The Formation of Galactic Disks

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Overview

- Progenitor Formation
- Assumptions
- Models of Disk Formation
- Disk Properties
- Effect of a Central Bulge
- Correlation to Observations

Quick Review of Galaxy Formation

- Perturbations in dark matter grow into dark halos
- Gas cools and condenses into and in those halos
- Tidal torques produce galactic spin
- Star formation/feedback

Assumptions on Disk Formation

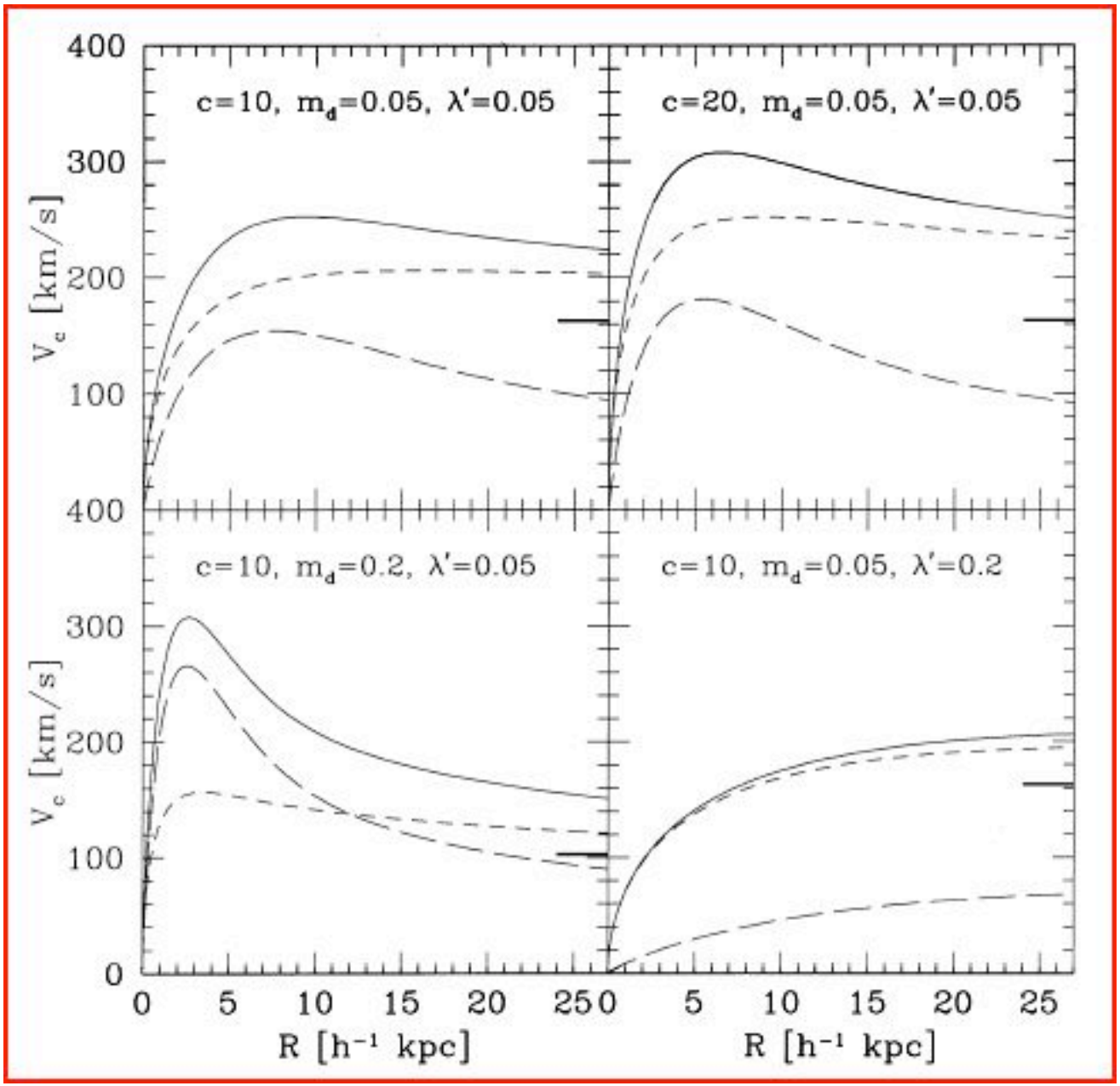
- m_d - fixed fraction of the halo's mass
- j_d - fixed fraction of its halo's angular momentum
- Centrifugally supported structure
- Dynamically stable systems - real disks
- Hierarchical cosmogony
- No bulge component (discuss later)

Model Cosmogonies

- SCDM ($\Omega_m = 1.0$ $\Omega_\Lambda = 0$)
  - Non-self-gravitating disks in isothermal spheres
- ΛCDM ($\Omega_m = 0.3$ $\Omega_\Lambda = 0.7$)
  - Self-gravitating disks in halos with realistic profiles
- Both cases: $\Omega_b > m_d\Omega_m$

