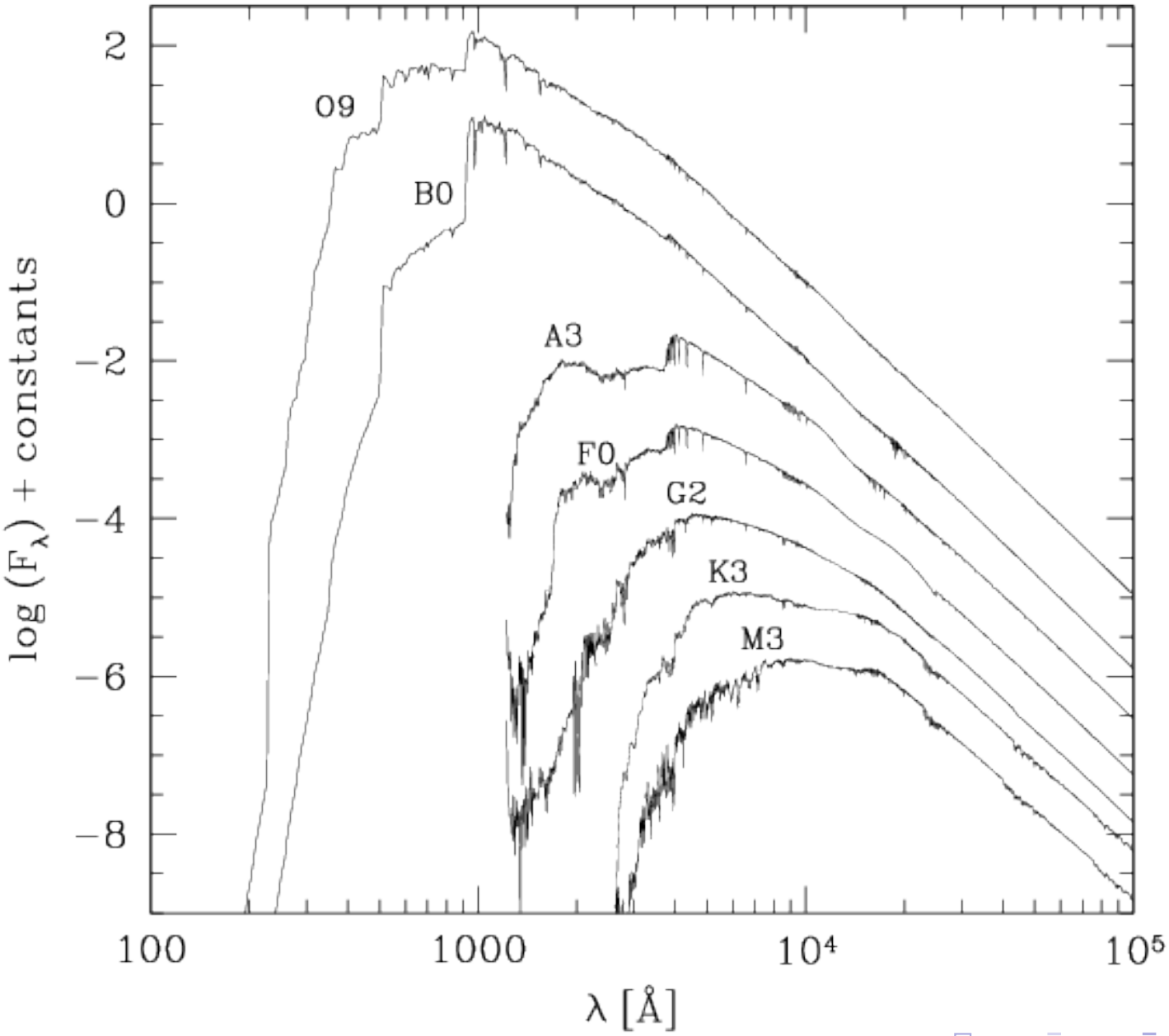
Stars & Galaxies

Stars
Galaxy classification
Galaxy population statistics
Clusters & groups of galaxies
Galaxies at high redshifts

