

Disk-Halo Interactions

Jerry Sellwood

Victor Debattista



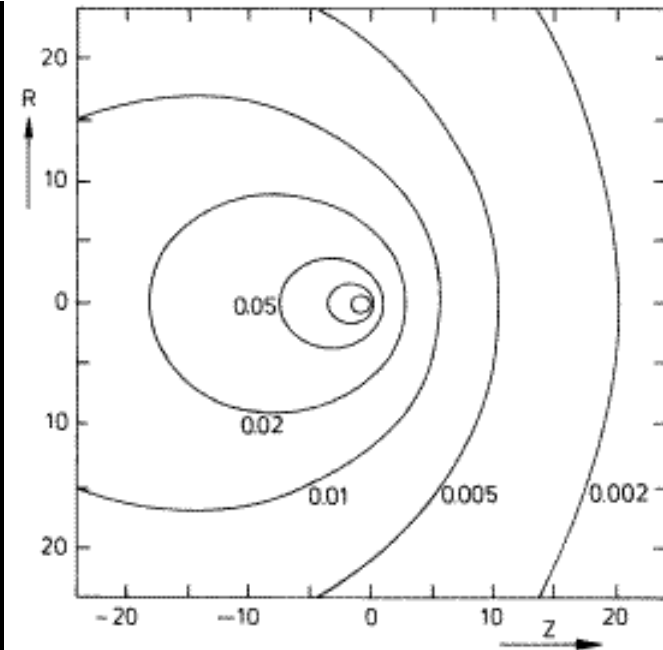
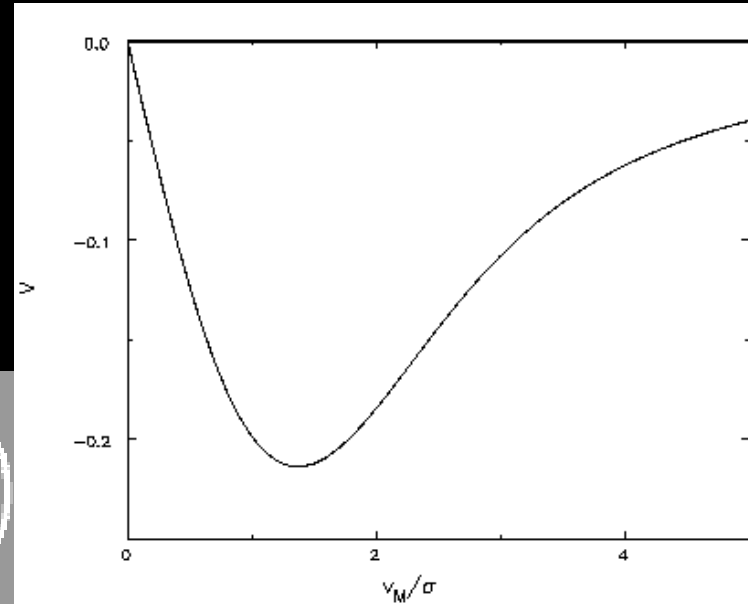
- Dynamical friction
- Numerical issues
- Constraint on halo density

Chandrasekhar Friction

- Chandrasekhar's formula

$$a_M(v_M) = 4\pi \ln \Lambda G^2 \frac{M\rho}{\sigma^2} V \left(\frac{v_M}{\sigma} \right)$$

describes a massive perturber moving through an infinite background of non-interacting particles

