The DARK MATTER SAGA:

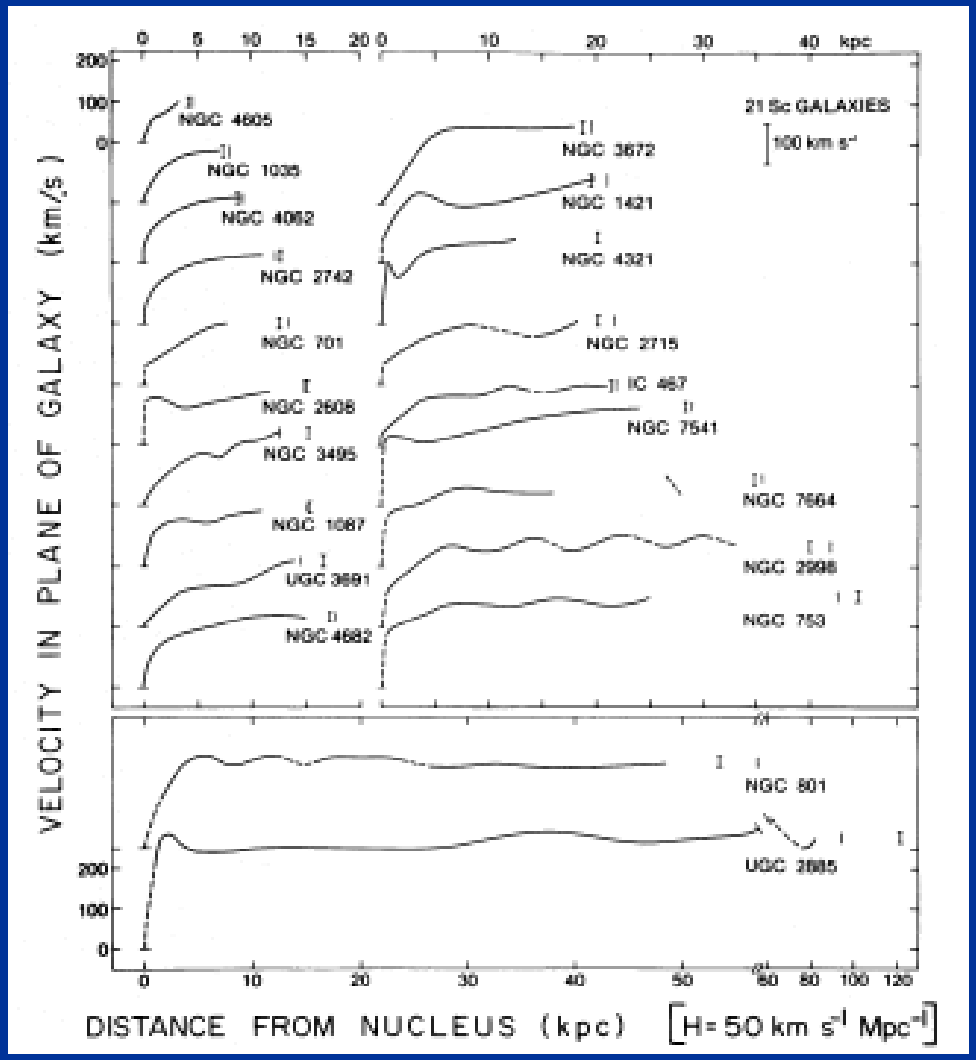
The decisive role of the WSRT

Renzo Sancisi

OPTICAL ROTATION CURVES

"FLAT"

DARK MATTER !

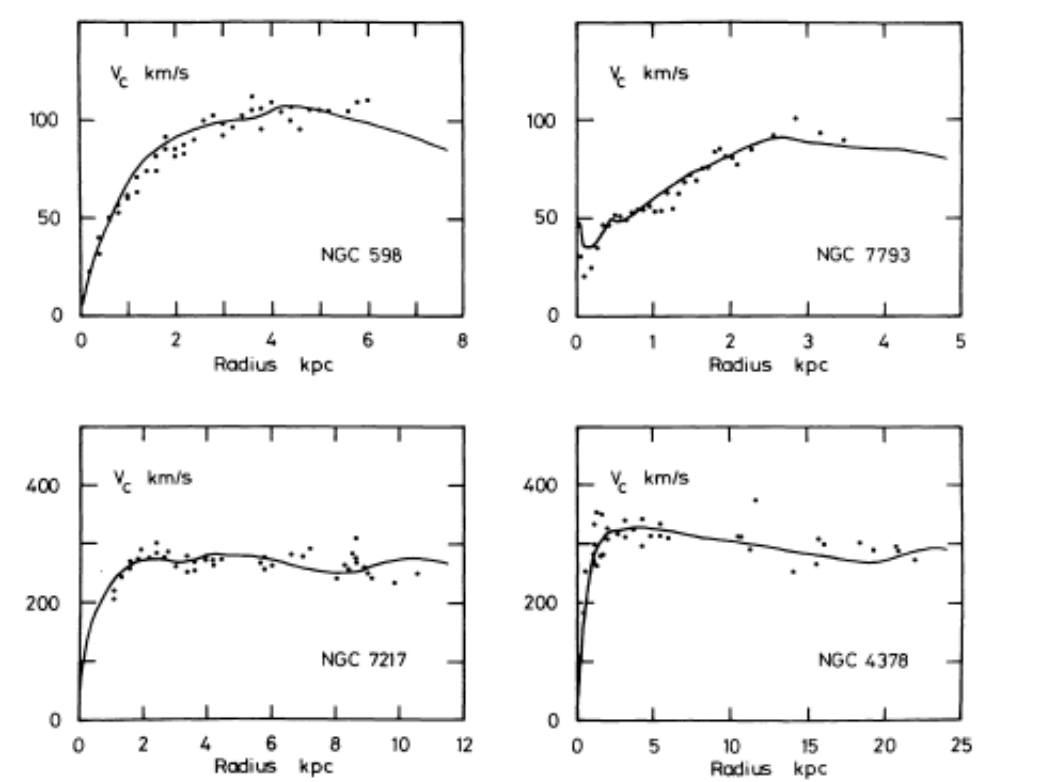


Rubin et al. (1980)

No need for dark matter!