September 8, 2022

University of Rochester

Stellar spectra

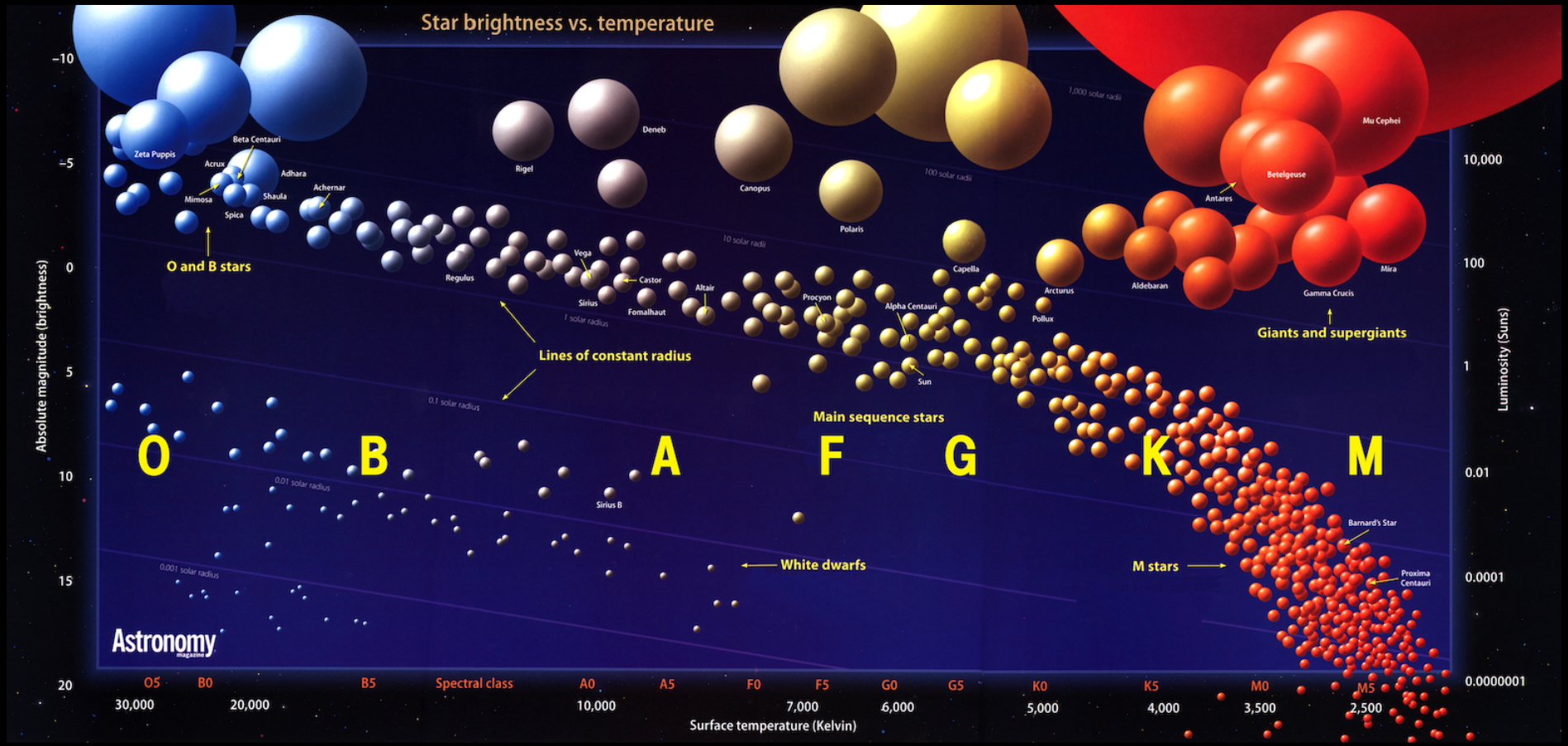


MK stellar spectral and luminosity classes

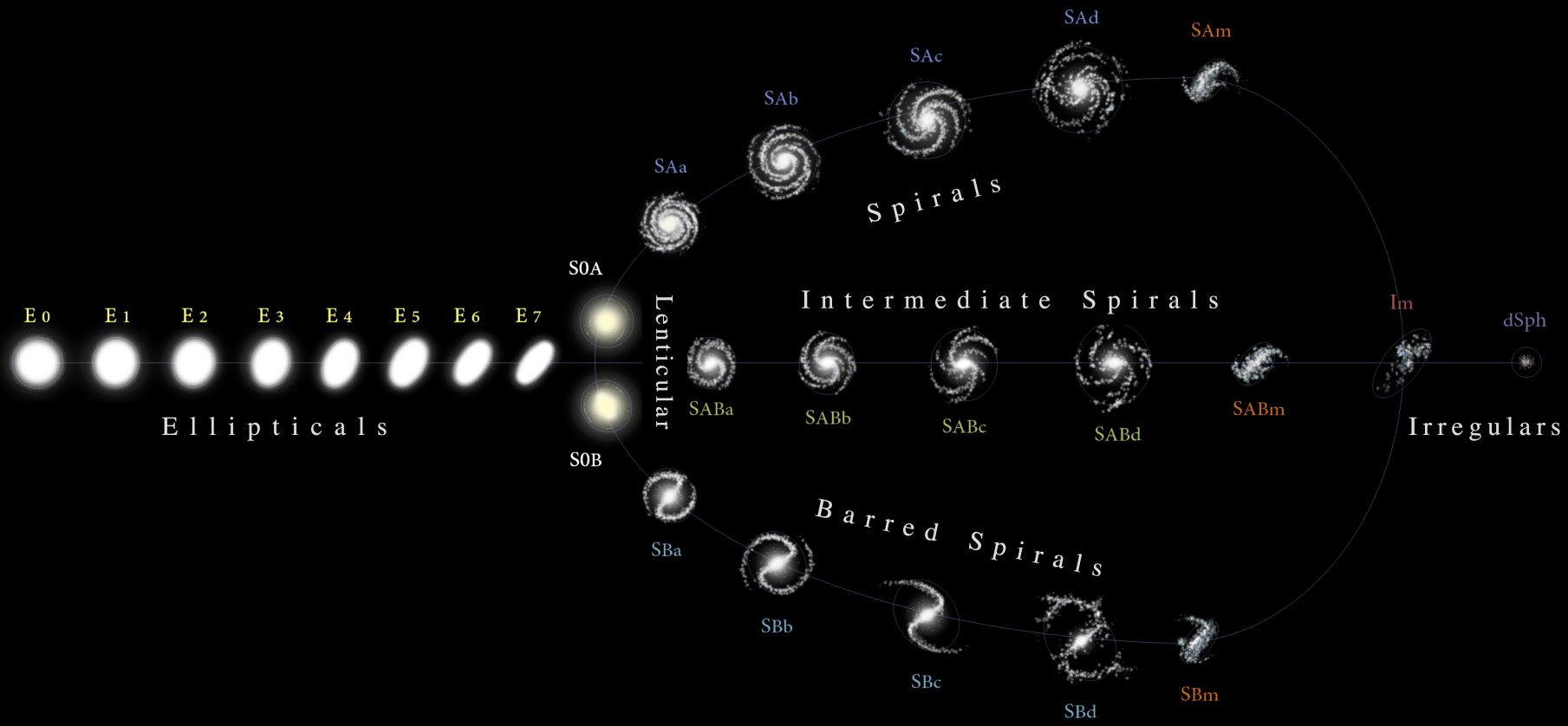
Class	Temperature	Spectral characteristics
O	28,000–50,000 K	Hot stars with He II absorption; strong UV continuum
B	10,000–28,000 K	He I absorption; H developing in late classes
A	7500–10,000 K	Strong H lines for A0, decreasing thereafter; Ca II increasing
F	6000–7500 K	Ca II stronger; H lines weaker; metal lines developing
G	5000–6000 K	Ca II strong; metal lines strong; H lines weaker
K	3500–5000 K	Strong metal lines; CH and CN developing; weak blue continuum
M	2500–3500 K	Very red; TiO bands developing strongly

I	Supergiants
II	Bright giants
III	Normal giants
IV	Subgiants
V	Dwarfs (main sequence stars)