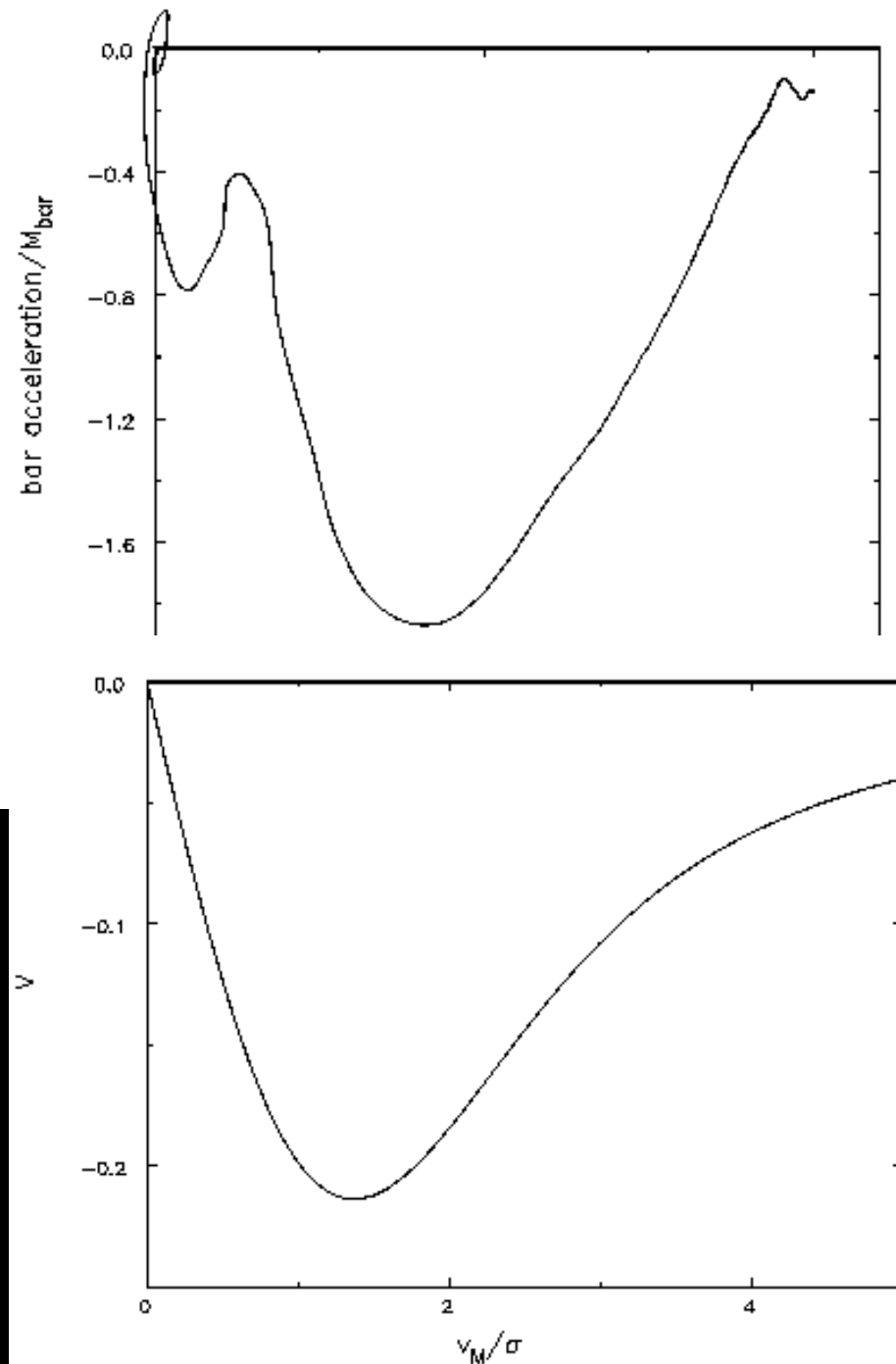


A bar rotating in a halo

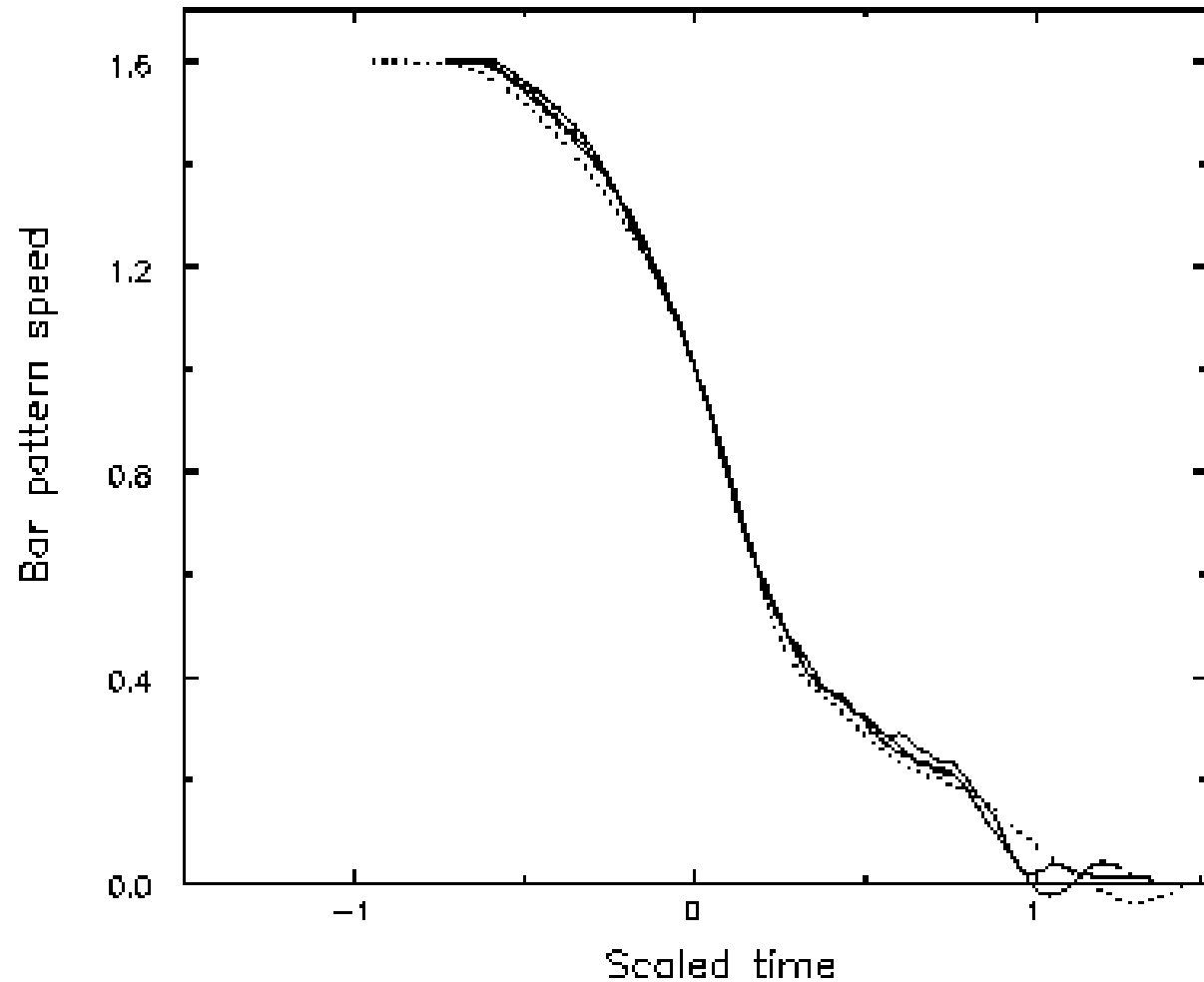
- More interesting problem
 - ◆ Particles in finite halos interact with the bar repeatedly giving rise to resonances (Tremaine & Weinberg)
 - ◆ Formula strictly invalidated
 - ◆ But we still find a similar scaling!

Simple experiments

- Non-interacting particles
- Cuspy (Hernquist) potential well
- Stirred with a rigid bar which slows through loss of angular momentum
- Smooth curve
- High Omega unrealistic

