Mass-Luminosity relationships

- Faber-Jackson relation: $L_e \sim \sigma_0^4$
- D_n - σ_0 correlation.
  - D_n = diameter within which <I> = 20.75 μ_B
- Fundamental plane in log R_e, $\langle I \rangle_e$, log σ_0 space
  - R_e = scale factor in $R^{1/4}$ law
  - $\langle I \rangle_e$ = mean surface brightness within R_e *Different from I_e !*
  - *Intro. to Principle Component Analysis*: astro-ph/9905079

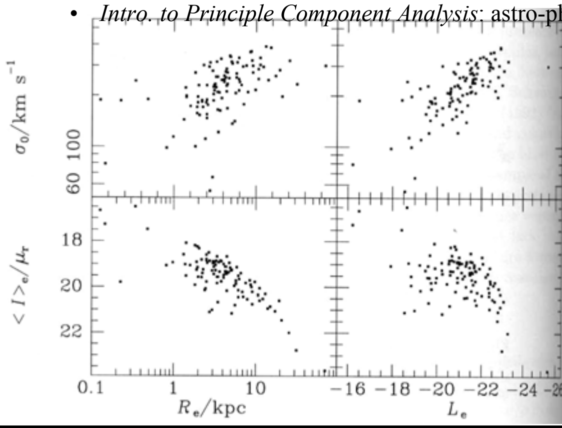
$$I(R) = I_e 10^{-3.33\left[\left(\frac{R}{R_e}\right)^{1/4} - 1\right]}$$

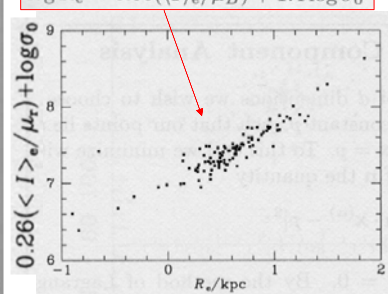
CO give different coefficients???

$$r_e \propto \sigma_0^{1.24} I_e^{-0.82}$$

$$L \propto \sigma_0^{2.65} r_e^{0.65}$$

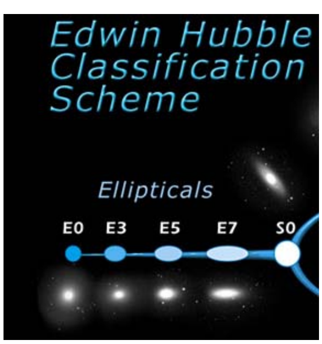
$$\log R_e = 0.36(\langle I \rangle_e / \mu_B) + 1.4 \log \sigma_0$$

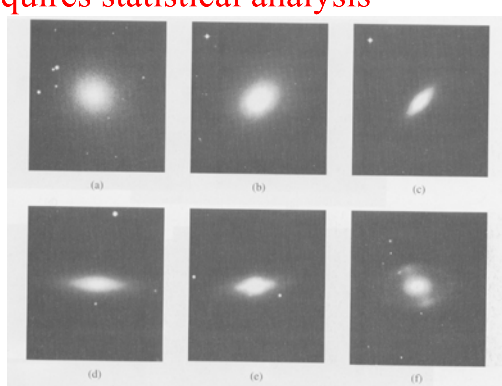




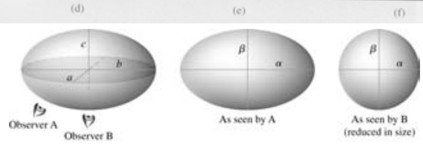
From Binney & Merrifield, *Galactic Astronomy*

True shapes requires statistical analysis

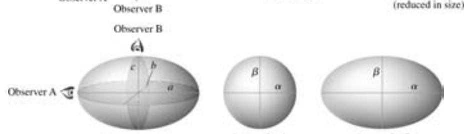




- *Oblate* = pancakes



- *Prolate* = footballs



True shapes requires statistical analysis

- Lower luminosity ➔ rotationally supported
  - $(V_{rot} / \sigma) \sim \sqrt{\epsilon/(1-\epsilon)}$
- Higher L ➔ pressure supported
  - $(V_{rot} / \sigma) << 1$

CO pgs. 988-989

Curve expected for galaxies that are flattened by rotation (i.e. have isotropic random velocity dispersions)