Hertzsprung-Russell diagram

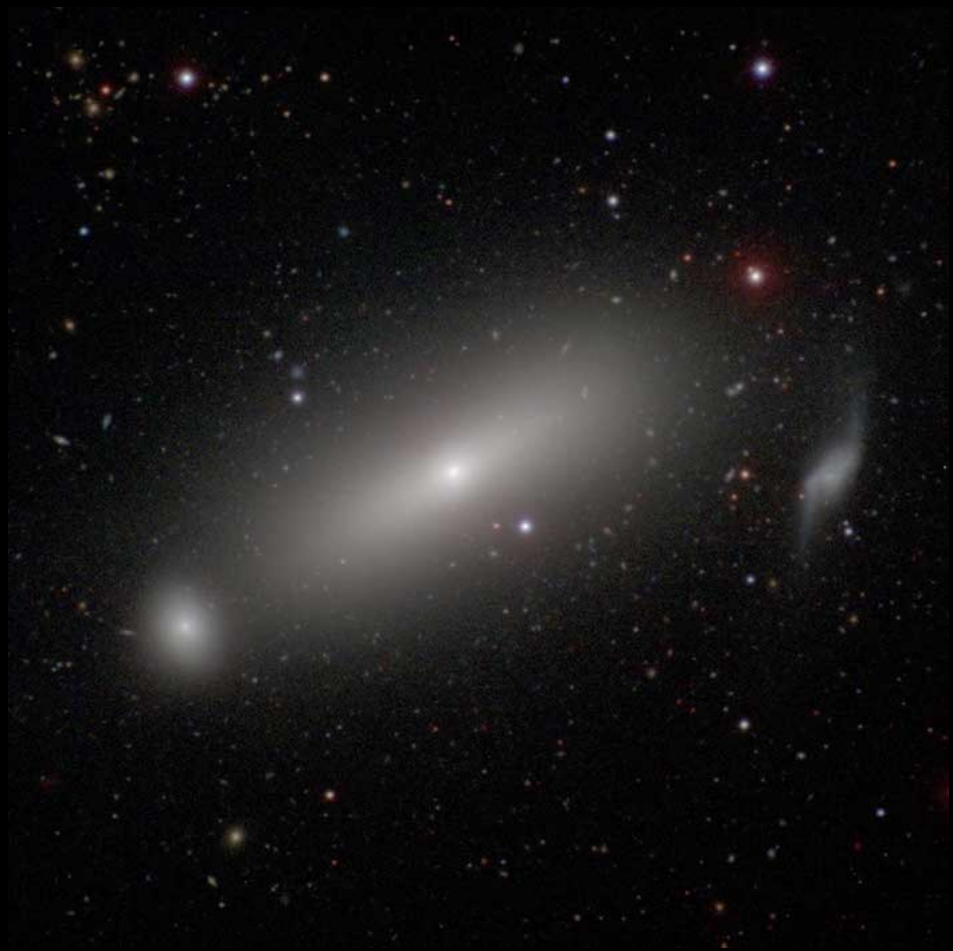


Galaxy classification: the Hubble sequence



Elliptical galaxies

Messier 87 & NGC 1332



Sérsic profile

$$I(R) = I_0 e^{-\beta_n \left(\frac{R}{R_e}\right)^{1/n}} = I_e e^{-\beta_n \left(\left(\frac{R}{R_e}\right)^{1/n} - 1\right)}$$