Kalnajs 1983

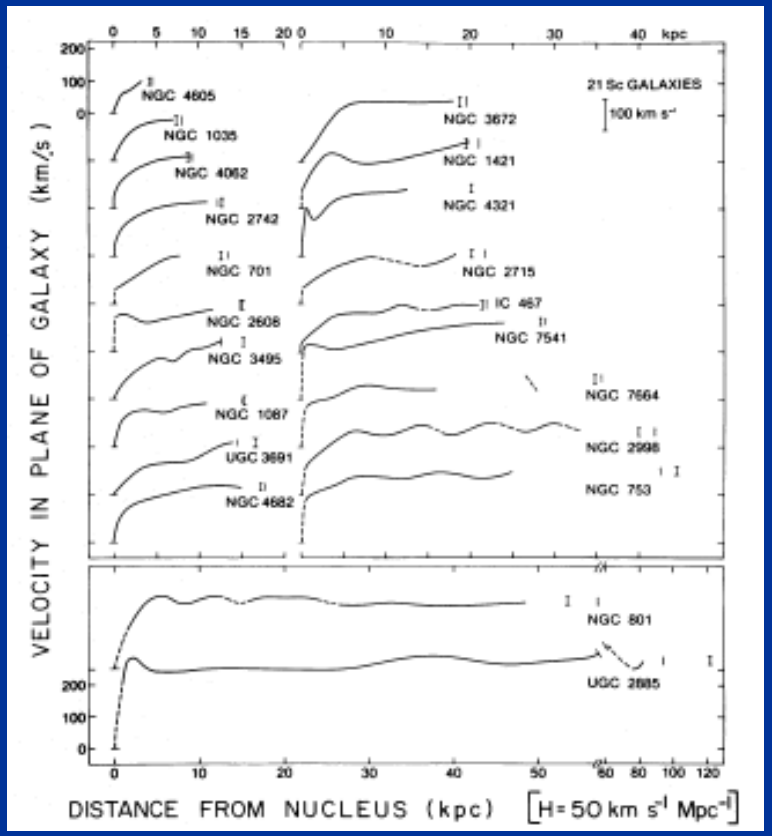
dots= measured optcal rot curves



Rotation curves computed from photometry assuming a constant M/L within each galaxy. The dots are the measured velocities. The values of M/L used are 5.0, 2.9, 4.2 and 6.5.

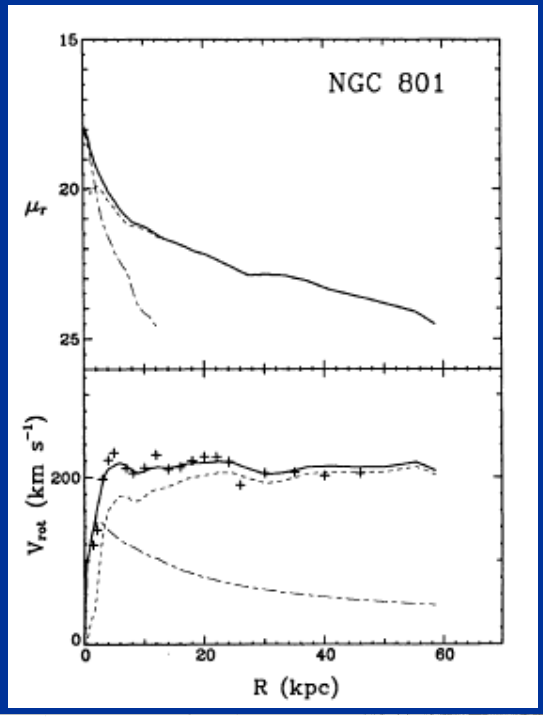
Result confirmed by Kent (1986, 1987)

M/L constant within a galaxy



Rubin et al. (1980)

NGC 801



Kent 1986

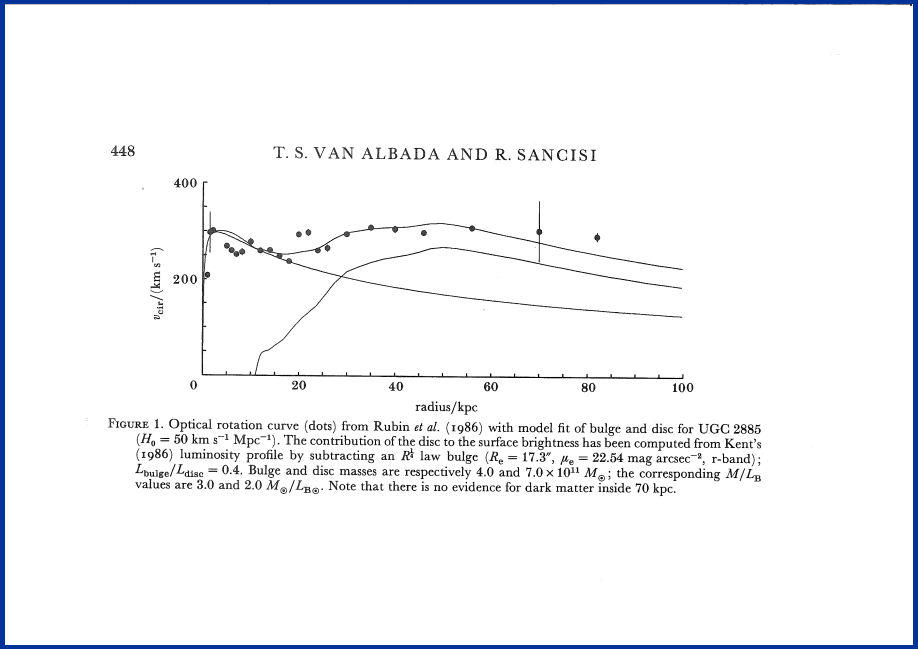


FIGURE 1. Optical rotation curve (dots) from Rubin *et al.* (1986) with model fit of bulge and disc for UGC 2885 ($H_0 = 50$ km s^{-1} Mpc^{-1}). The contribution of the disc to the surface brightness has been computed from Kent's (1986) luminosity profile by subtracting an $R^{\frac{1}{4}}$ law bulge ($R_e = 17.3''$, $\mu_e = 22.54$ mag arcsec^{-2}, r-band); $L_{bulge}/L_{disc} = 0.4$. Bulge and disc masses are respectively 4.0 and 7.0×10^{11} $M_\odot$; the corresponding M/L_B values are 3.0 and 2.0 $M_\odot/L_{B\odot}$. Note that there is no evidence for dark matter inside 70 kpc.

