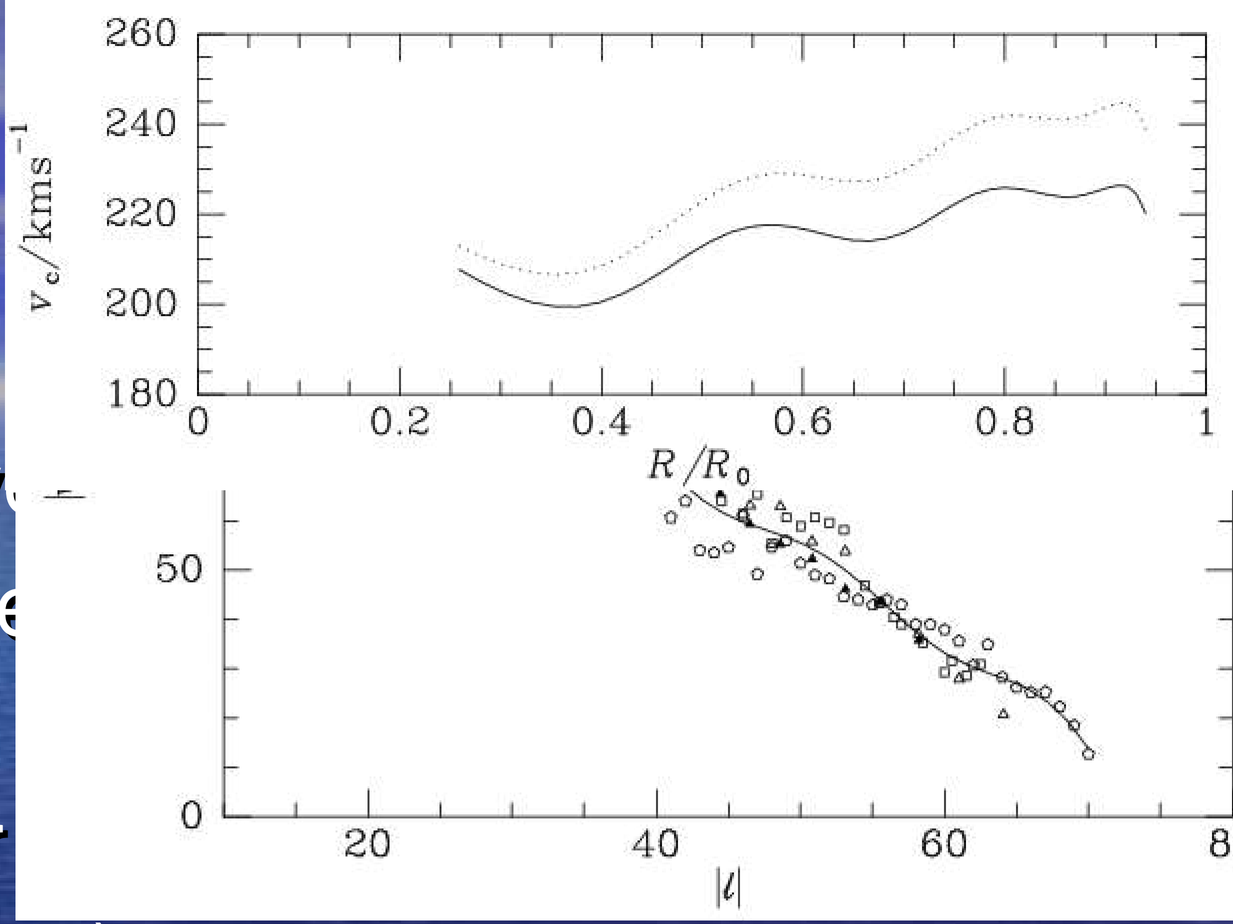
DM in the Galaxy

James Binney
Oxford University

$½_{DM}=½-½_{B}$
Constraints on ½

- The disk, inner & outer
- The bar/bulge
- Which dark halo?
- Microlensing data
- Fine structure
- Conclusions