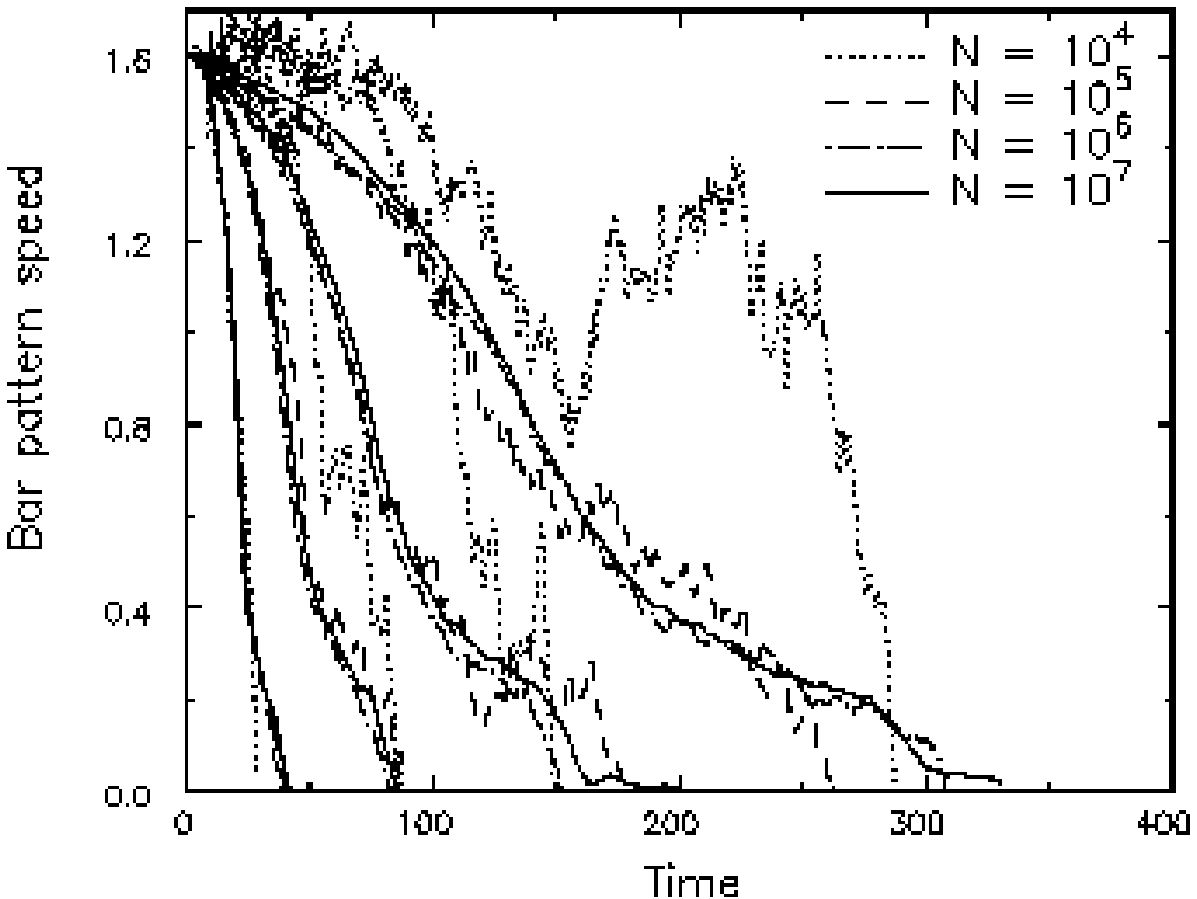


Mass scaling



- Time axis scaled by bar mass
- ✓ Deceleration proportional to mass

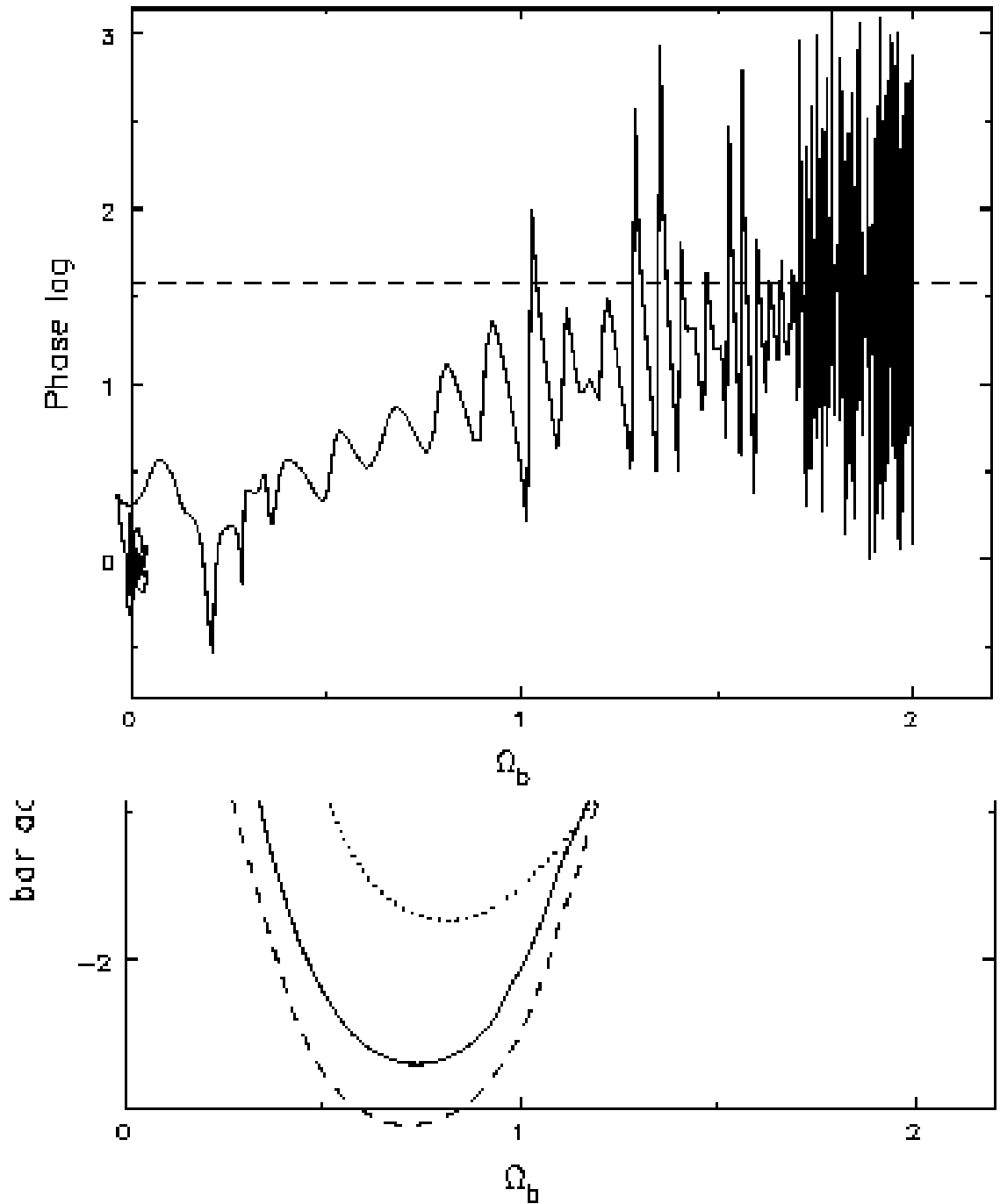
N-dependence



- Tests only for density in phase space