UGC 2885

Van Albada and Sancisi 1987

Conclusion:

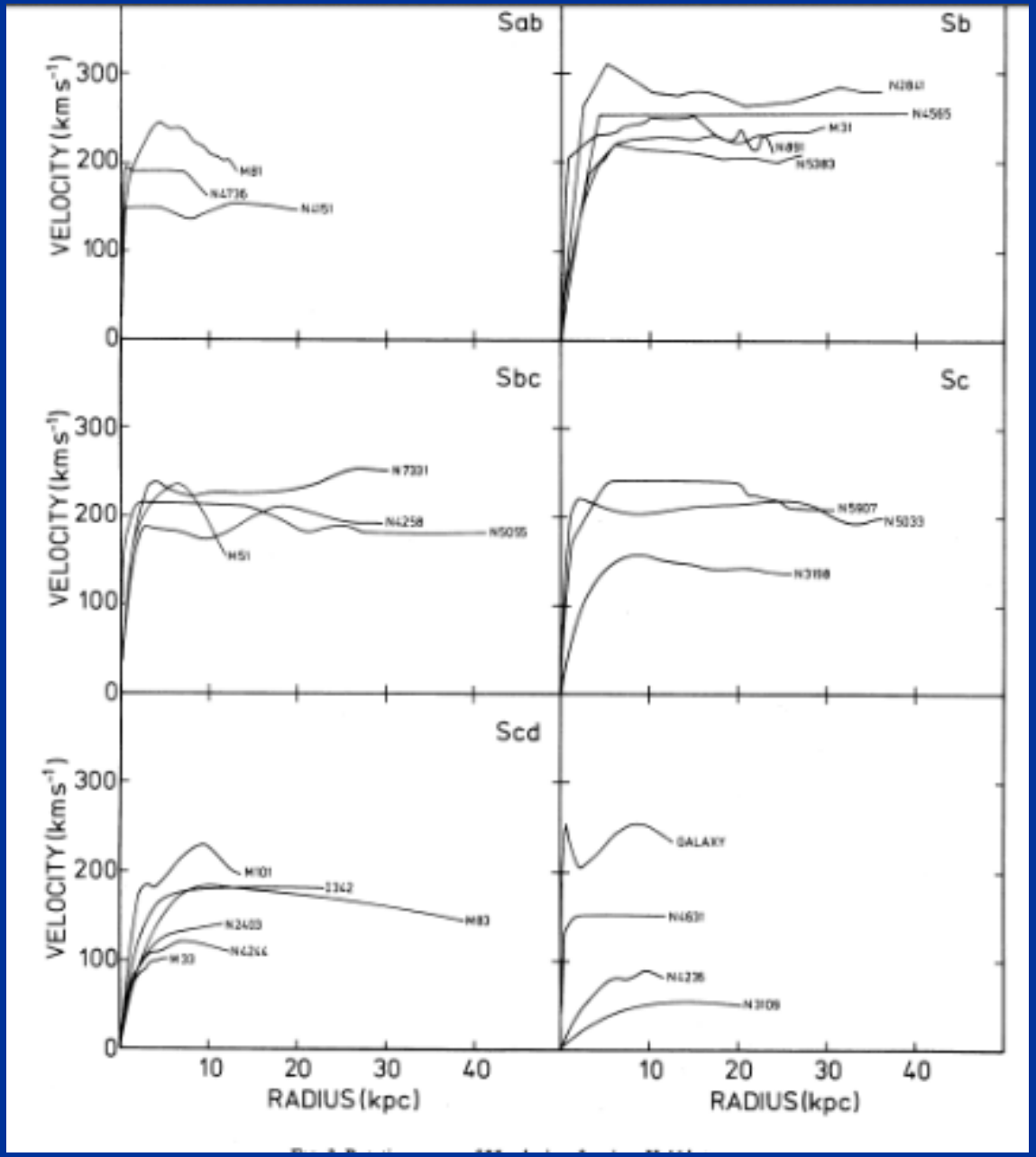
A flat rotation curve in itself does not imply the presence of dark matter.

21 cm radio observations of neutral hydrogen gas in the outermost regions are indispensable.