• = low L ellipticals
x = spiral bulges

high L ellipticals

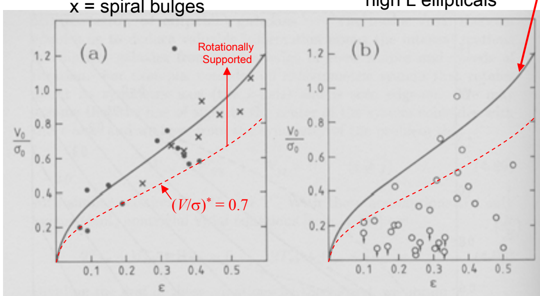
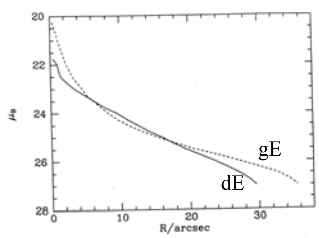


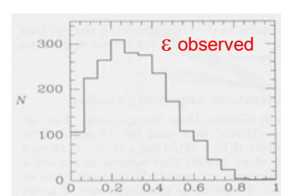
Figure 4-6. (a) The positions in the $(v/\sigma, \epsilon)$ plane of elliptical galaxies (dots), and of spheroids (crosses), that have luminosities smaller than $L = 2.5 \times 10^{10} L_\odot$. (b) The same as (a) but for elliptical galaxies brighter than $L = 2.5 \times 10^{10} L_\odot$. (After Davies et al. 1983.)

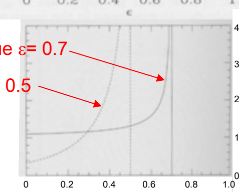
From Binney & Tremaine, *Galactic Dynamics*

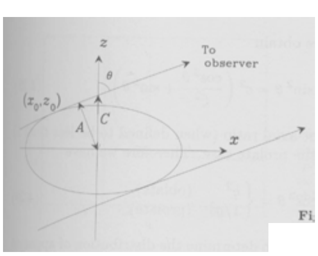


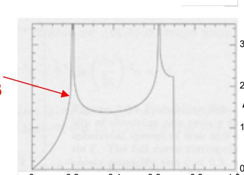
Statistics of ε = (1-b/a)

- Oblate, prolate spheroids can't fit the observed distribution.
  - Summing over wide range of true values of ε would fill in the dip at $\epsilon_{obs} = 0$.
- Triaxial spheroids can fit.
  - Nearly oblate triaxial spheroids seem best.









From Binney & Merrifield, *Galactic Astronomy*

Other evidence for triaxial systems

- Isophotal twists
- Kinematics (star motions)

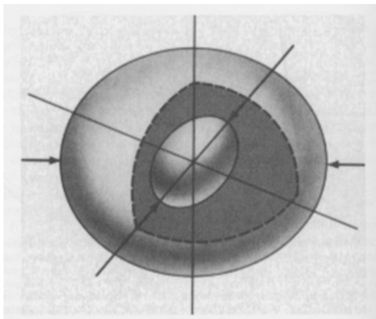
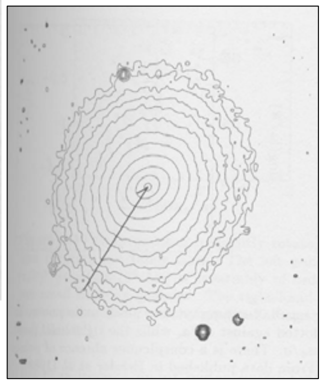


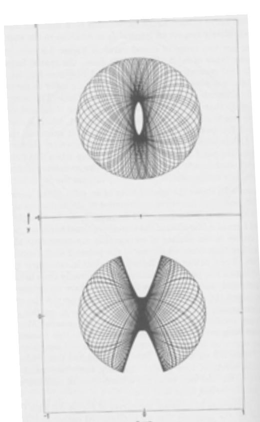
Figure 4.24 Isophotal twist as a consequence of triaxiality. Two concentric, coaxial ellipsoids are shown. The dashed lines mark the intersections of the ellipsoids with the coordinate planes, while the solid lines show their outlines to the observer. The arrows mark the directions of their apparent principal axes.



From Binney & Merrifield, *Galactic Astronomy*

Orbits in E galaxies

- Some families of non-closed orbits in a mildly triaxial potential.



