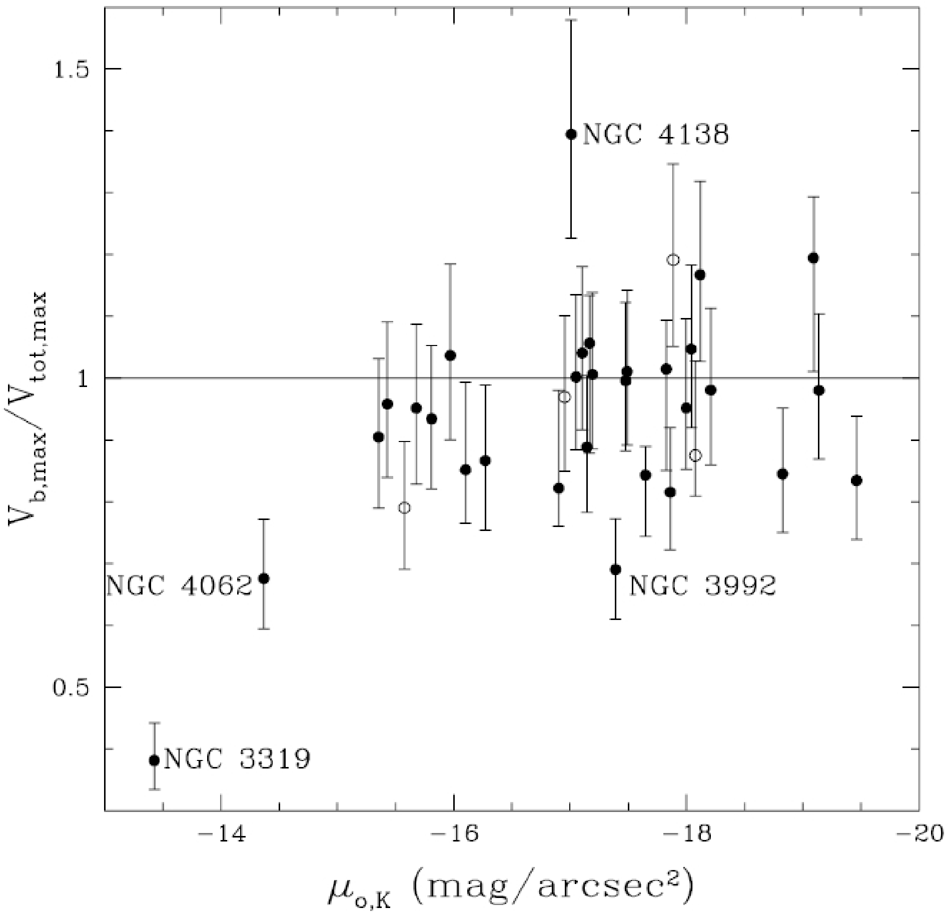
Maximum disc incompatible with NFW

How to constrain it?

Colour – M/L relation
Dyn : Spiral structure and swing amplification
Dyn : Response simulations of gas flow in discs with spirals or bars
Dyn : Velocity dispersions
Dyn : Bar formation
Deviations from the TF relationship
Lensing
Our own Galaxy has not much room for NFW halo in central parts

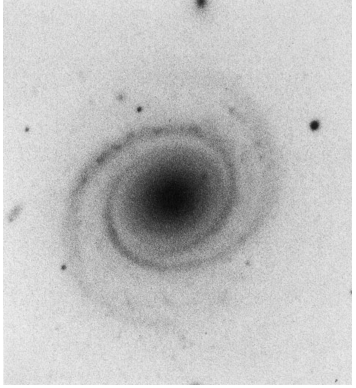
Colour – M/L relation

Kassin et al (2006a, 2006b)



Colour – M/L relation by Bell & de Jong (2001) from spectrophotometric evolution models. They give an upper limit to the baryonic mass.

Halo fits by NFW are poor and worse if adiabatic compression is included



Rotation curves and swing amplification

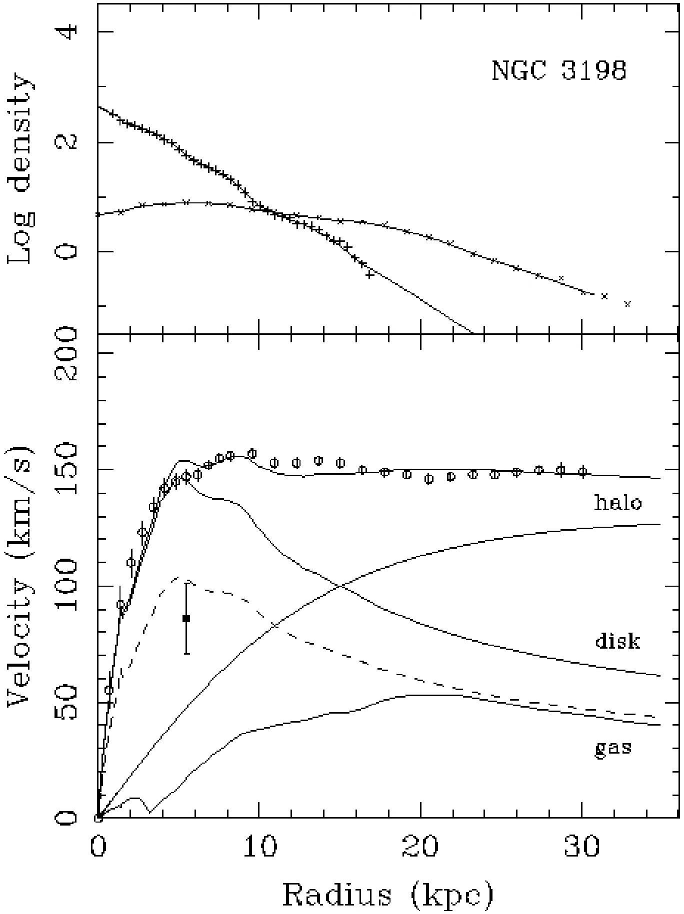
Athanassoula, Bosma & Papaioannou 1987 = ABP

Disc stability theory:
M_H/M_D limits the number of arms a spiral can have (Toomre 1981). Therefore, simply by counting the number of arms, one can set limits on M_H/M_D

No m=1 (model near maximum disc)
No m=2

Advantages
-give good fits to the data
-consistent with the number of arms observed (e.g. m=4 in the outer parts)
-predict the right radial extent for the spirals
-result in reasonable gas fractions, M/L, etc

But: Are all spirals due to swing amplification?