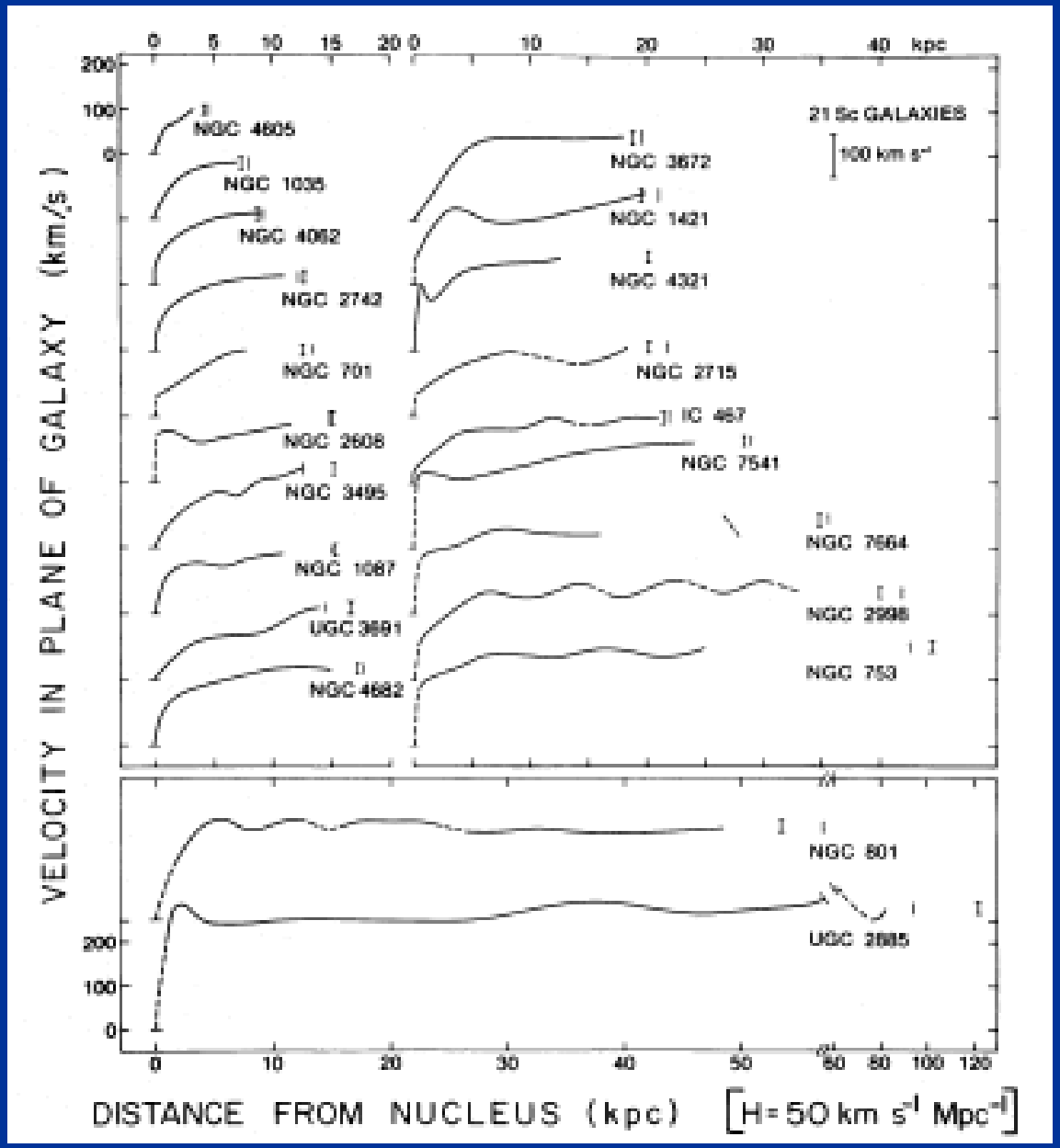
The role of the WSRT

WSRT:
HI rotation curves

Bosma 1978
PhD Thesis
Groningen



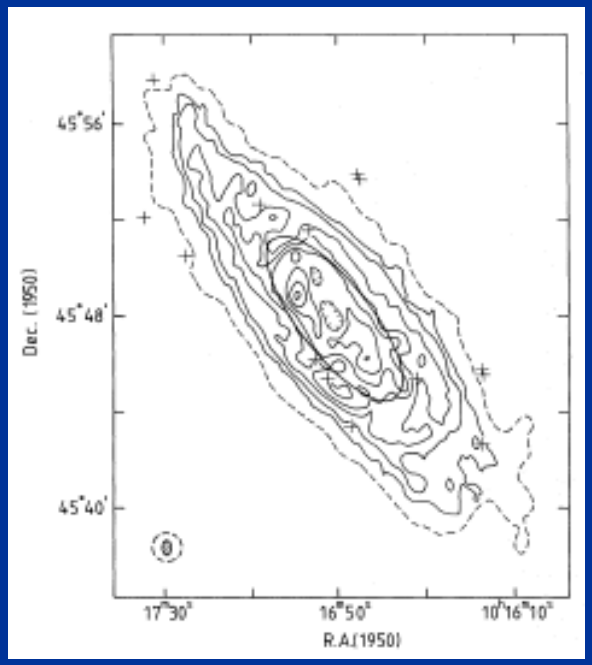
O P T I C A L



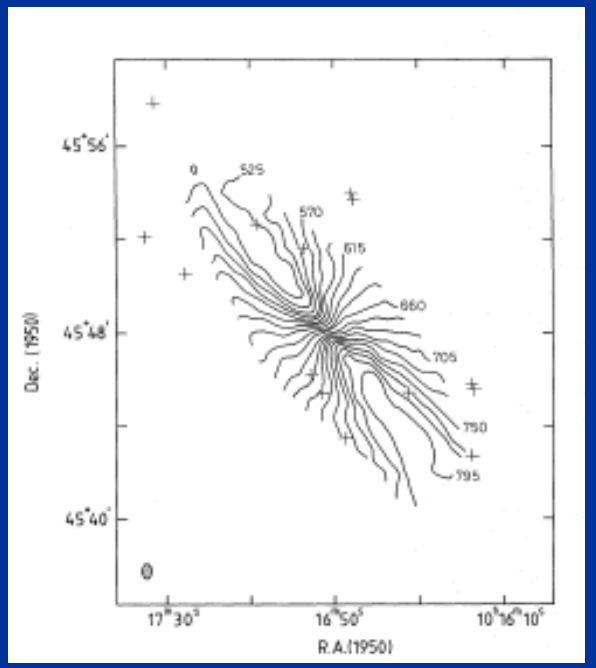
Rubin et al. 1980

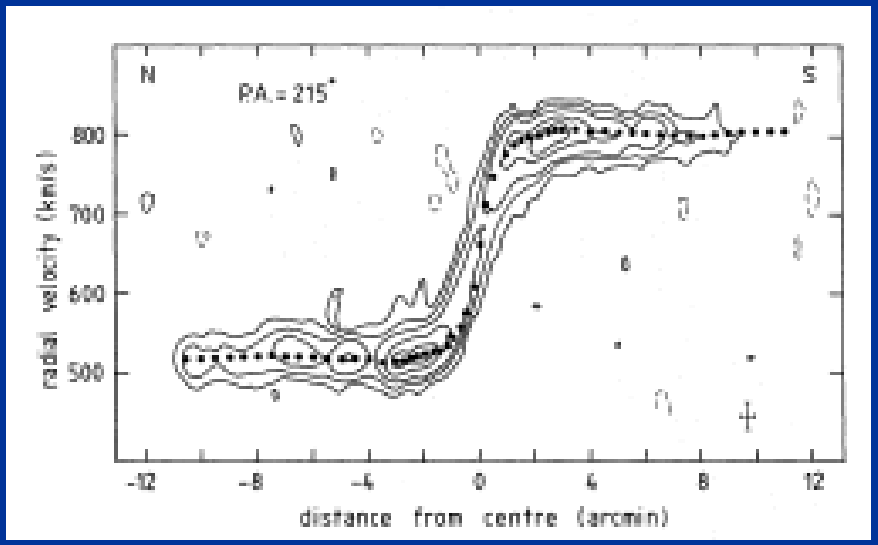
NGC 3198

HI map



vel field