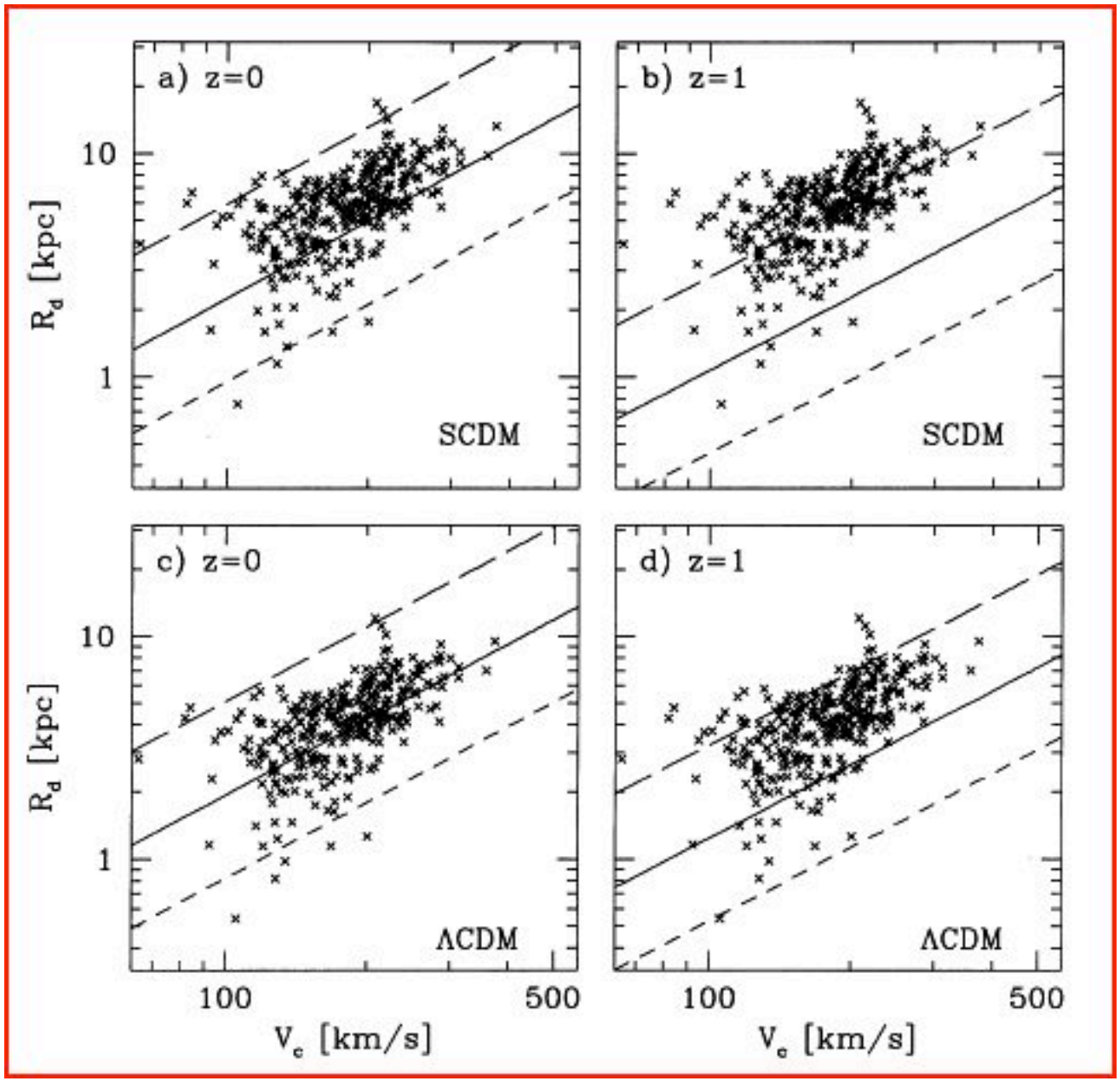
Rotation Curves

- Concentration of halo
- Fraction of halo mass
- Angular momentum
  - Large L_z case
  - Small L_z case
- All rotation curves flatten out