where

I_0 $\equiv$ central surface brightness

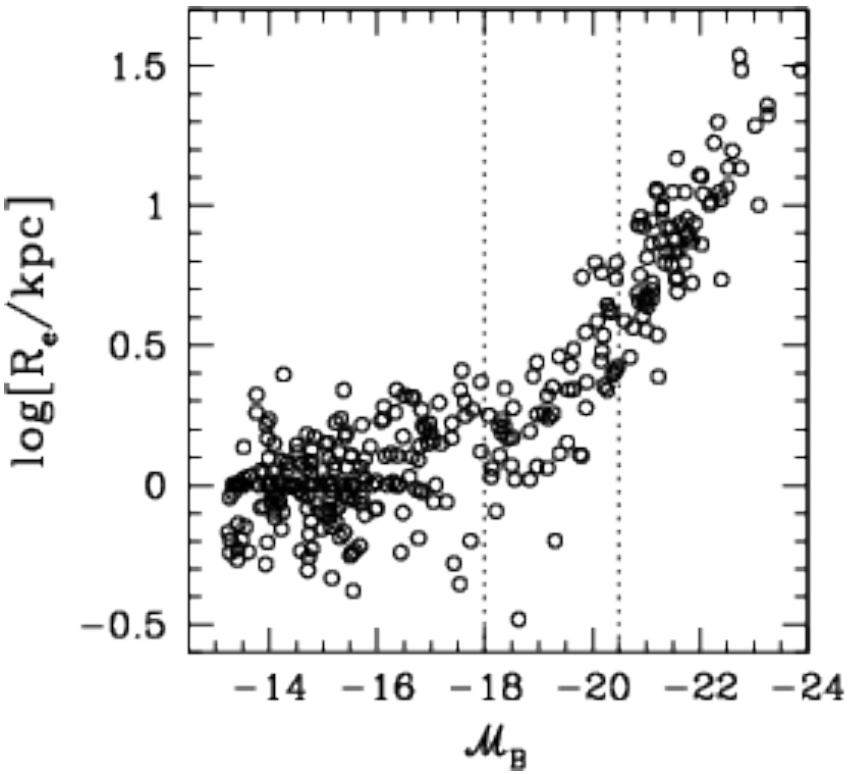
n $\equiv$ Sérsic index

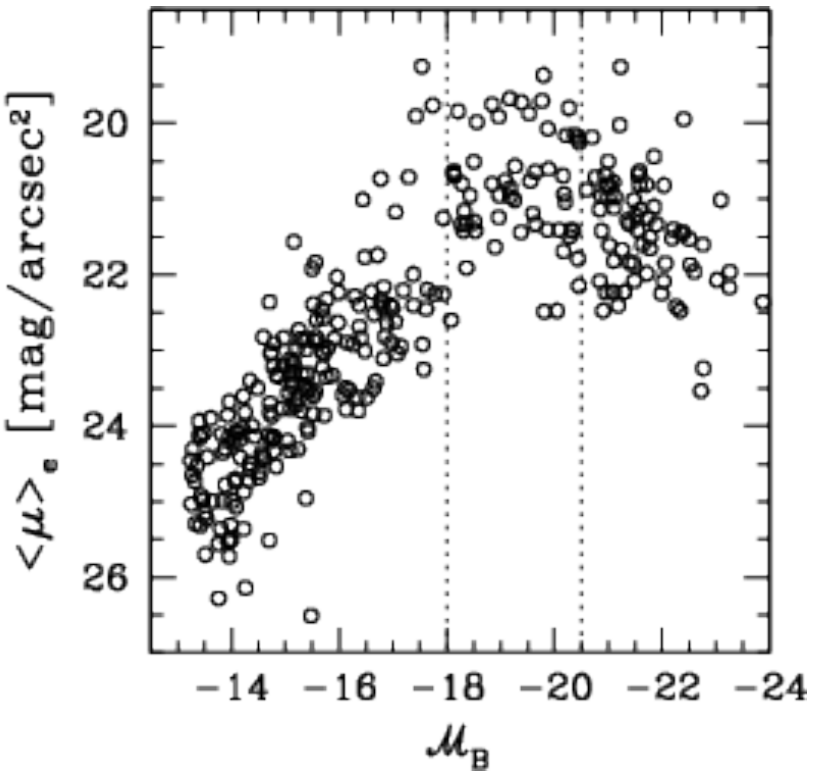
R_e $\equiv$ effective radius enclosing 50% of the total light