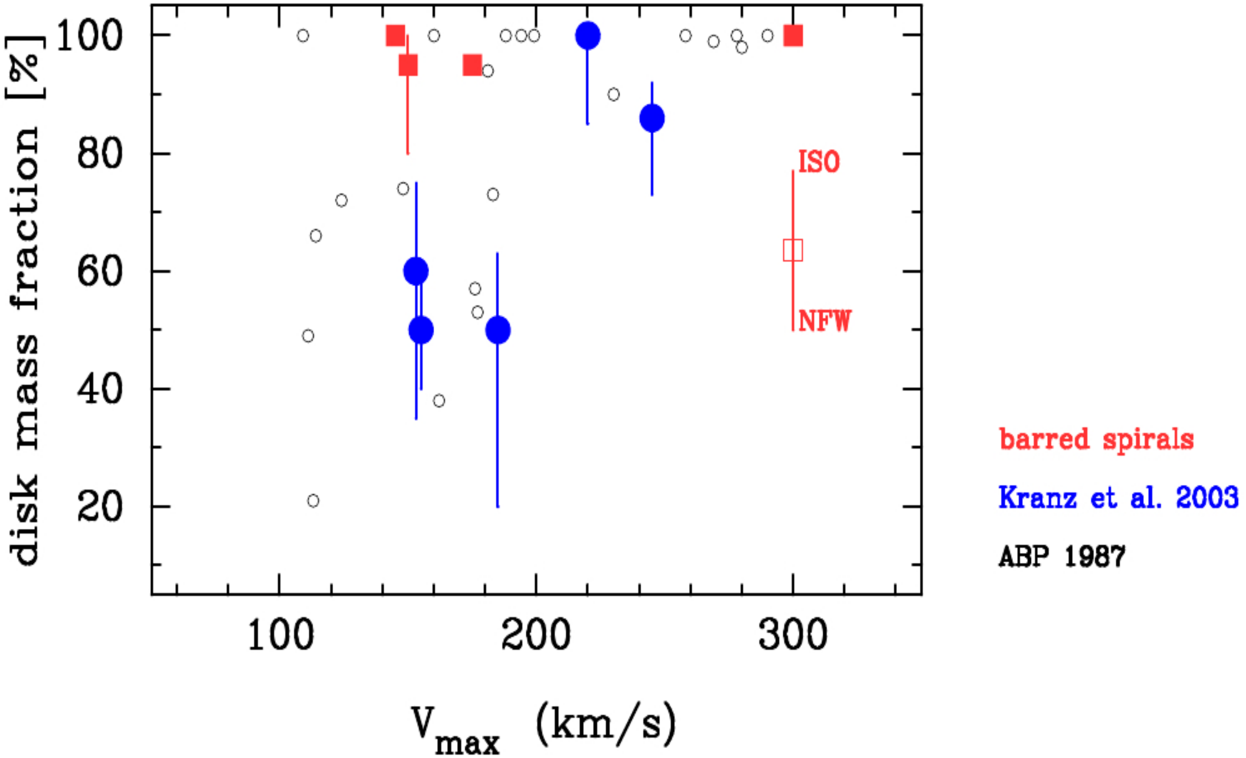


Gas flows in discs with non-axisymmetric components

Spirals : Kranz, Slyz, Rix 01, 03 (NGC 3810, 3893, 4254, 5676, 6643)

Bars : Lindblad, Lindblad, Athanassoula 96 and Zanmar-Sanchez et al. 08 (NGC 1365); Weiner, Sellwood, Williams 01 (NGC 4123); Weiner 04 (NGC 3095); Perez, Fux, Freeman 04 (IC 5186)

Different hydro codes
Different ways of calculating the potential from the photometry



Vertical motions

$$\langle v_z^2 \rangle_{R=0}^{1/2} = \sqrt{\pi G \mu_0 \left(\frac{M}{L}\right) z_0}$$

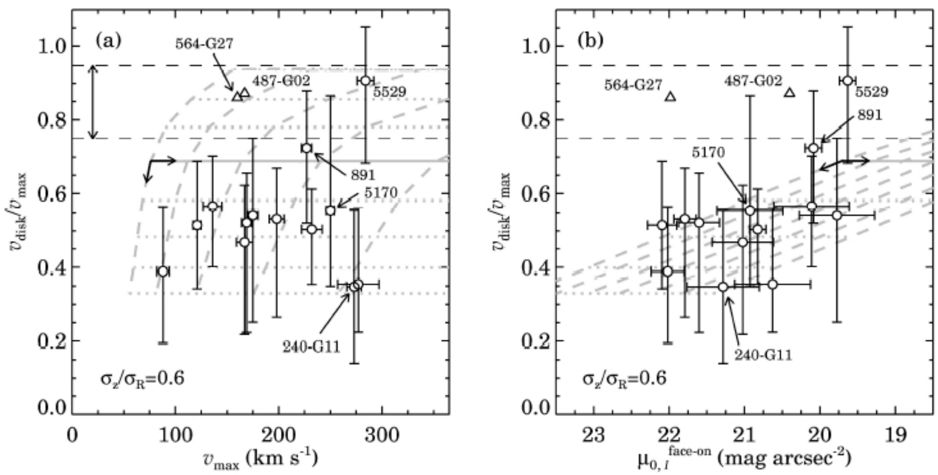


Figure 7.10: Contribution of the disk to the observed maximum rotation for $\sigma_z/\sigma_R = 0.6$. (a) – as a function of maximum rotational velocity (circles). The black dashed lines bracket the range for maximal disks (Sackett 1997). (b) – as function of face-on central surface brightness. In both panels several galaxies are highlighted, and the triangles indicate the outliers in Fig. 7.9, ESO 487-G02 and ESO 564-G27. The gray lines show the prediction of the collapse model (Dalcanton et al. 1997); dashed lines connect models of the same total mass ($\log_{10}(M_{tot}) = 10$–13 in steps of 0.5) and dotted lines connect models of with same spin parameter (logarithmically spaced, separated by factors of 0.2 dex, with the solid line at $\lambda = 0.06$). The arrows indicate the direction of increasing M_{tot} and λ.

Bottema (1993)
Kregel et al. (2003)
Hermann & Ciardullo (2009)

Reasons to doubt this:

1. σ_z/σ_R could be > 0.6

2. dispersions underestimated

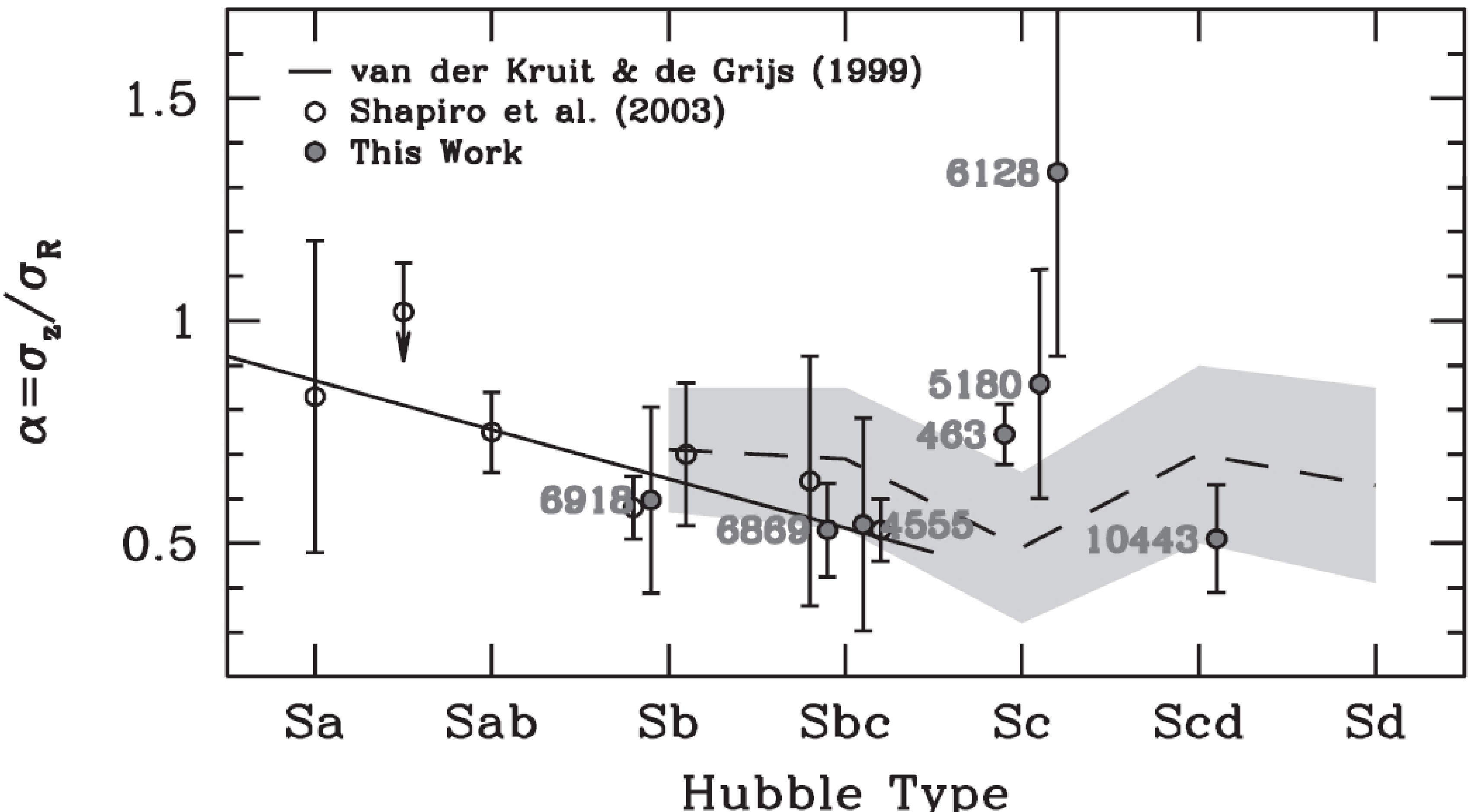
3. vertical densities are more peaked than exponential at low z

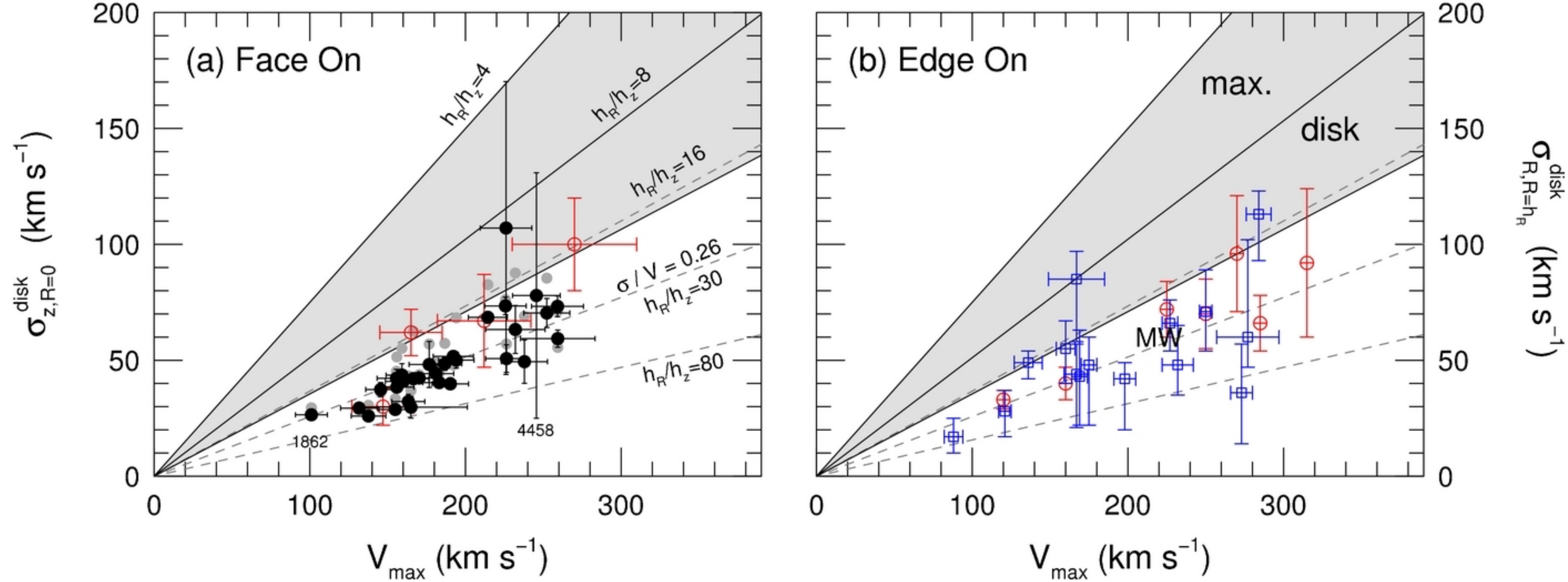
note that the slit has been placed above the dust lane, was this correctly taken into account ?

Barred galaxies seen edge-on?