- Self-gravity ignored – no collisional relaxation

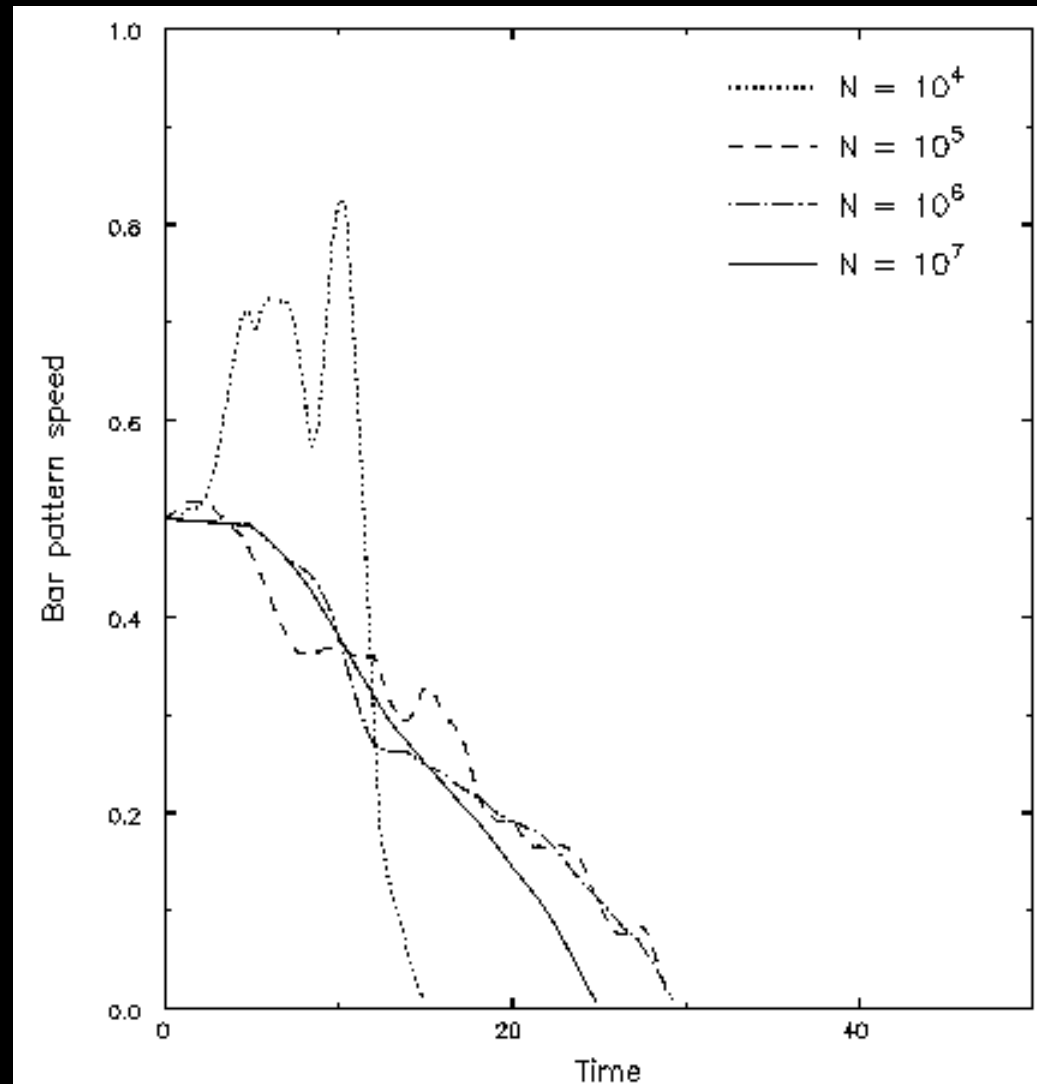
Effect of self

- Solid curve: quadrupole field of halo only
- Dotted curve: no self-G at all
- Dashed curve: full self-G