I_e $= I(R_e)$

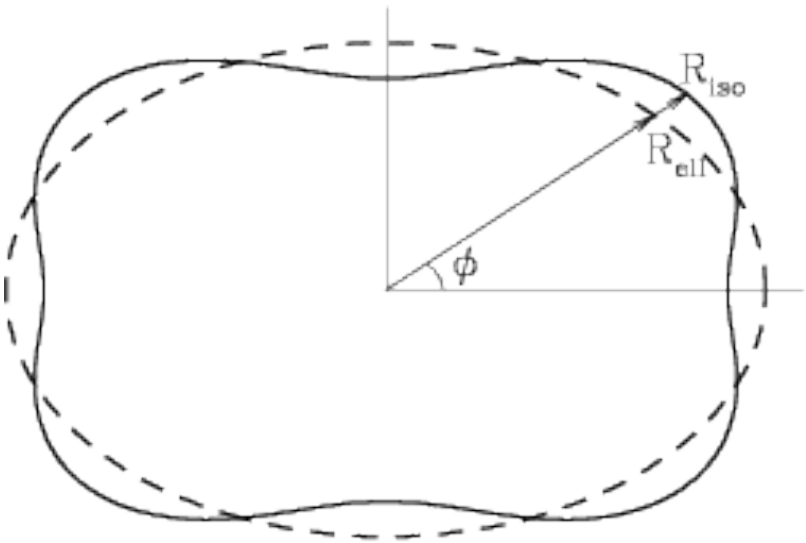
β_n $= 2n - 0.324$ for $n \gtrsim 1$

Elliptical galaxy trends

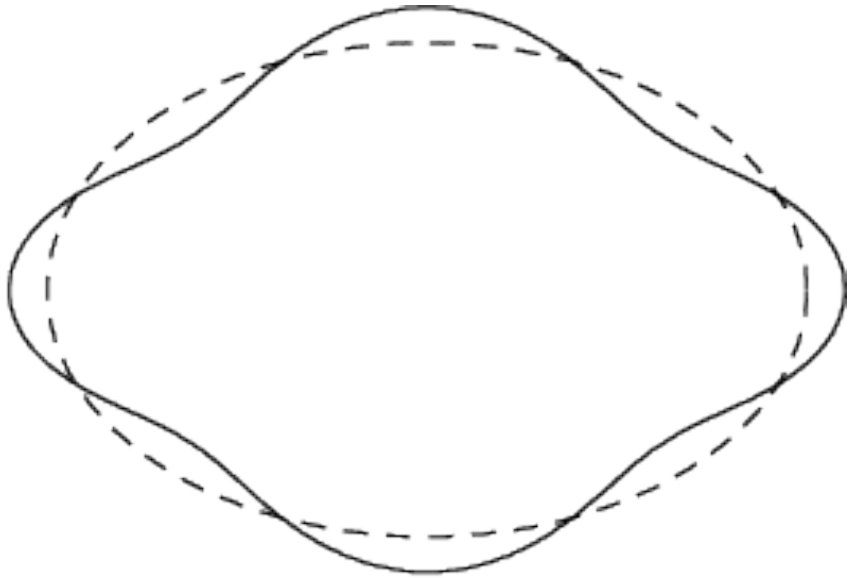




Ellipticity of elliptical galaxies



BOXY



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Kinematics of elliptical galaxies

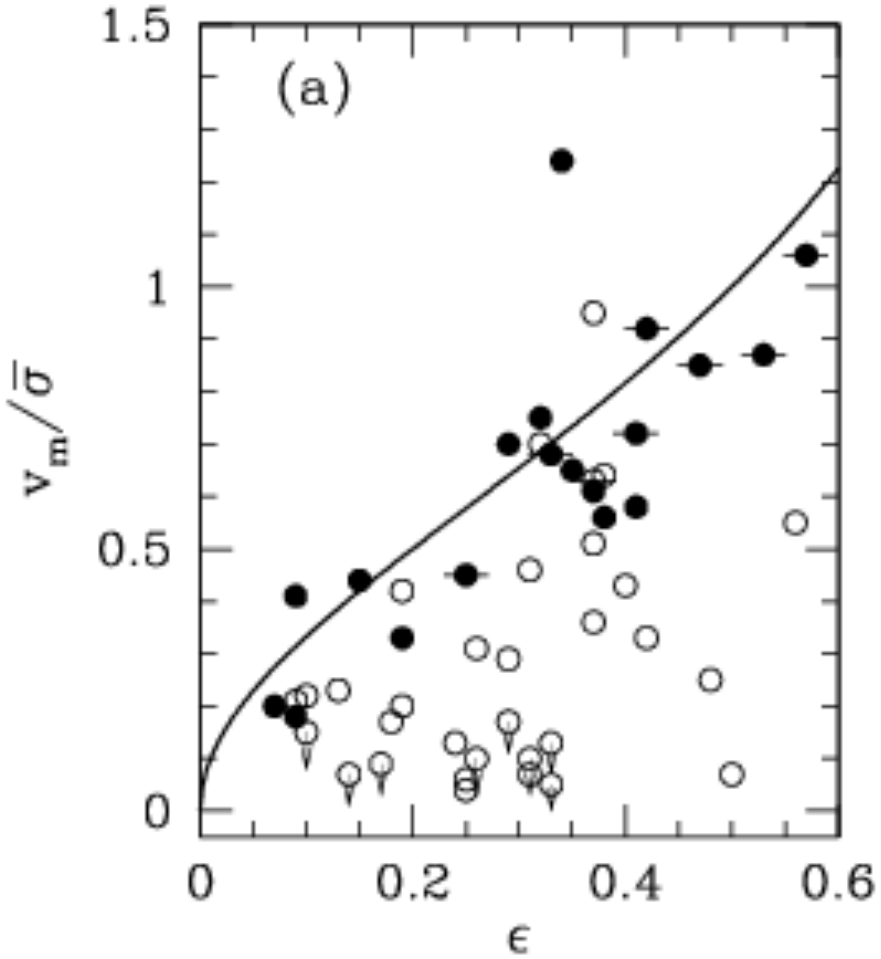
For isotropic, oblate galaxies flattened by the centrifugal force due to rotation,