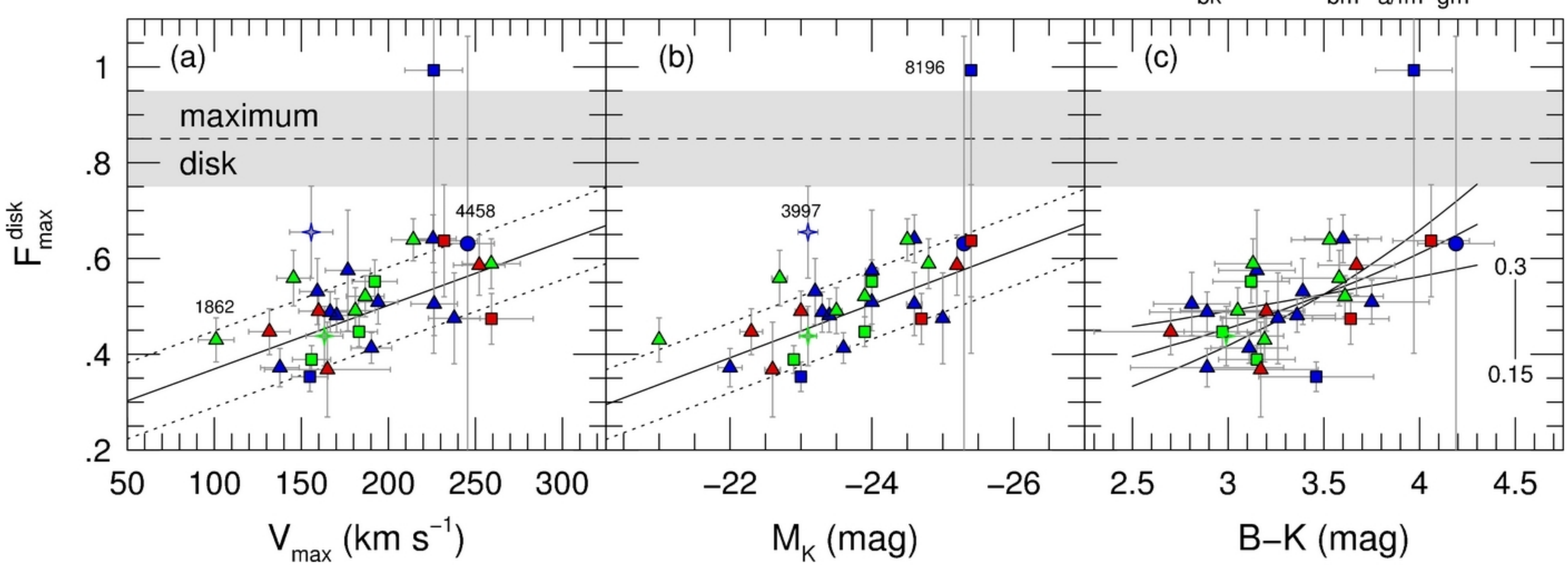
Velocity dispersions

Disk Mass Survey : Bershady et al. 2010; Westfall et al. 2009

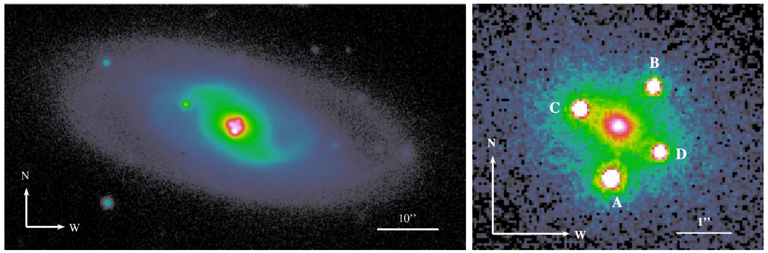


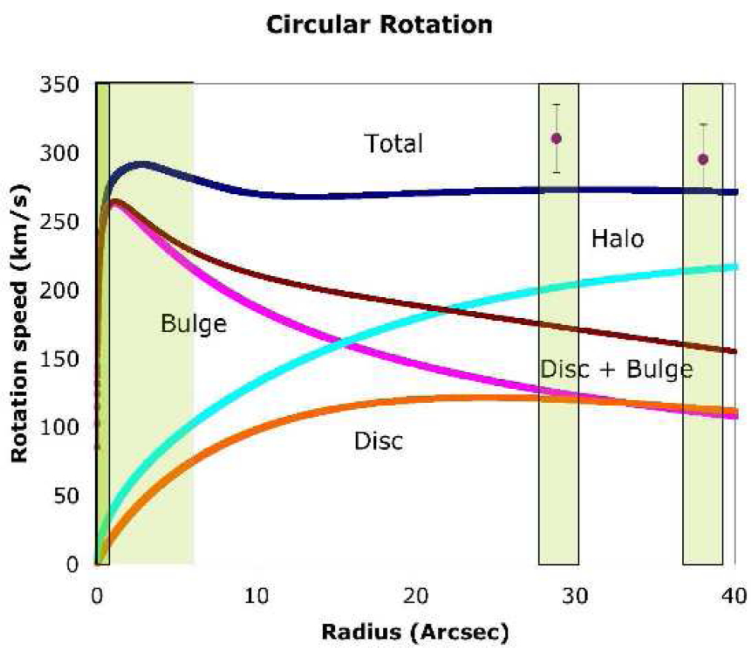


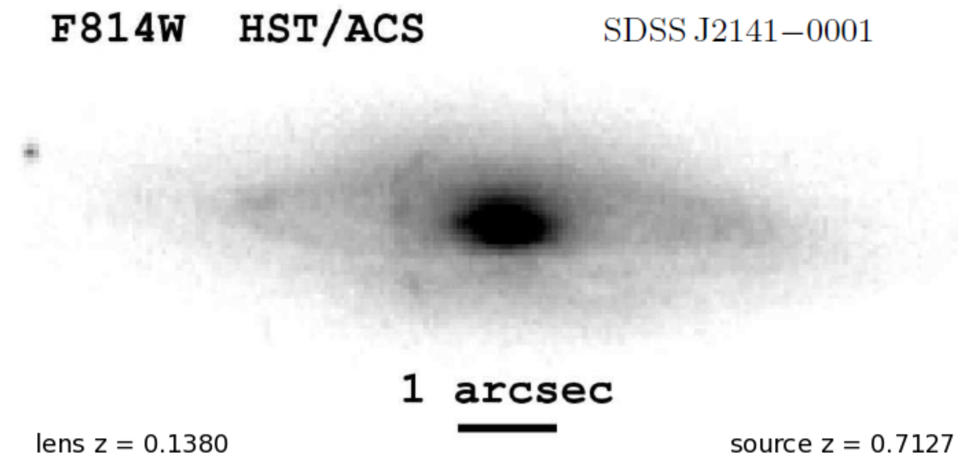
Bershady et al. 1108.4314

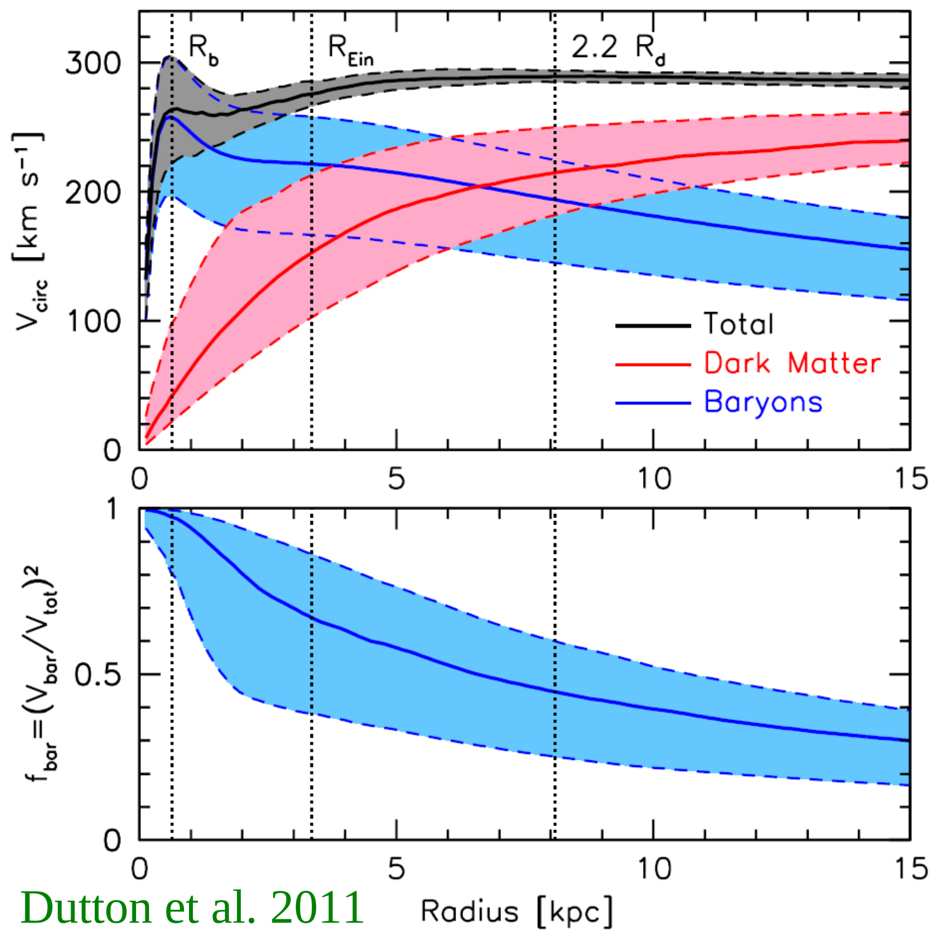


Bulges are 'maximum' : Lensing – 2237+0305









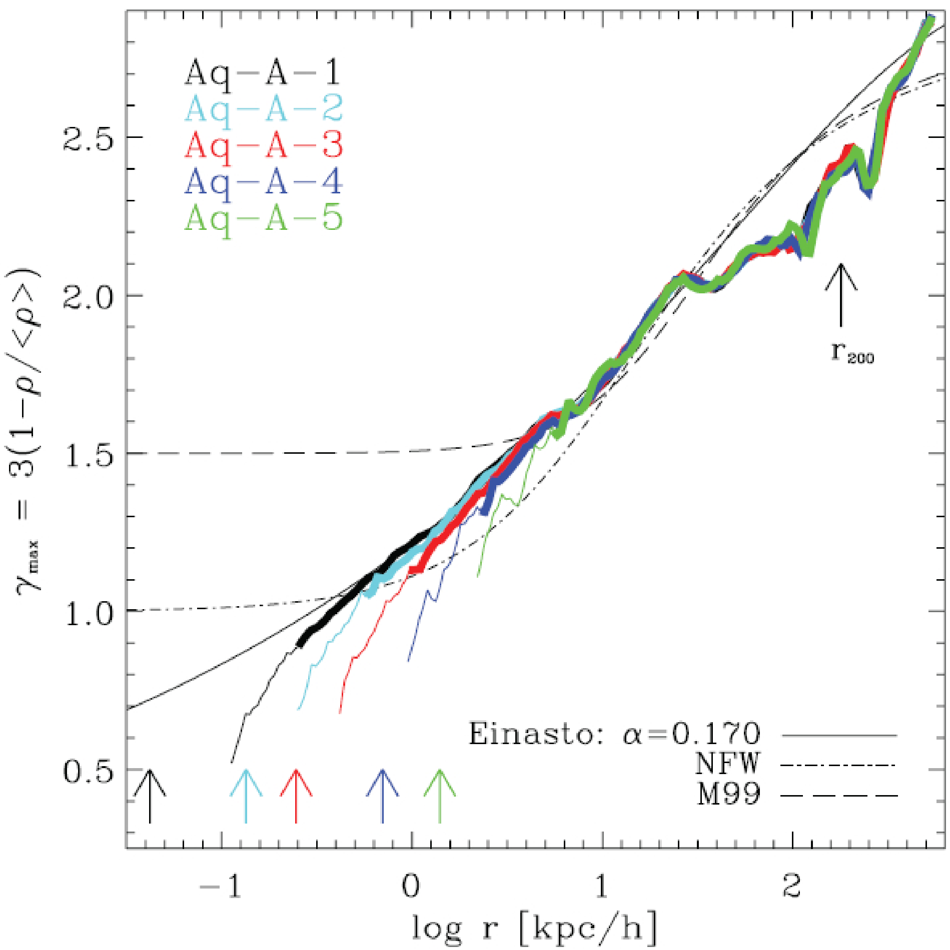
Trott et al. 2010

Dutton et al. 2011

core - cusp controversy

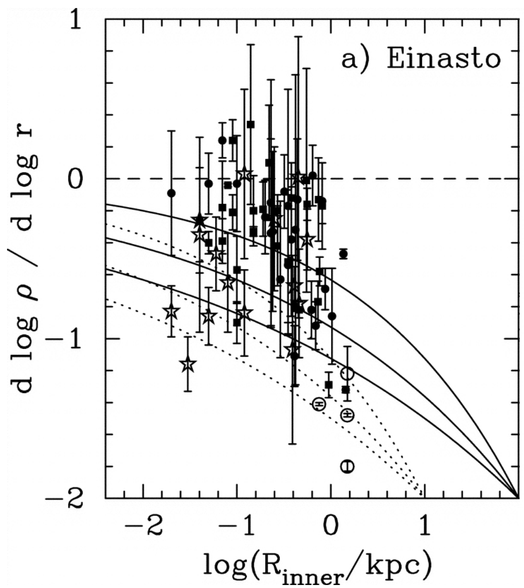
DM only, VERY high resolution cosmological simulations

Navarro, Frenk, White 1996, Navarro et al 2004, 2010

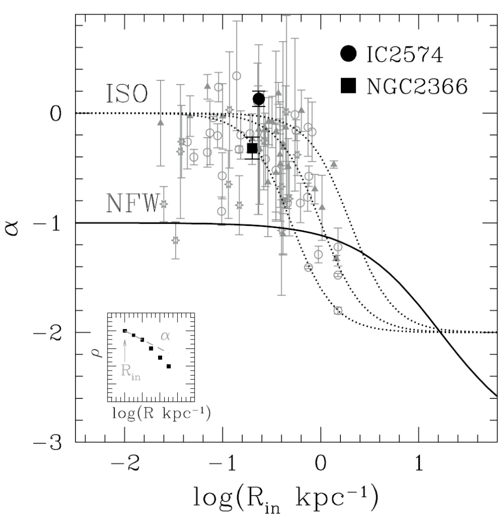