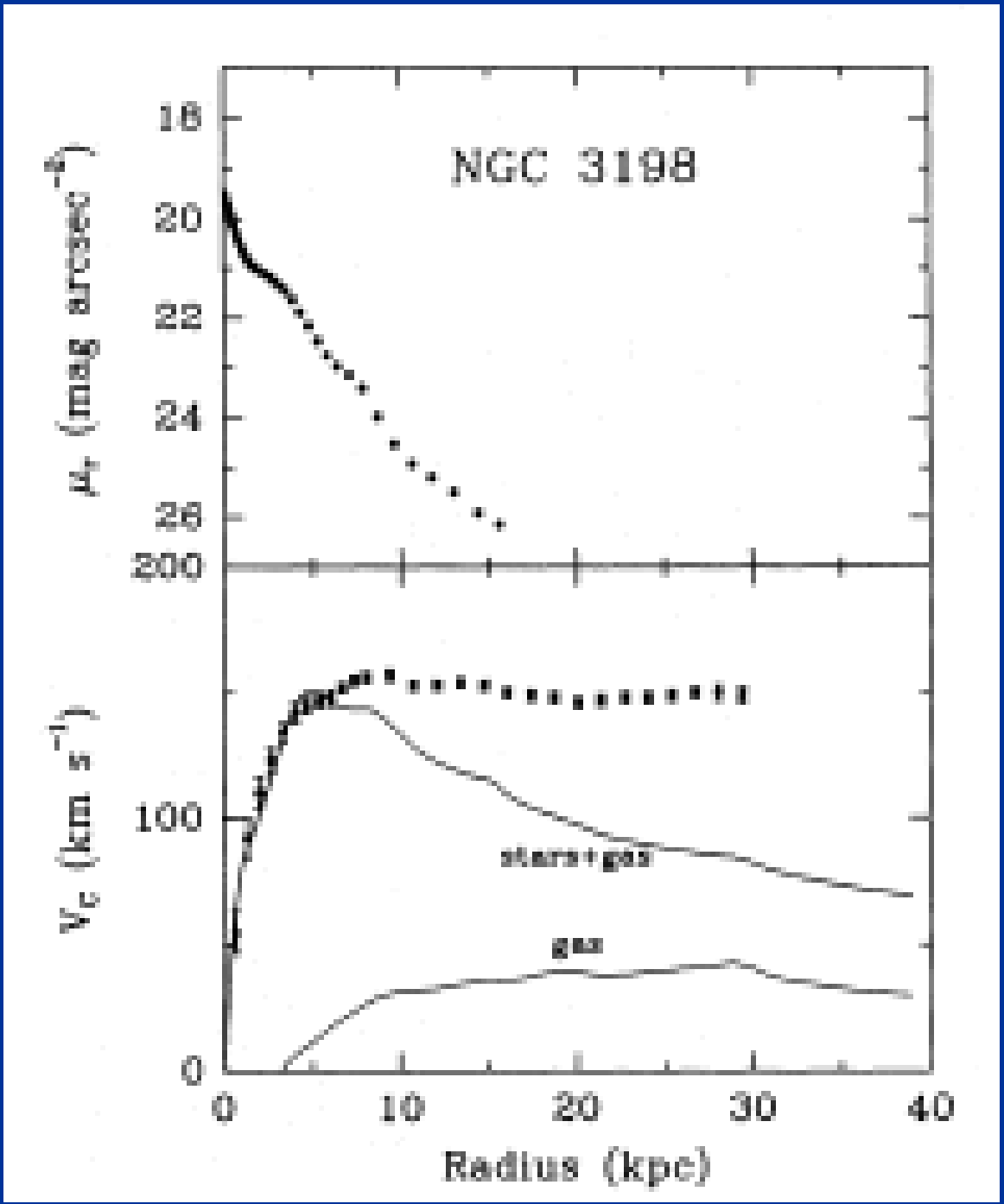
slice along major axis

Begeman 1985

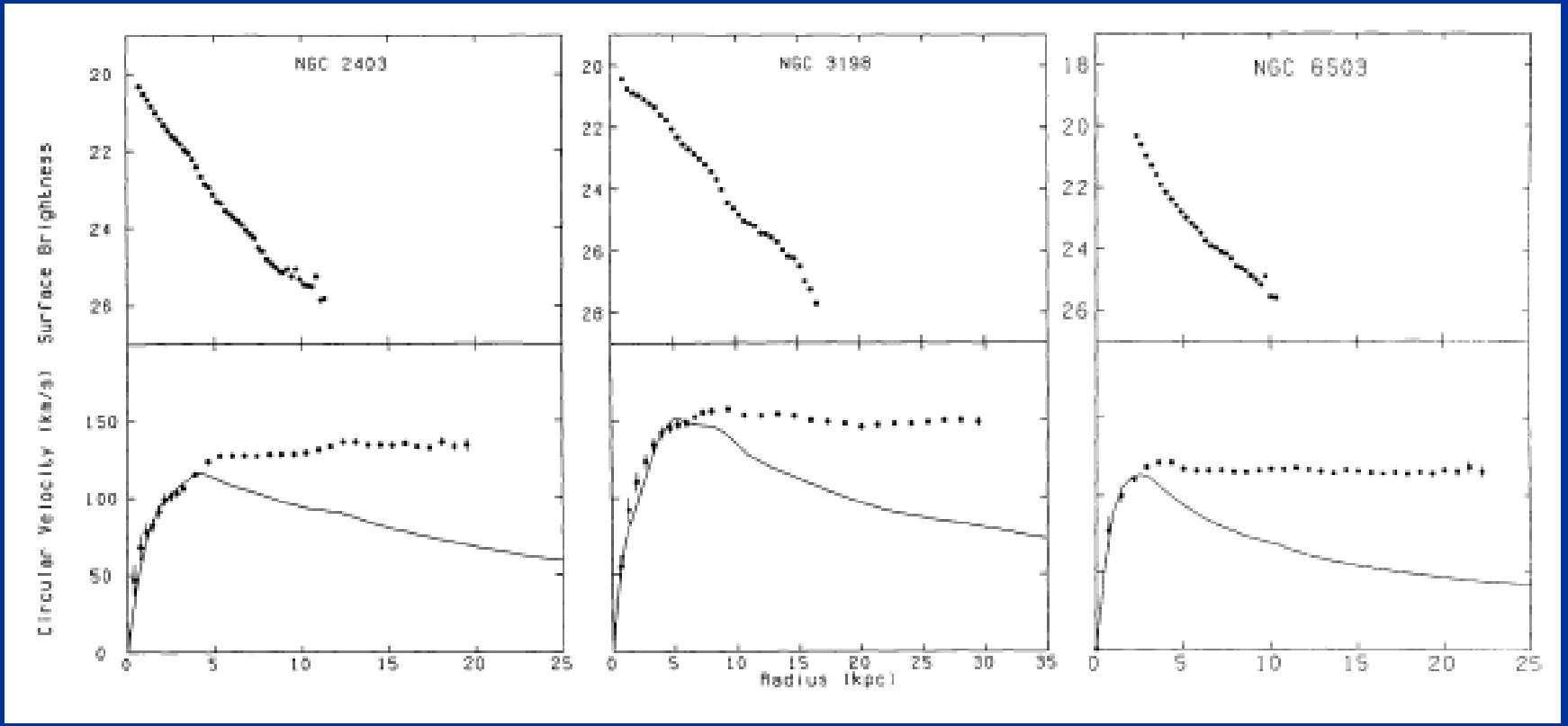
"Maximum disk" hypothesis

Discrepancy
between expected (from photometry) and measured rotation curve

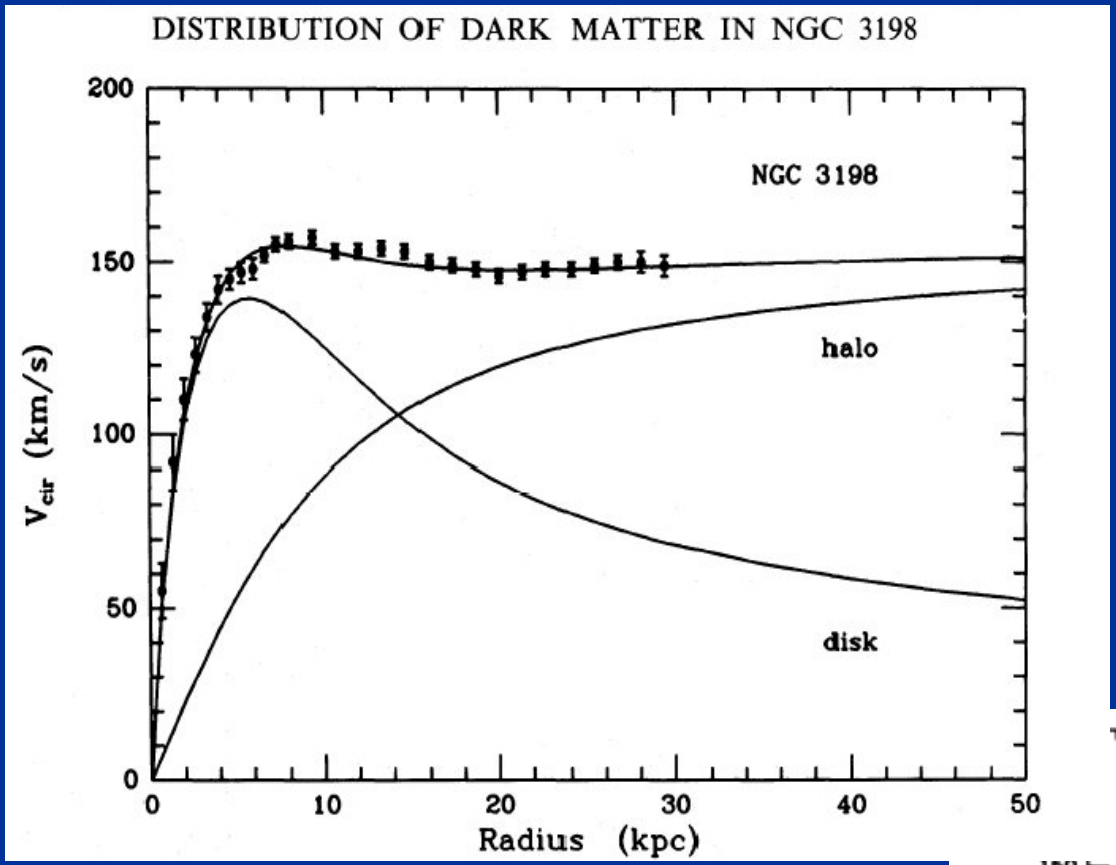
Begeman 1985



Same in other galaxies !!