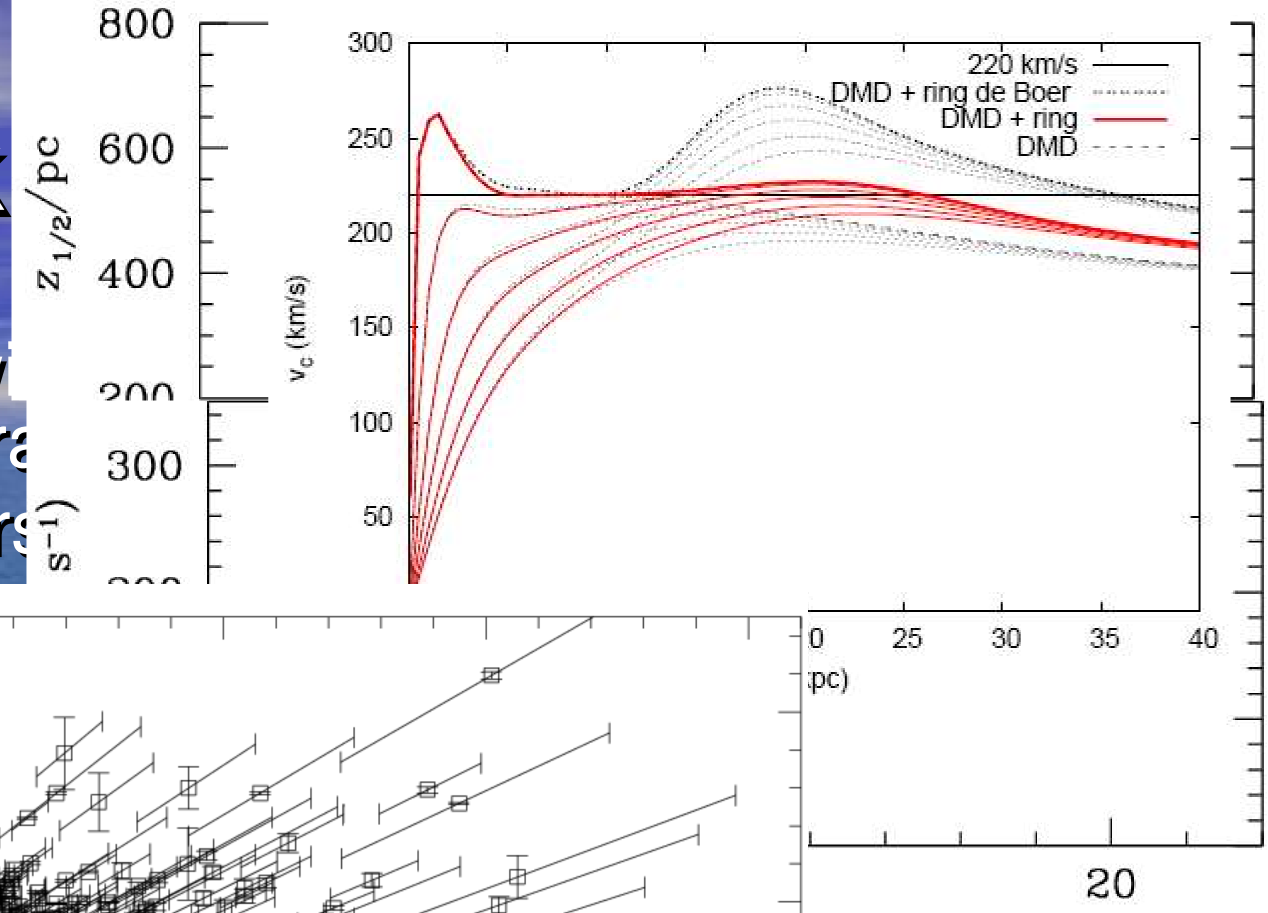
The disk

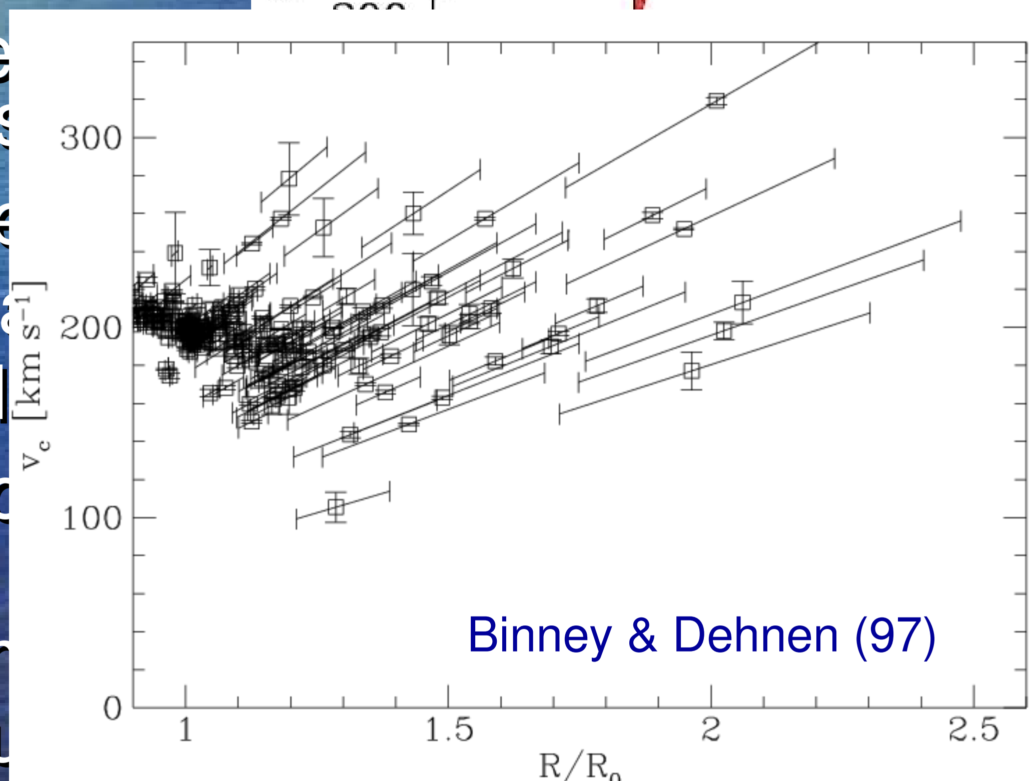


- Rotation curv
- At $R<R_0$ tange
  effects of bar
- From ¹ of Sgr
  & Brunthaler 04)
- Take R_0=7.6 (Eisenhauer+05)) £$_0$=229 km/s