Observations of dwarf and LSB galaxies

Graham et al. 2006



Oh et al. 2008



De Blok et al. 2003

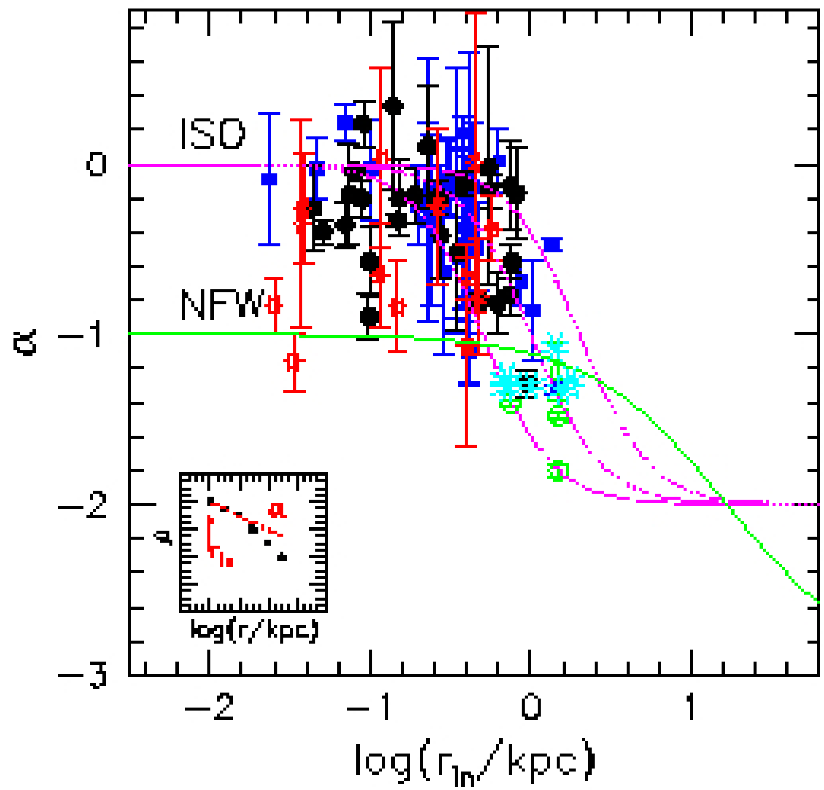


Figure 3. Inner mass-density slope α versus resolution r_{in} of the LSB rotation curves. Symbols with error bars are observational data. Circles: de Blok et al. (2001a); squares: de Blok & Bosma (2002); open stars: Swaters et al. (2003). The large asterisks near $\alpha \sim -1$, $r_{in} \sim 0$ are the simulations by Hayashi et al. (2003). Curves indicate predicted slopes for various core models (dots) and a NFW model (full line). See de Blok et al. (2001b) for a full description.