Begeman 1987, Sancisi and Van Albada 1987



Maximum disk

The CONSPIRACY

Van Albada et al. 1985

minimum disk

also acceptable!?!

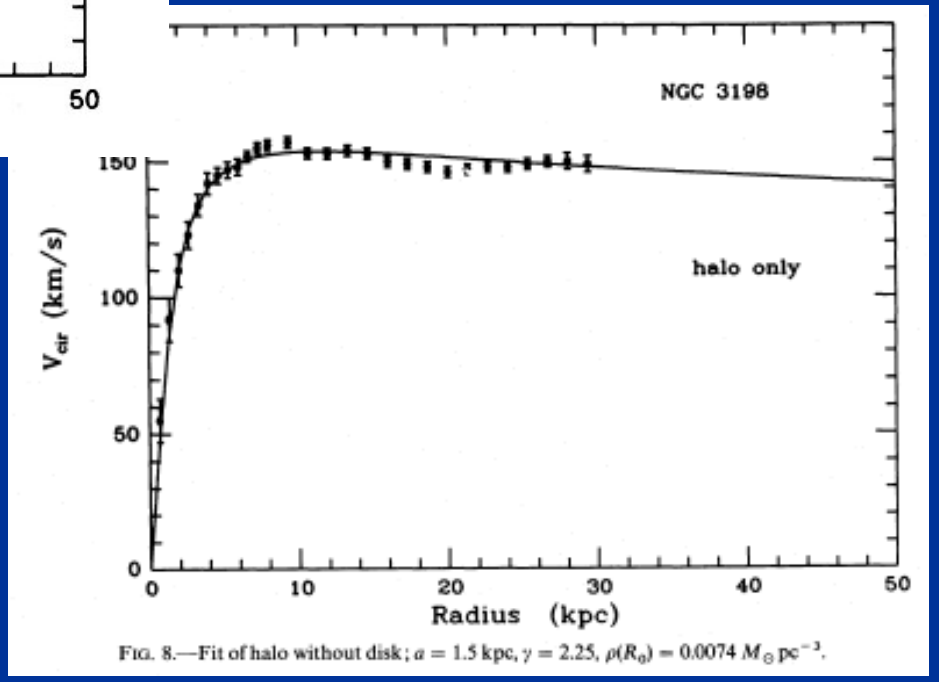


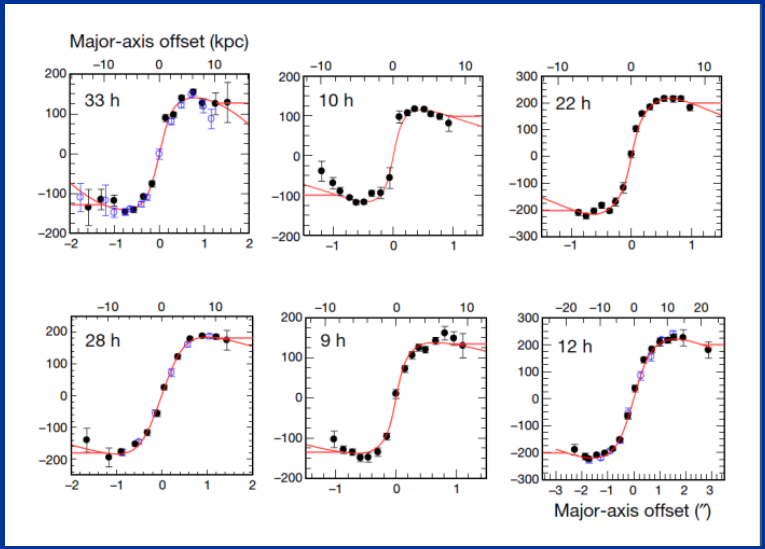
FIG. 8.—Fit of halo without disk; $a = 1.5$ kpc, $\gamma = 2.25$, $\rho(R_0) = 0.0074\ M_\odot\ \mathrm{pc}^{-3}$.