3.4 Orbits in Three-Dimensional Triaxial Potentials 155

From Binney & Tremaine, *Galactic Dynamics*

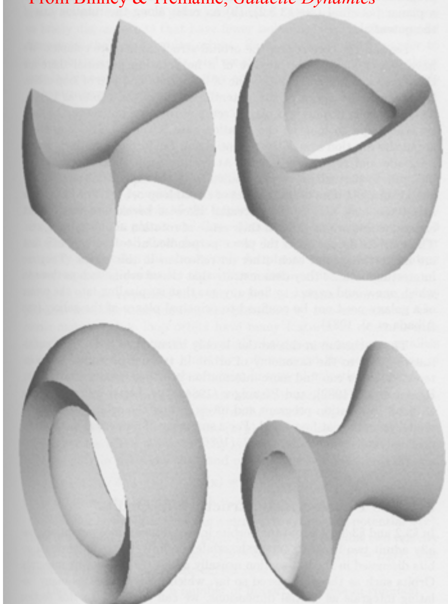
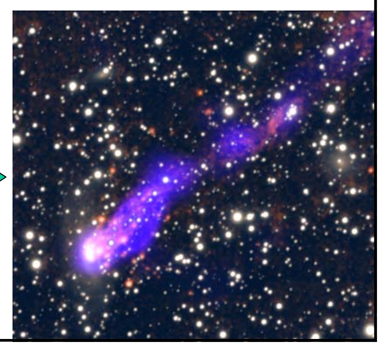


Figure 3-20. Orbits in a nonrotating triaxial potential. Clockwise from top left: (a) box orbit; (b) short-axis tube orbit; (c) inner long-axis tube orbit; (d) outer long-axis tube orbit. [Courtesy of T. Statler; see Statler (1986).]

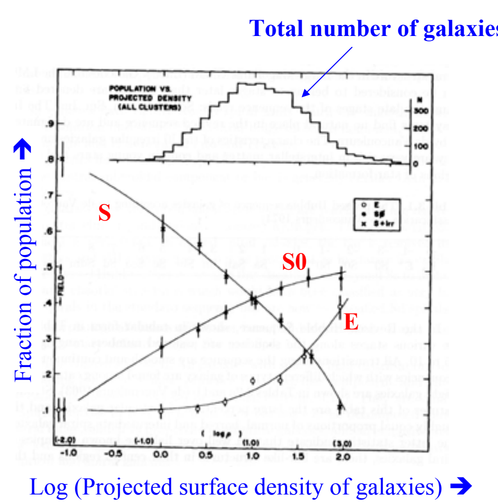
E galaxies are transparent, but 40% still have some dust lanes

- Even if complete star formation at t=0, stars must subsequently have lost gas.
- Detected by:
  - X-rays (Brehmsstrahlung): 10^8-10^{10} $M_\odot$
  - H I emission lines: 10^7-10^9 $M_\odot$
  - H II emission lines: 10^4-10^5 $M_\odot$
- But gas can be lost by
  - Supernova-driven winds
  - Ram pressure stripping



Distribution of galaxy types

- Dense regions (cluster centers) predominantly ellipticals.
- Field galaxies predominantly spirals.
- On average, roughly even split between E and S.



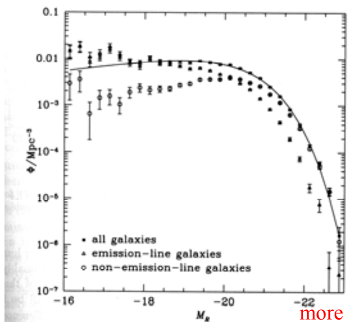
Dressler 1980

Schecter Luminosity Function

$$\phi\,(L)dL = L^{\alpha}\, e^{-L/L_*}\, dL$$

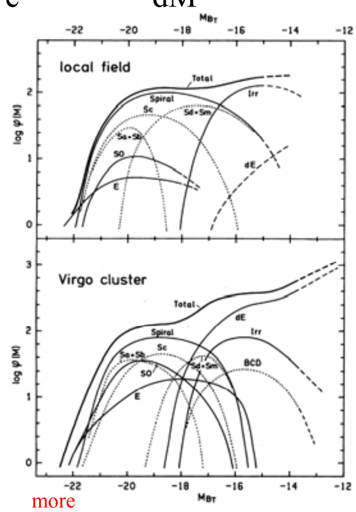
$$\phi(M)dM = 10^{\,-0.4(\alpha+1)M}\, e^{\,-10^{\,0.4(M^* - M)}}\, dM$$

- The Milky Way is an L_* galaxy.



more luminous

[BM 4.12]



more luminous

[CO 25.36]