$$\frac{v_m}{\overline{\sigma}} \approx \sqrt{\frac{\varepsilon}{1-\varepsilon}}$$

where

$v_m \equiv$ maximum relative velocity along the line of sight

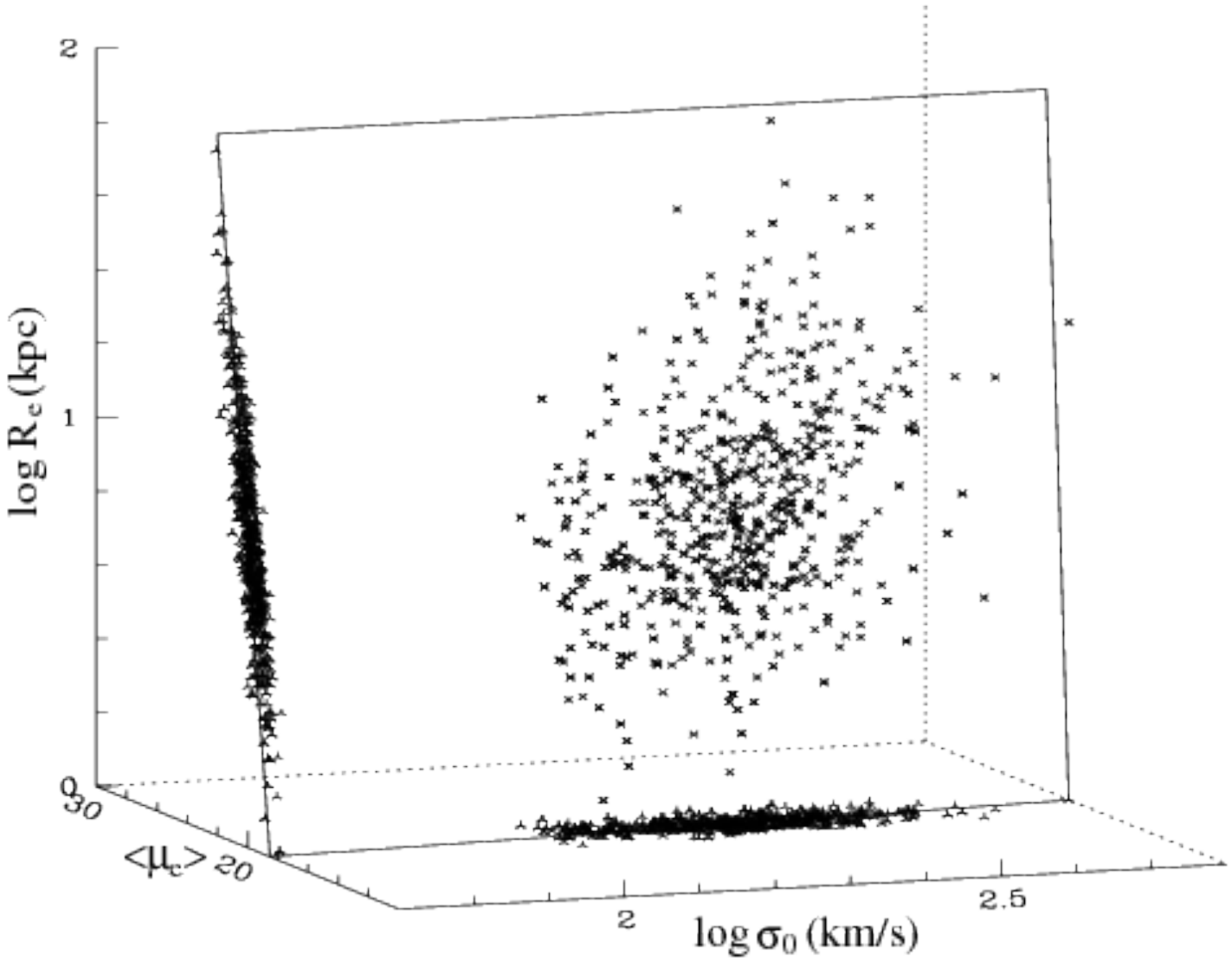
$\overline{\sigma} \equiv$ average line-of-sight velocity dispersion interior to $\sim 0.5 R_e$