The SAGA continues

at high redshift

Declining rot curves high redshift galaxies

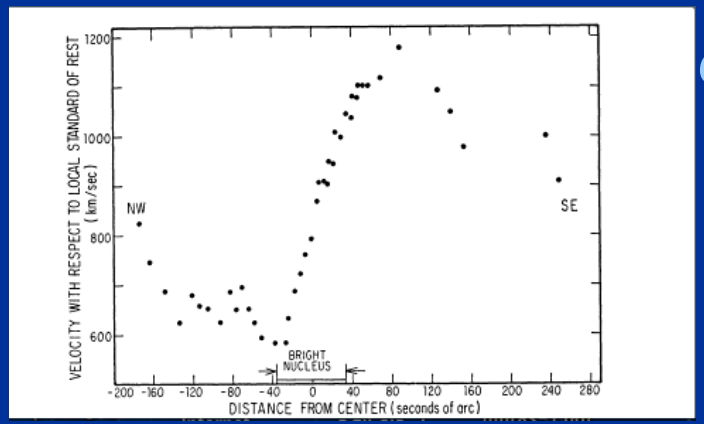
Genzel et al. 2017

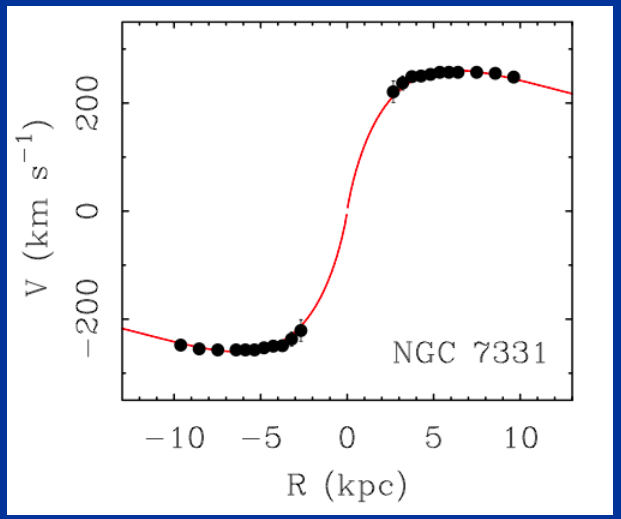


Baryons dominate!

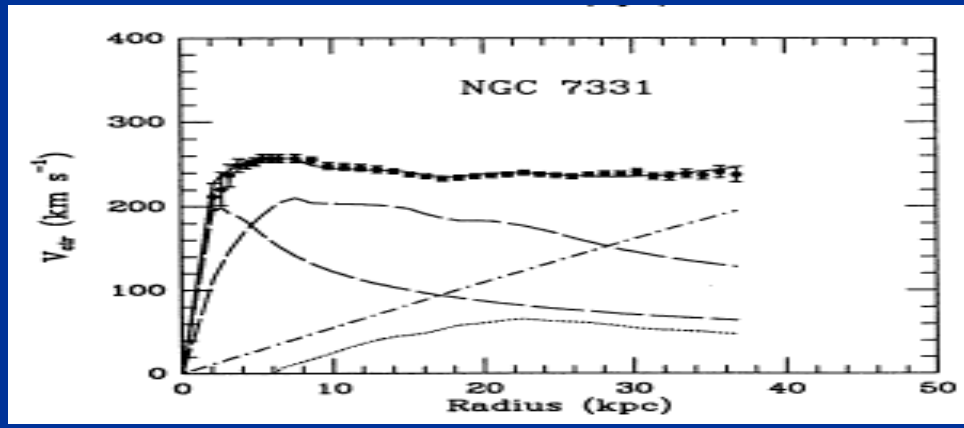
NGC 7331 Rubin et al. 1965

optical





N7331
HI rot curve
Begeman 1987



Analysis of rotation curves

BUILDING BLOCKS :

1. BULGE — $R^{1/4}$ law spheroid

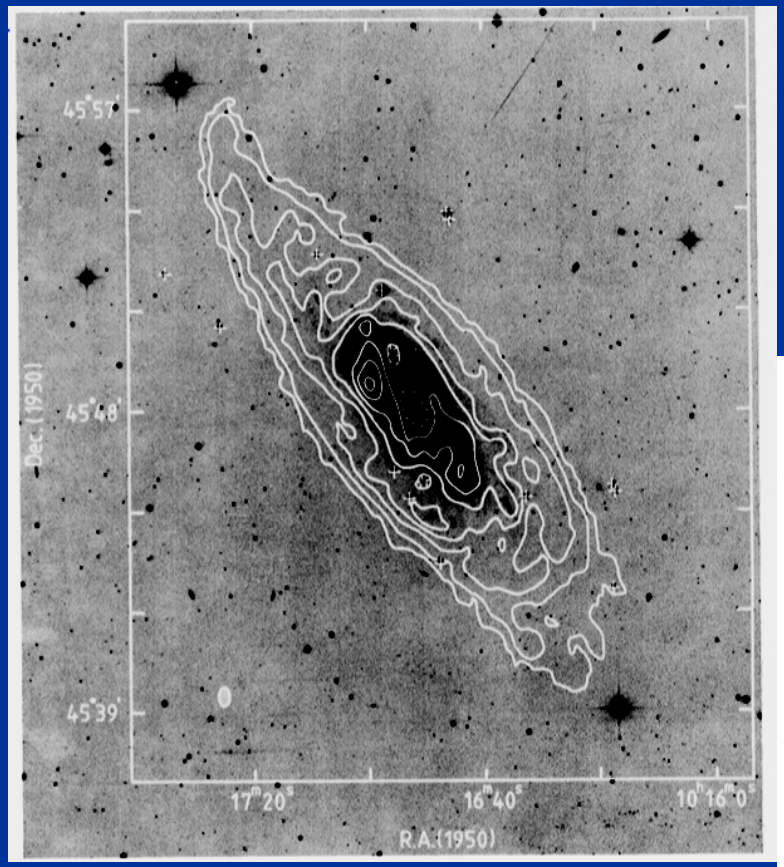
2. DISK — Exp. $\Sigma = \Sigma_o\, e^{-r/h}$
   M/L indipendent of radius

