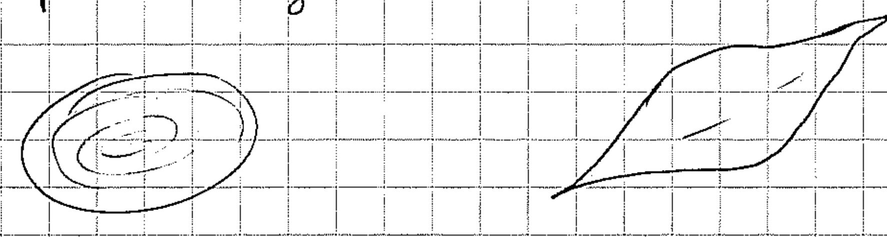
ASTR 333/433 continued – 2nd half of semester

Early Type Galaxies

Elliptical & S∅ galaxies



Mostly 3D elliptical blobs where
pressure support is important.
S∅s have a feeble disk component (not star-forming)
often hard to distinguish from Es.

Range of Hubble types E∅, 1 ... 7
a combination of intrinsic ellipticity $\mathcal{E}$
and projection effects (major axis rarely in plane of sky)

Unlike spiral galaxies, Ellipticals are a
natural result of hierarchical galaxy merging.
Most stars formed early (old pops)
either in-situ or in smaller fragments
that subsequently merged ("dry mergers")
→ no gas to make new stars in merger

Anisotropy parameter

In general, orbits of stars in pressure supported systems need not be isotropic, i.e. ($\sigma_{l.o.s.} \neq \sigma_{max}$)
σ is different in different directions
σ_r, $\sigma_t = \sigma_\theta = \sigma_\phi$ radial & tangential

In general

$$M(r) = \frac{r\sigma_r^2}{G}(\gamma_* + \gamma_\sigma - 2\beta)$$

where $\gamma_* = -\frac{d\ln n_*}{d\ln r}$ logarithmic slope of stellar density profile (measurable

$\gamma_\sigma = -\frac{d\ln \sigma_r^2}{d\ln r}$ logarithmic slope of $\sigma_r^2(r)$ [radial, not l.o.s]

$\beta = 1 - \frac{\sigma_t^2}{\sigma_r^2}$ anisotropy parameter

σ_t = " " " tangential (θ, ϕ) direction
σ_r = velocity dispersion in radial direction within body

extreme cases ~~β...~~

circular orbits $\sigma_r = 0$ $\beta = -\infty$
isotropy $\sigma_r = \sigma_t$ $\beta = 0$ — implicitly assumed in most virial estimates: $\sigma_{los} = \sigma_r = \sigma_t$
radial $\sigma_t = 0$ $\beta = 1$

more generally, $\beta < 0$ "tangential" bias
$\beta > 0$ "radial" bias

β can vary with r. This is the biggest systematic uncertainty in mass modeling elliptical galaxies

2 things happen during disk formation
to alter DM halos

Adiabatic contraction (see Keynote slides)

As baryons dissipate, they sink to the center of the potential well and drag some DM with them. If the process is gradual enough, this contraction can be modeled as adiabatic.
[This approximation appears to be better than it "should" be even in hierarchical simulations - Cho et al]

DM becomes denser in center, fluffier further out.

Details matter. Most commonly used "Blumenthal" algorithm is WRONG

Feedback

Fresh energy input by sources formed in the galaxy can, in principle, somewhat counteract compression by putting energy into the surroundings. Gas is heated and perhaps expelled, perhaps dragging dark matter with it.

Important energy sources:

BIG galaxies - AGN thought to matter at high mass end
SMALL galaxies { - SN " " " " low " "
- stellar winds "

Feedback is invoked in a hand-waving way to solve many problems