N-dependence with self-gravity

- Full self-G of halo but still an imposed bar
- Relaxation now possible
- Realistic initial Omega



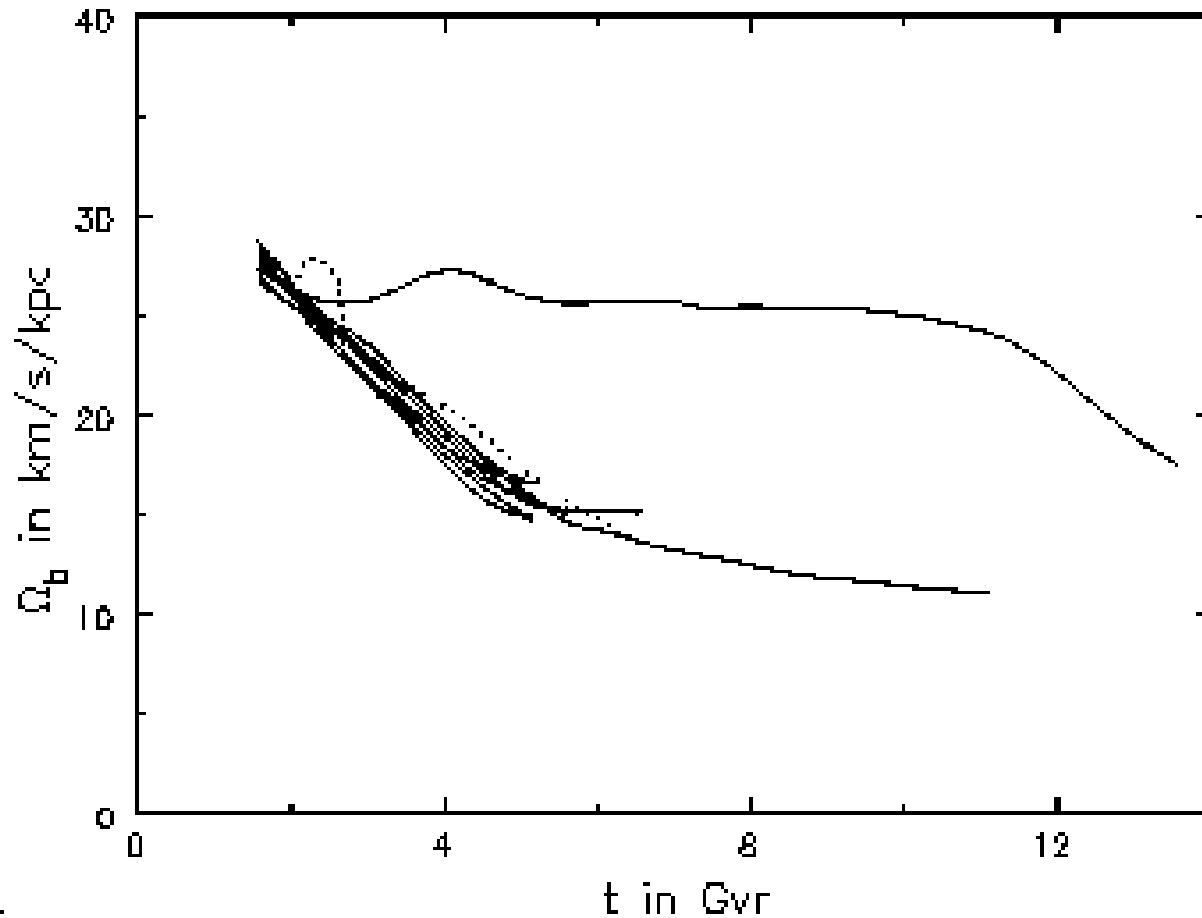
Fully self-consistent models

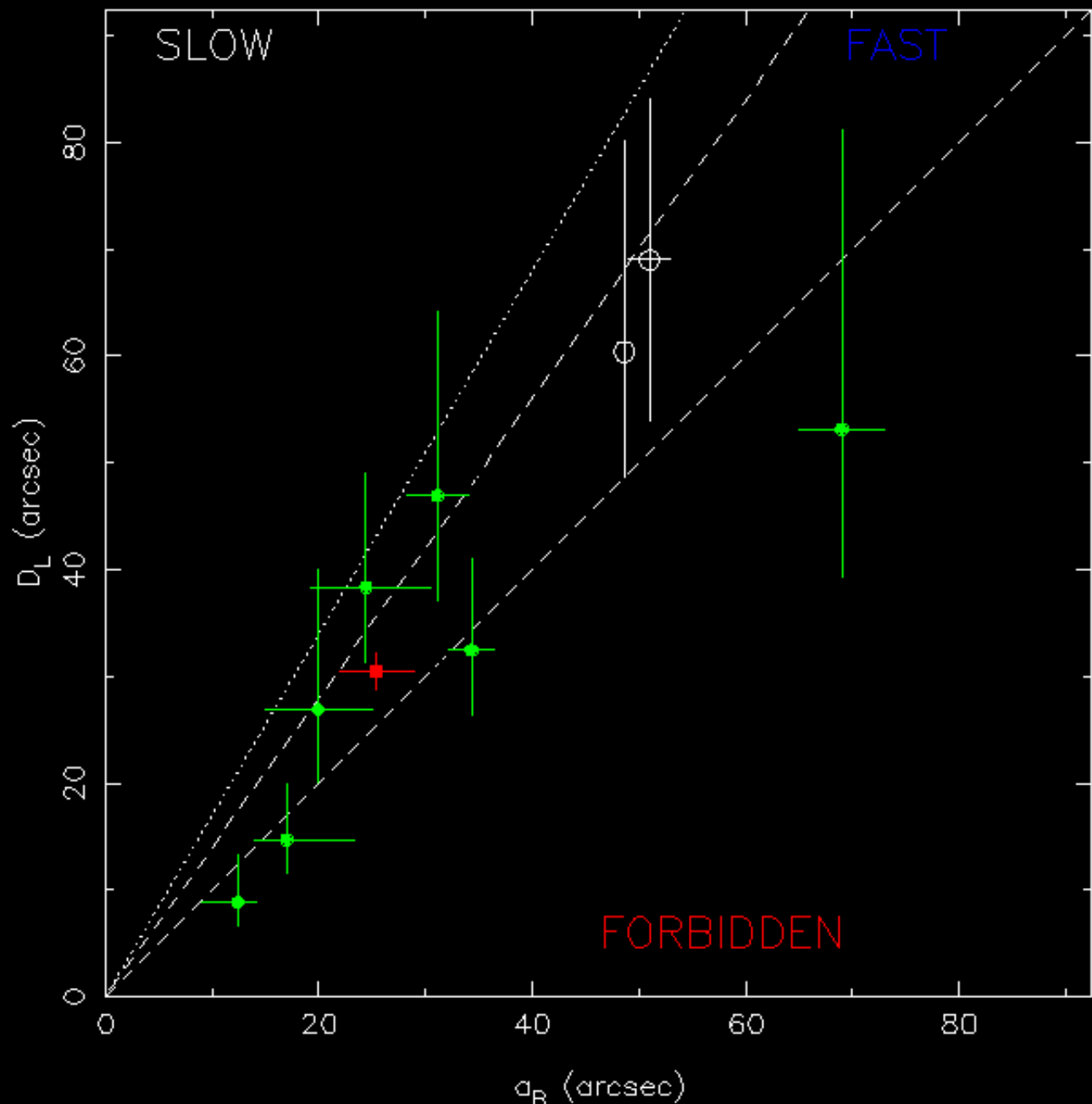