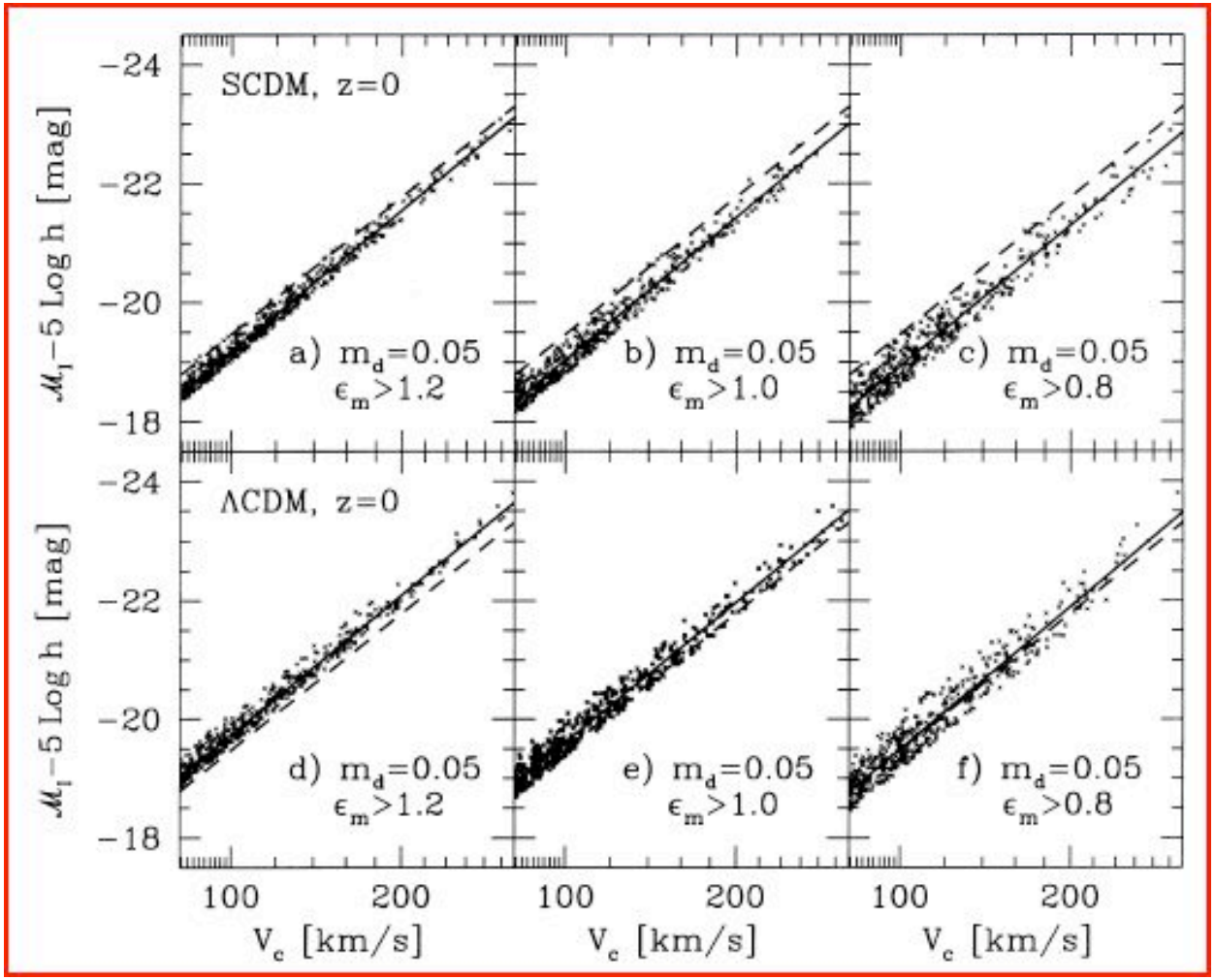

c=10, m_d=0.05, λ'=0.05
c=20, m_d=0.05, λ'=0.05
c=10, m_d=0.2, λ'=0.05
c=10, m_d=0.05, λ'=0.2
V_c [km/s]
R [h^-1 kpc]
0
100
200
300
400
5
10
15
20
25

Disk Scalelengths and Formation Times

- R_d - proportional to luminosity
- All disks form at the same time
- Most observed disks form recently
  - Too big to form at high-z in Ω_m dominated epoch
  - High-z disks – relatively small and compact
- Substantial loss of angular momentum to dark matter $j_d << m_d$ – small disks at all z
- Models predict enough halos to support observed number of disks


a) z=0
b) z=1
c) z=0
d) z=1
SCDM
SCDM
ΛCDM
ΛCDM
10
1
10
1
R_d [kpc]
R_d [kpc]
100
500
100
500
V_c [km/s]
V_c [km/s]

Tully-Fisher Relation



Effect of a Central Bulge

- Bulge assumptions
  - Pointlike
  - Fixed fraction of halo
  - Negligible angular momentum OR ($j_d=m_d+m_b$)
- Bulge effects
  - m_b – little effect on R_d and v_c ($j_b=0$)
  - For $m_d=2j_d$, $m_b=0$, R_d => $2R_d$ and v_c drops significantly

Observations

- Compare to Damped Lyα absorption Systems
- Predict high-z disks to be smaller comparatively
- ΛCDM model can easily explain observations
- 1/3 observed systems have v_c>200km/s
- 2/3 observed systems have v_c>100km/s
- Constrain m_d, j_d
  - $m_d < 0.05$
  - $j_d \sim m_d$

Conclusions

- Milky Way type disks formed recently
- Disks at high z-values are smaller and more compact comparatively
- Loss of angular momentum problem (may be due to strong feedback)
- In hierarchical model, there must be strong feedback to suppress early star formation
- Disk/halo mass fraction – much less than observed baryon mass fraction (process must be inefficient)