Outer disk

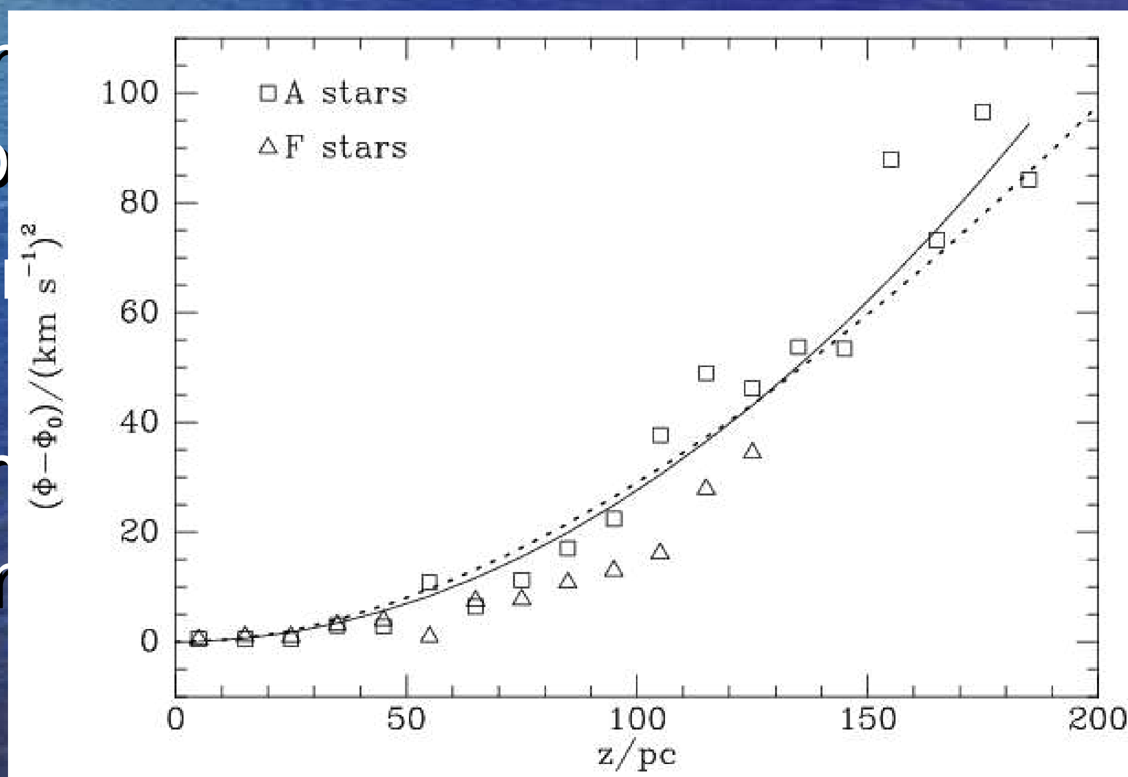
- For R>R_0, wi
  distances to tra
- Distance errors
- Merrifie
  $W=v_{los}/s$
- Revisite
- Kalberla
- v_c gentl
- evidenc 13<R<18.5
  kpc, M
- Problen $f(v_z)$ away
  from Su





Local disk density

- Near Sun v_{rand}!
- ½(R_0,0) = 0.1§0.01 M- pc^{-3} (Holmberg & Flynn 00; Creze et al 98)
- Countin … §$_d$ '
  49 M- p
- Stellar … .1kpc)
  = 71§6 … mberg
  & Flynn
- Differen