- Bars made of mobile particles
- General agreement:

A strong bar rotating in a dense halo cannot stay fast

Numerical artifact

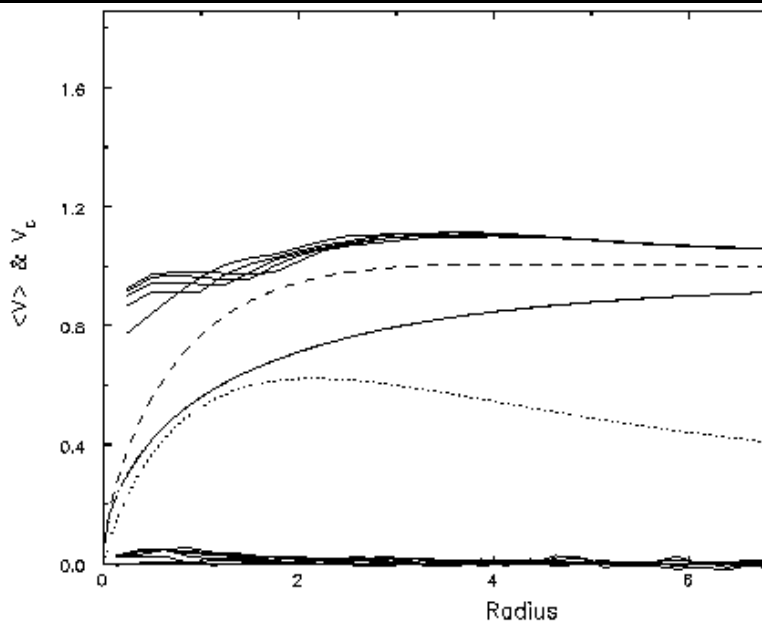
- Rerun of Valenzuela & Klypin's model A₁