Core-cusp problem – perhaps resolved ? (Oh et al. 2010)

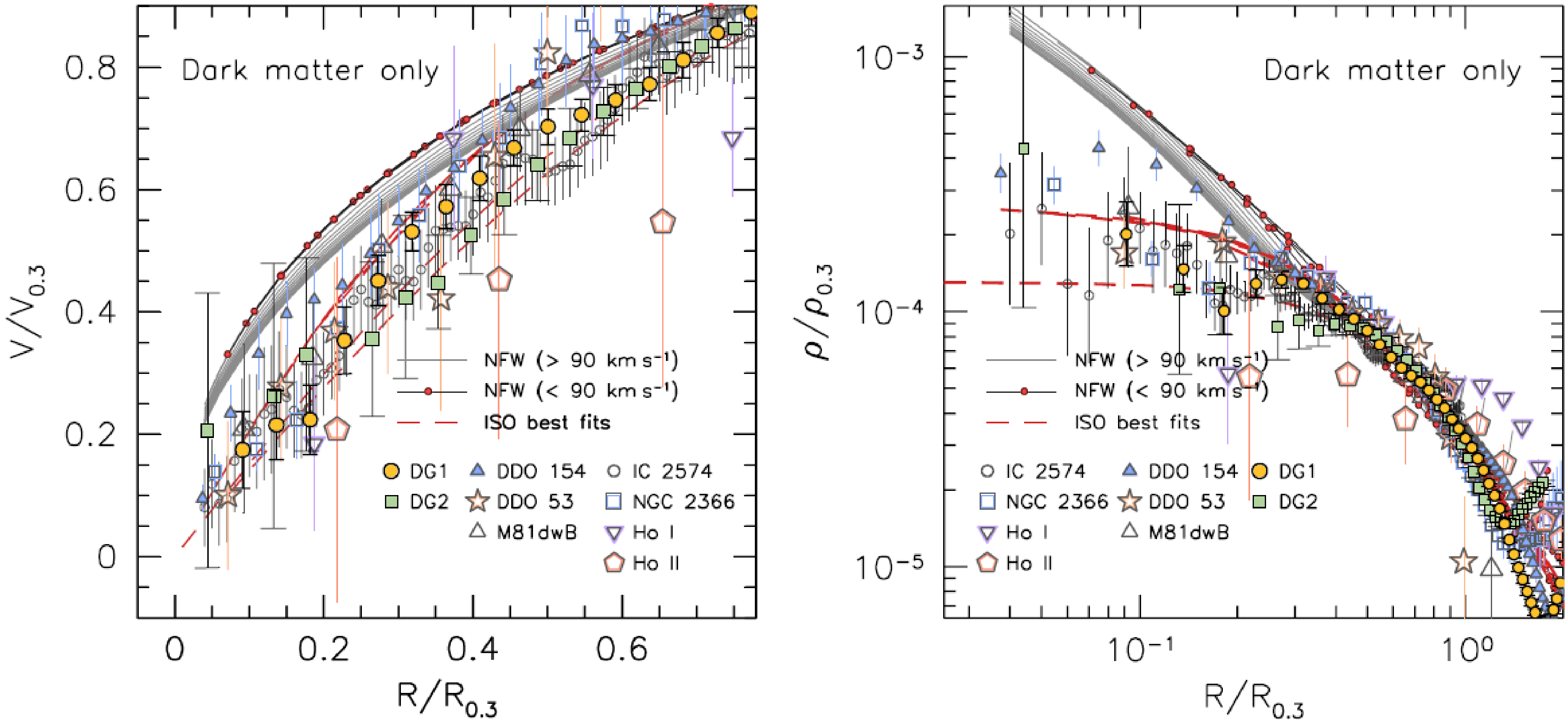


FIG. 6.— **Left:** The rotation curve shape of DG1 and DG2 as well as the 7 THINGS dwarf galaxies. The dark matter rotation curves (corrected for baryons as shown in Fig. 4) are scaled with respect to the rotation velocity $V_{0.3}$ at $R_{0.3}$ where the logarithmic slope of the curve is $d\log V/d\log R = 0.3$ (Hayashi & Navarro 2006). The small dots indicate the NFW model rotation curves with V_{200} ranging from 10 to 90 km s^{-1}. See text for further details. The best fitted pseudo-isothermal halo models (denoted as ISO) are also overplotted. See Section 4.2 for more details. **Right:** The scaled dark matter density profiles of DG1 and DG2 as well as the 7 THINGS dwarf galaxies. The profiles are derived using the scaled dark matter rotation curves in the left panel. The small dots represent the NFW models ($\alpha\sim-1.0$) with V_{200} ranging from 10 to 90 km s^{-1}. The dashed lines indicate the best fitted pseudo-isothermal halo models ($\alpha\sim0.0$). See Section 4.3 for more details.

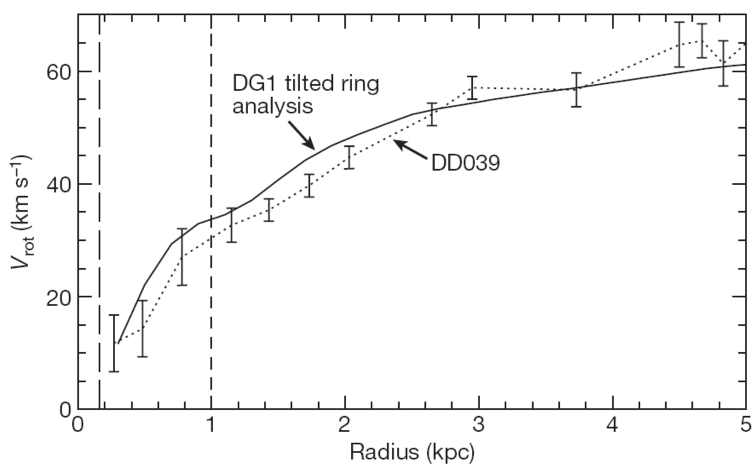
Dark matter cores due to supernova-driven outflows