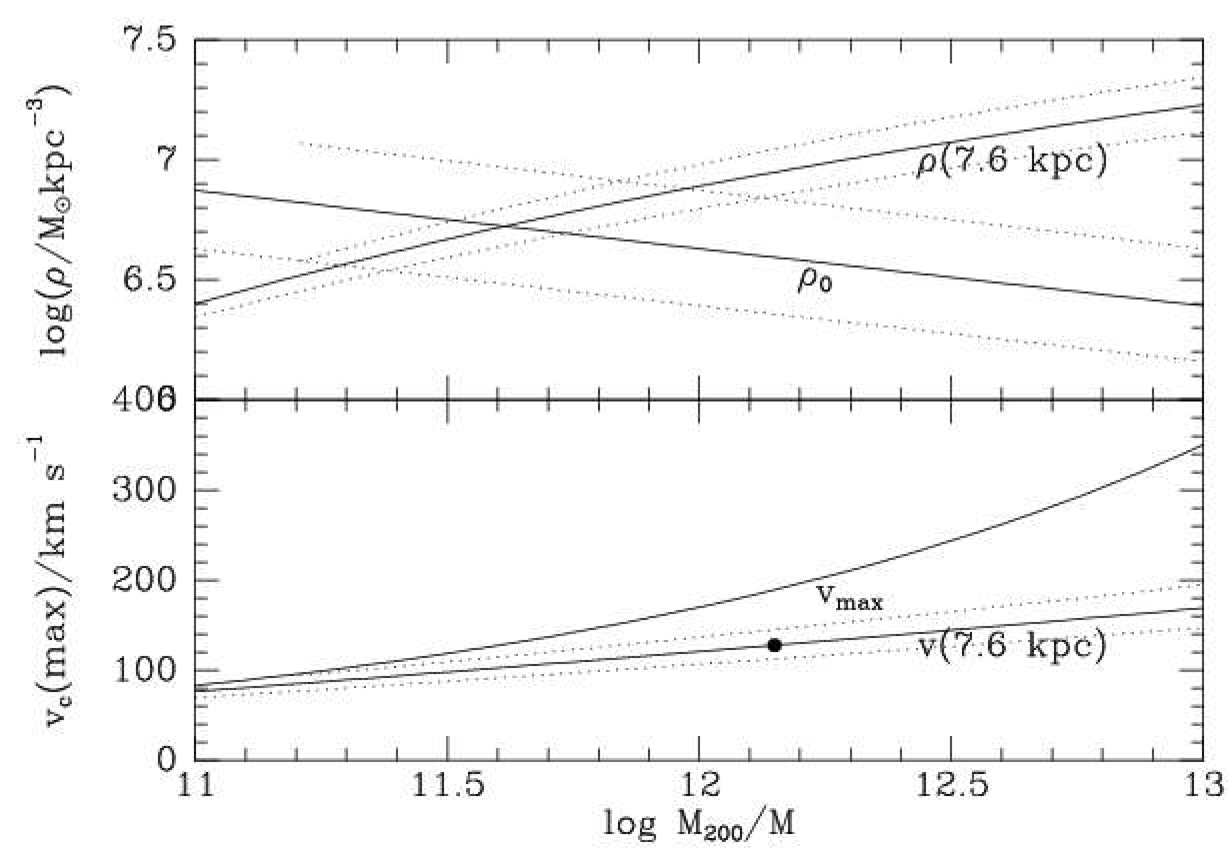
Photometry of disk

- Use NIR to (a) beat dust absorption, (b) be sensitive to mass-bearing stars
- COBE/DIRBE data provide unique overview – but 0.7^o resolution
- 2MASS star counts allow more detailed work (Robin+03)
- Data consistent §(R) / exp(-R/R_d)
- R_d ' 2.5 kpc
- Using §(R_0)=49M- pc^{-2} get
  M_d = 5.8£10^{10} M- ! £$_0$=187 km/s
  (only 2/3 measured acceleration & falling)

The bulge

- For contribution to $£^2$ use $GM/R_0 = (28.2 \text{ km/s})^2$
- $M = 1.4§0.6£10^9 M_-$ (Launhardt et al 01)
- ! $£_0 = 189$ km/s
- The dark halo has to provide
- $V_c=(229^2-189^2)^{1/2}=129.3$ km/s