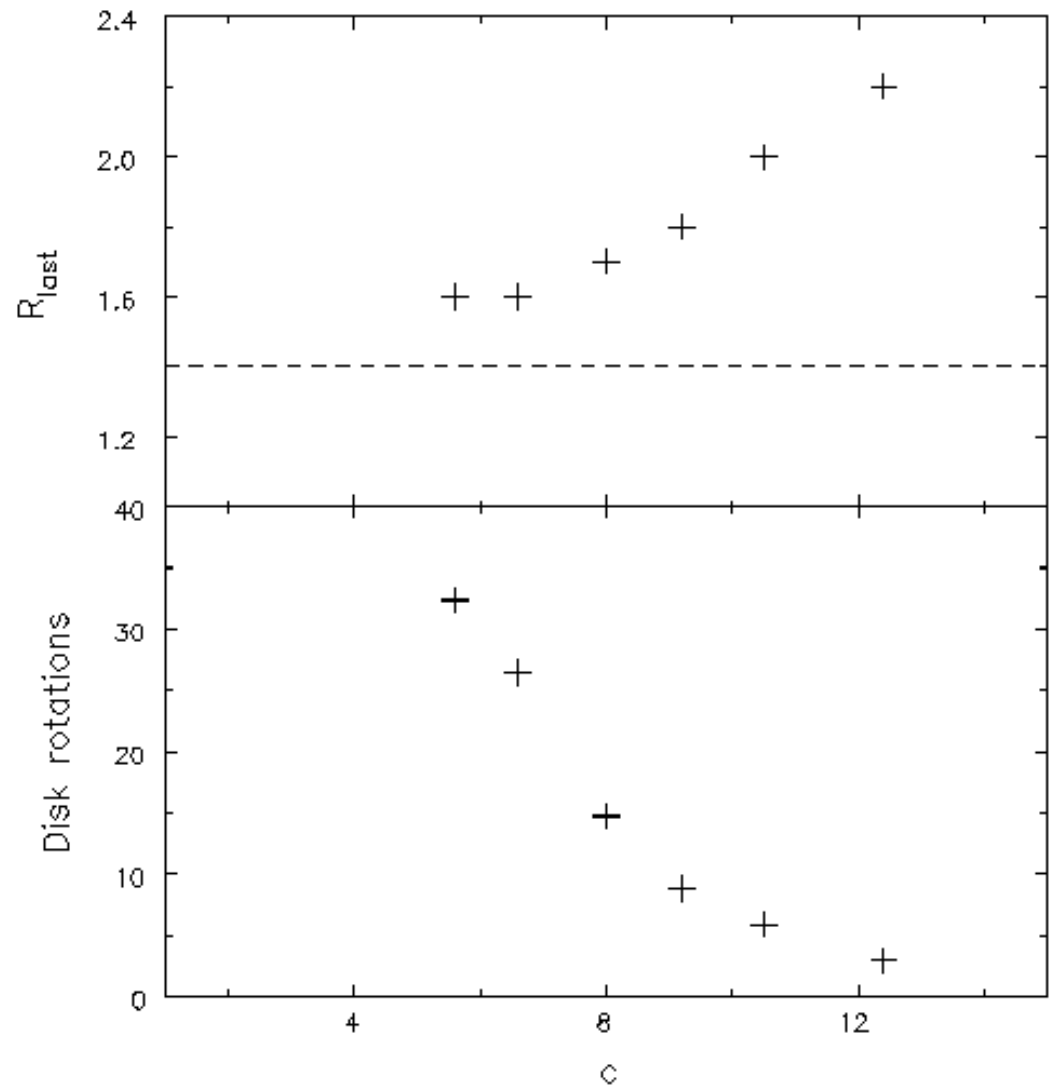


< 1.4

Friction constraint on NFW concentration



- Find $c < 6$ if bars are to stay fast for half a Hubble time



Conclusions

- Friction scales as Chandrasekhar's formula predicts
 - ◆ modified only slightly by resonances
 - ◆ and by self-gravity
- Numerical techniques are generally adequate
 - ◆ Must remain alert for artifacts (rare)
- Everyone agrees that strong bars cannot stay fast in dense halos
- If halos are NFW, then $c < 6$ for fast bars to survive