3. DARK HALO

$$\rho(r) = \rho_0 \left[1 + \left(\frac{r}{r_c} \right)^2 \right]^{-1}$$

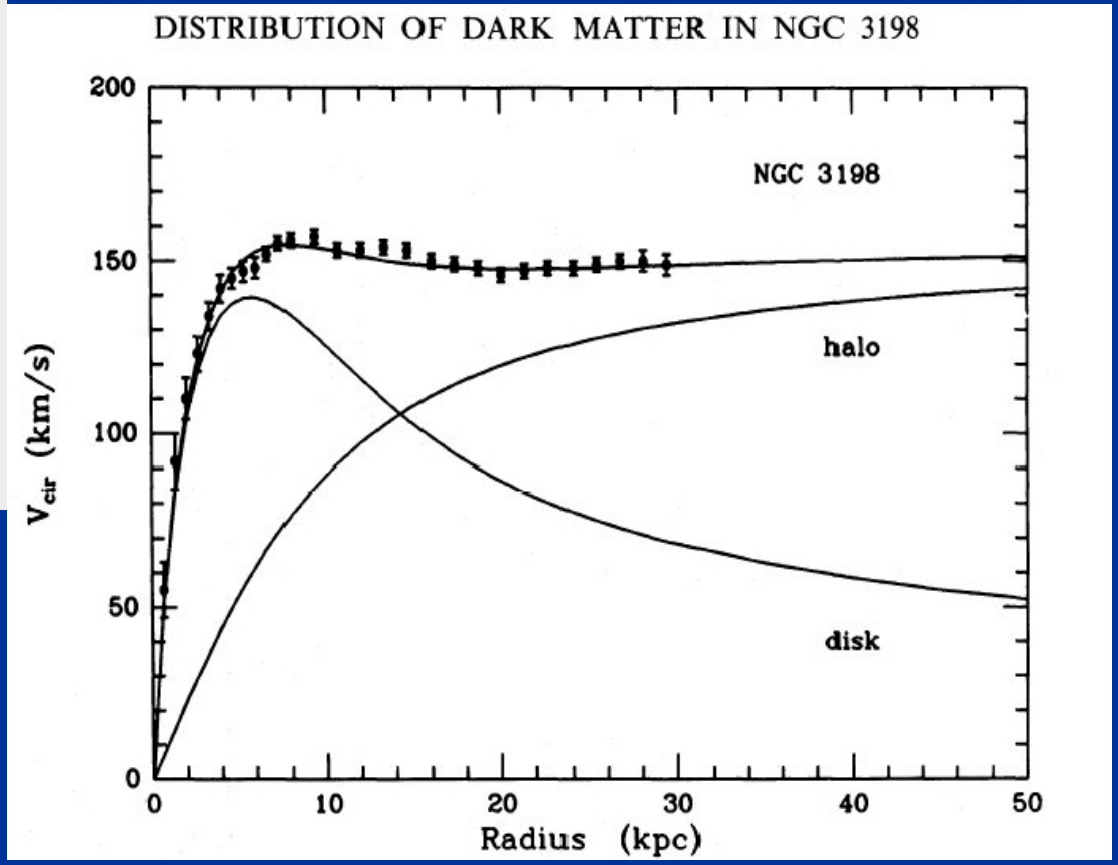
$$V_{cir}(r) = [\, V^2_{bulge}(r) + V^2_{disk}(r) + V^2_{halo}(r) \,]^{1/2}$$

NGC 3198 *neutral hydrogen (21 cm line)*

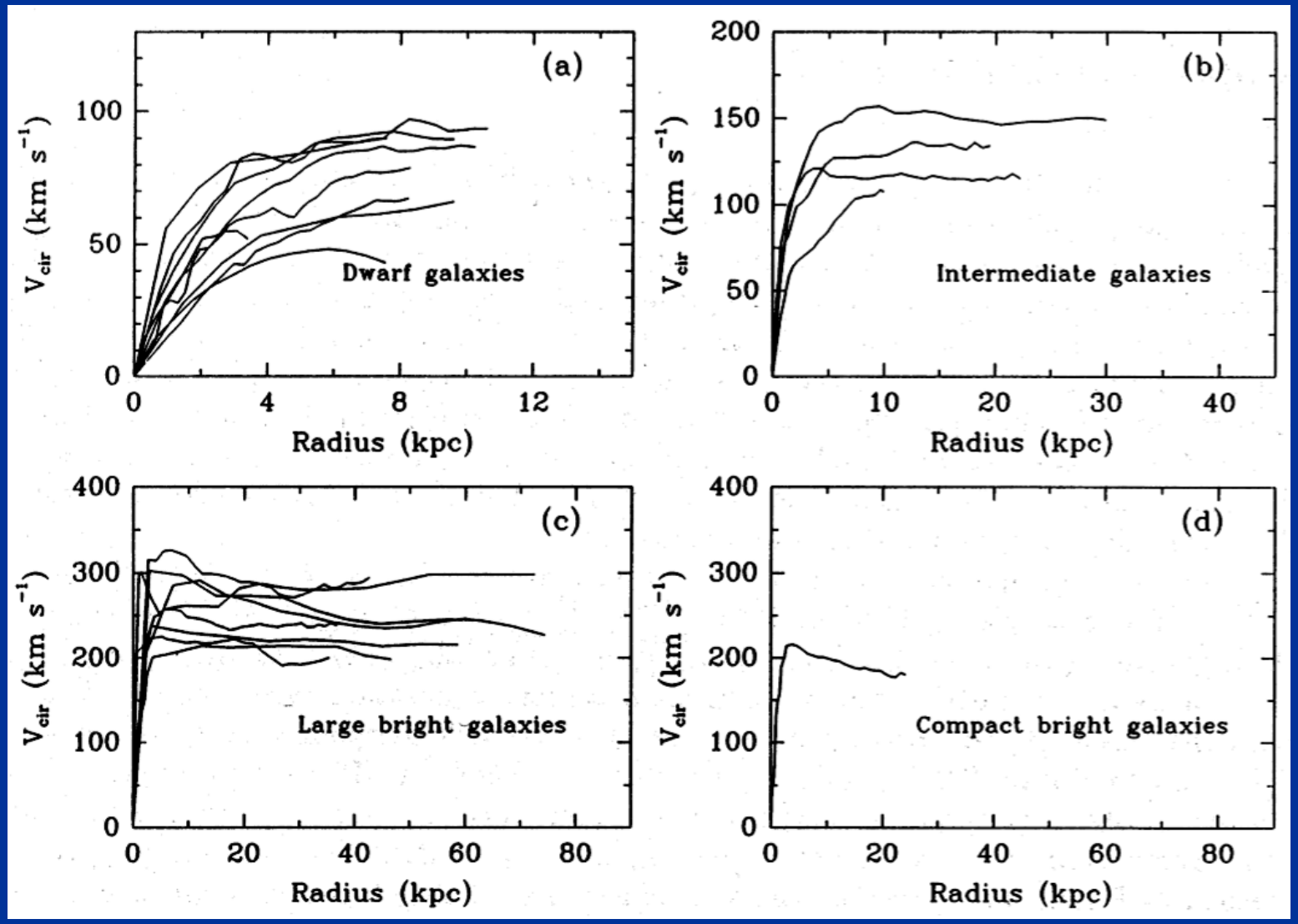


HI MAP with WSRT (Begeman 1987)

Rotation curve



Properties of rotation curves



Bosma 1978