Binney, Gerhard & Silk 2002, Mashchenko, Couchman & Wadsley 2006, 2008

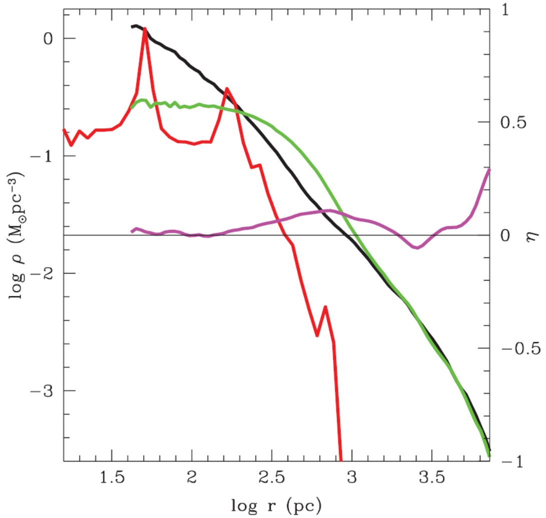
Winds from SN removing selectively low angular momentum material

Navarro, Eke, Frenk 96, Mo, Mao 04,
Governato, Brook, Mayer et al. 2010,

High resolution LCDM cosmological simulation of a dwarf galaxy with 'resolved' ISM: Feedback drives large-scale, bulk motions of the gas, leading to substantial potential fluctuations and a sizeable decrease of the central density



Governato et al. 2010



Mashchenko et al. 2008

2 *C. B. Brook et al.* zoom-simulation 1105.2562

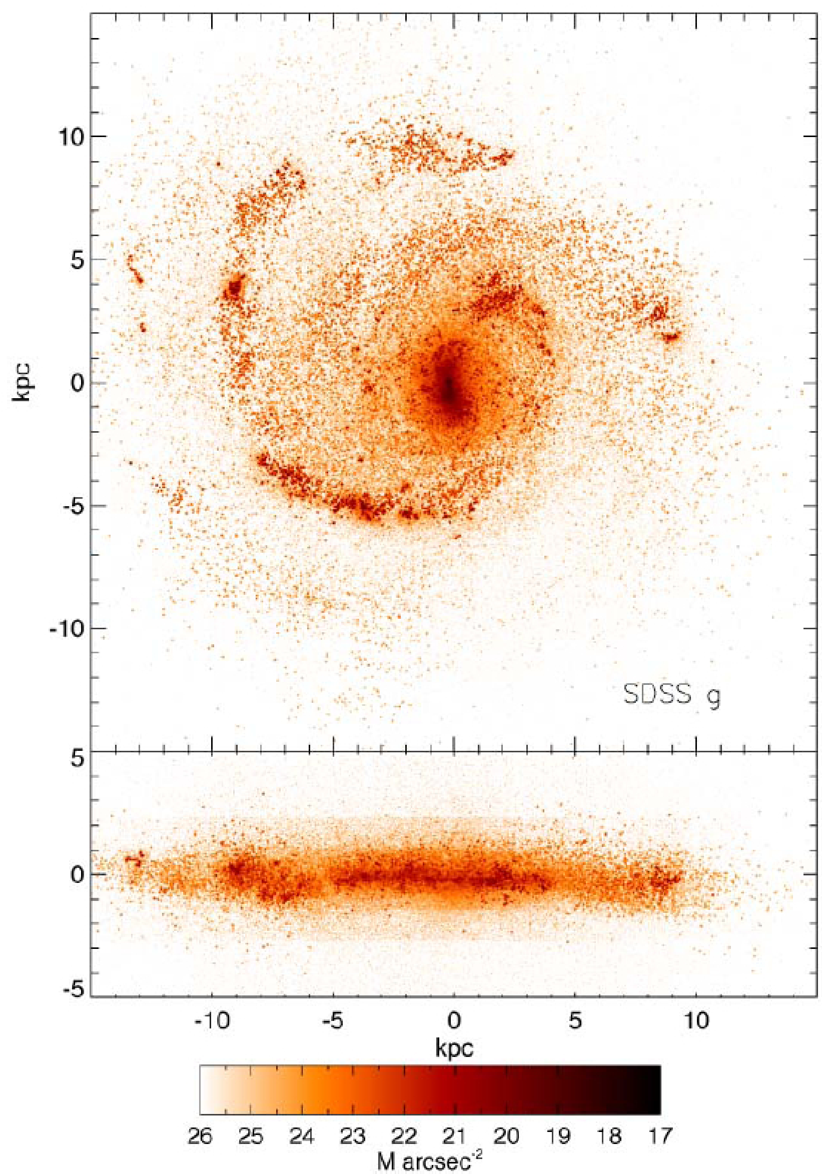


Figure 1. Face and edge on surface brightness maps in the SDSS g-band. Note the loose spiral arms and the existence of a bar. The effects of dust reprocessing have been included.

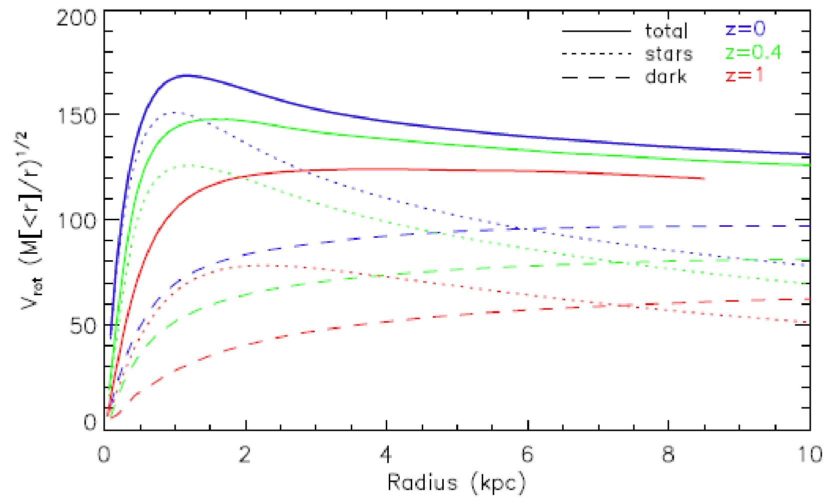
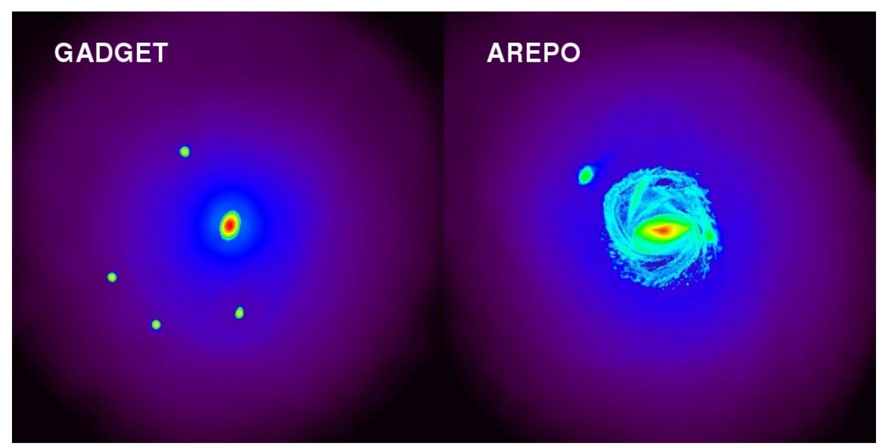