Which dark



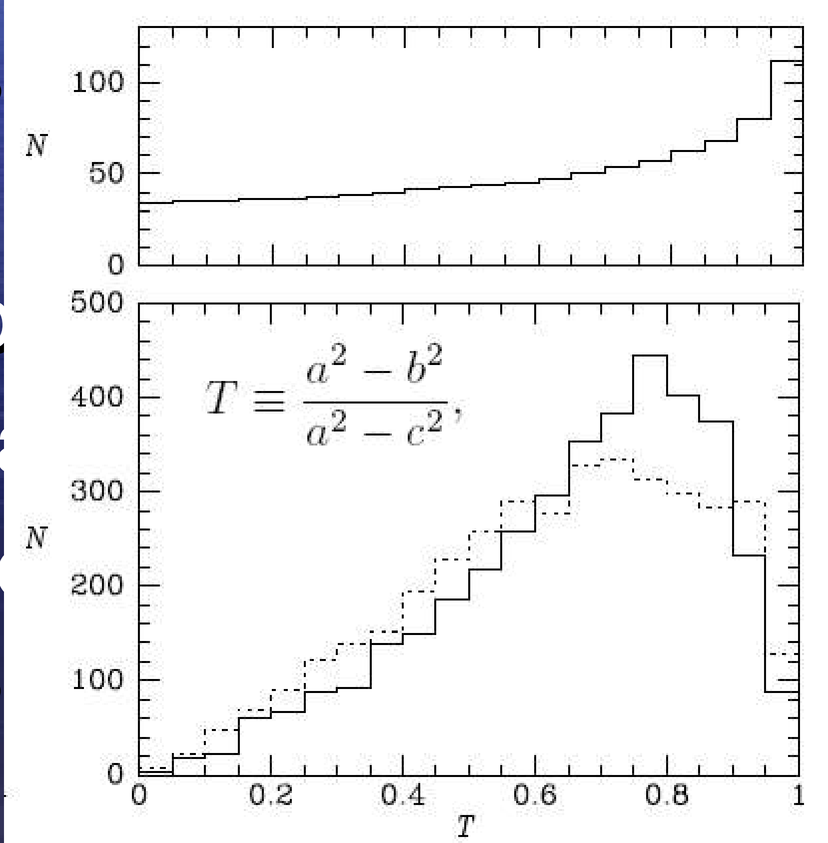
- Dark halos ~ 1 para
- ½(r)=½$_0$/[(r/a)(1+r/
- ½(r_{200})=200½$_c$
- c=r_{200}/a
- Log(c) ' 2.121 - 0.1 log(M_{200}) § 0.1 (Neto+07)
- Then observables fns(M_{200})
- From v_c need
- M_{200}= 1.4£10^{12} M- a=27.9 kpc
- V_c(max)=189 km/s ½$_{DM}$(R_0)=8.9£10^{6}M- kpc^{-3}
- So DM contributes 2.2£8.9=17.8 M- pc^{-2} to §(1.1kpc) (cf 22§6 from v_{rand})

Density at large r

- Random Vs of satellites
- Proper motions essential: v_{los} ! v_r, v_t! r^1
- Need also dº/dr for population
- Wilkinson & Evans (99): M (50kpc)=(5.2 to 1.9)£$10^{11}$$M_-$
- Battaglia+(05): $¾_{los}$ falls 100 to 50 km/s at r>50 kpc; suggest low end
- NFW gives M(50kpc) = 4.1£10^{11} M_-

Shape of dark halo?

- Without baryons, halos generically triaxial
- Baryons drive towards
- Uncertain predictions
- Should be able to prob
- Conflicting results to da
- SDSS and Leiden-Arg
  should transform the s



Microlensing

- Measures mass in stars only
- ¿ = P(lensed) ~ 10^{-6} towards GC and 10^{-7} outwards
- So need rich target starfields – bulge and Magellanic clouds
- Major problems: "blending" & intrinsic stellar variability
- ¿$_{LMC}$=1£10^{-7} (Alcock+00, Bennett 05); 1.5£10^{-8} (EROS: Jetzer 04)
- Given blending, best interpreted as upper limits
- <20% of ¿ expected if DM stellar; excludes masses down to 10^{-7}M$_{-}$
- ¿ possibly compatible with known stars (Evans & Belokurov)

Bulge microlensing

- Consider only lensing of clump giants (V<18)
- Basel model (based on IR photometry, kinematics & dynamics of gas and stars) Strongly non-axisymmetric © required; hard to generate non-circular motions of required magnitude
- So model has no DM ! ¿-map and durations
- Durations consistent with reasonable stellar mass function
- If NFW added, must reduce predicted ¿
- Very tight budget, zero room for obs ¿ to be over-estimated

Fine structure

- ~20% of mass in substructures
- Low prob of our being in one
- Key question: depth of troughs in “smooth” background
- Way beyond resolution of existing N-bodies

Conclusions

- Rotation curve of MW well determined inside R_0
- At R À R_0 situation confused
- At R<R_0 MW baryon-dominated
- Near Sun data consistent with expected DM halo
- At R ¿ R_0 little scope for axisymmetric component and microlensing ¿ only slightly overpredicted when all matter stellar