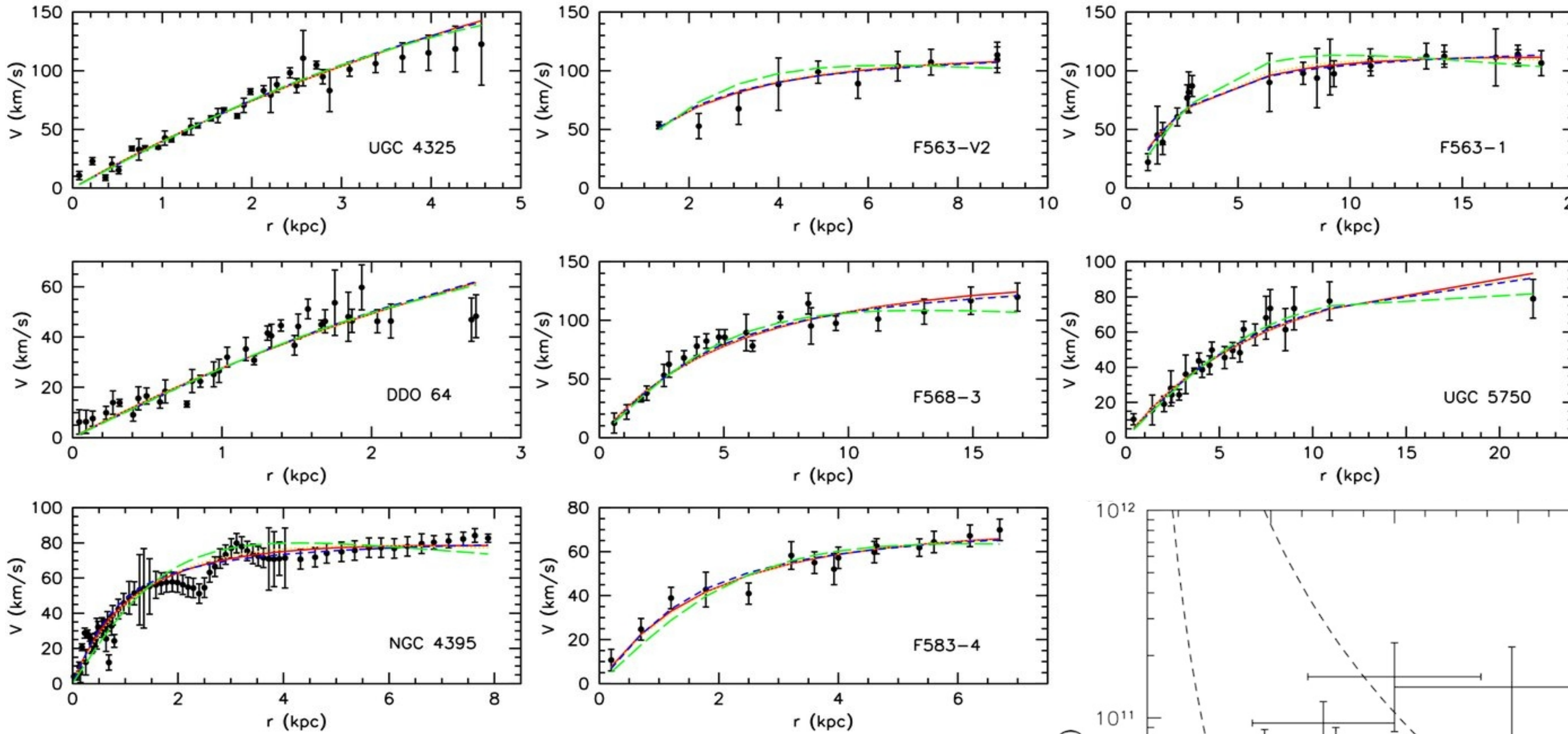
Figure 3. The rotation curve ($V_c = \sqrt{\frac{M(<r)}{r}}$) of the simulation at $z = 0$ (blue line), $z = 0.4$ (green) and $z = 1$ (red). Also shown are the contributions from stars (dotted lines) and dark metter (dashed). The rotation curve is flat at $z = 1$, while it has a slight inner 'peak' at $z = 0$.

Maybe change in code ?? AREPO

1109.1281, 1109.3468, 1109.4638



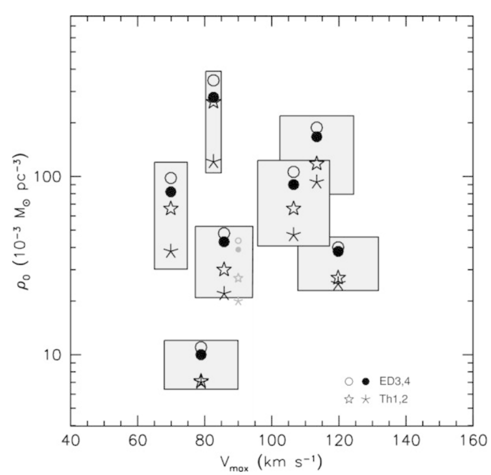
LSB galaxies and WDM or SIDM   Kuzio de Naray et al. 2010

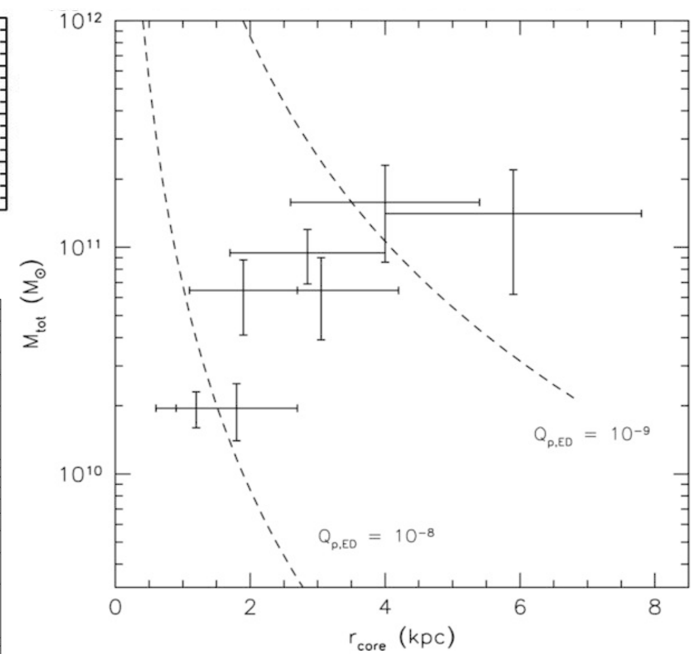


WDM : expect smaller cores
for more massive systems
if no phase-space mixing

SIDM : expect constant core
density, or central density
correlates with V_max

Core size set by baryonic physics





Conclusions (second part)

Are discs maximum?

No definite answer : larger discs are more self-gravitating?

Maximum discs are not in good agreement with NFW-like profiles

Cusps or cores?

DM-only , very high resolution simulations argue for NFW-like profiles (cusps)

Observations argue mainly for cores

Feedback from the baryons around $z \sim 1$ may flatten the cusps in dwarf galaxies. Then large spirals would form with cores. This could perhaps also solve the problem of satellite over-abundance.

Further examination of ΛCDM and WDM models is warranted