Open circles: bright galaxies

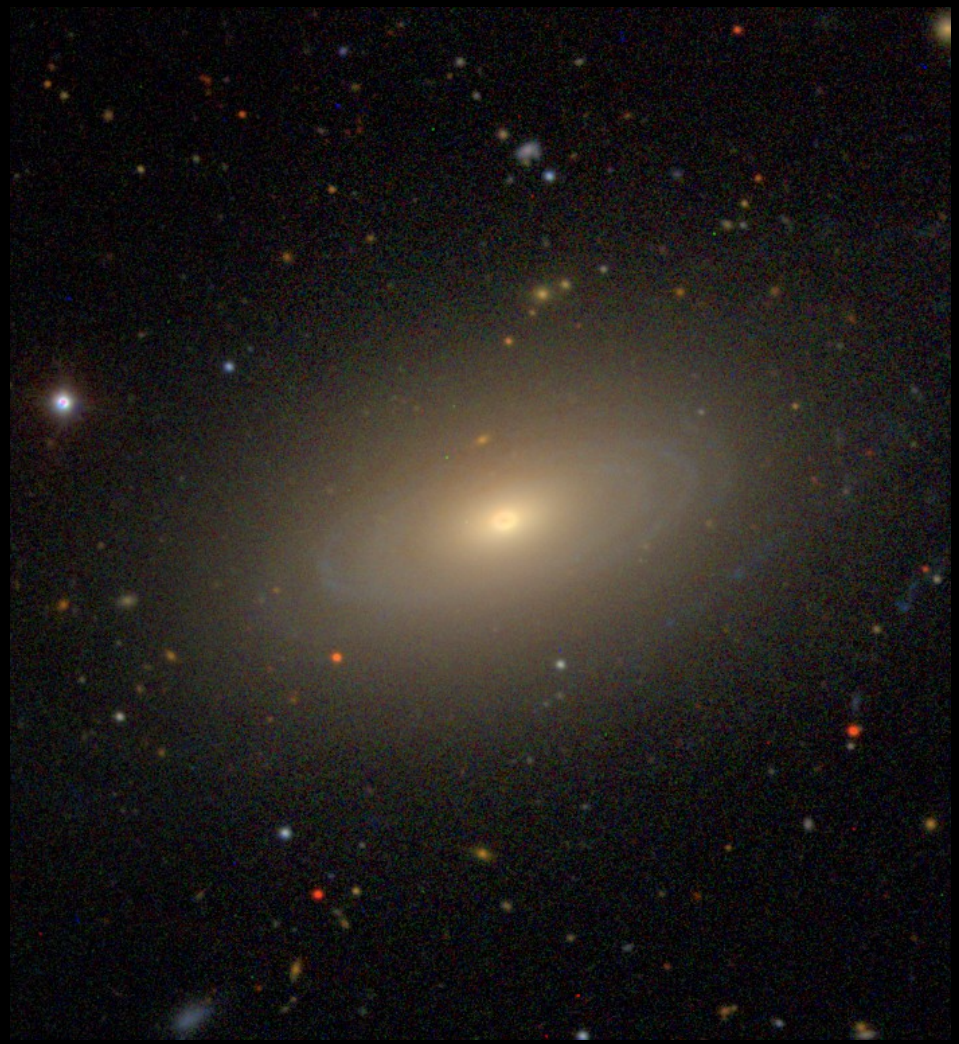
Filled circles: fainter galaxies

Fundamental plane



Spiral galaxies

Messier 74 & NGC 3898



Barred spiral galaxies

NGC 1398 & NGC 1365

Exponential profile

$$I(R) = I_0 e^{-R/R_d}$$

where

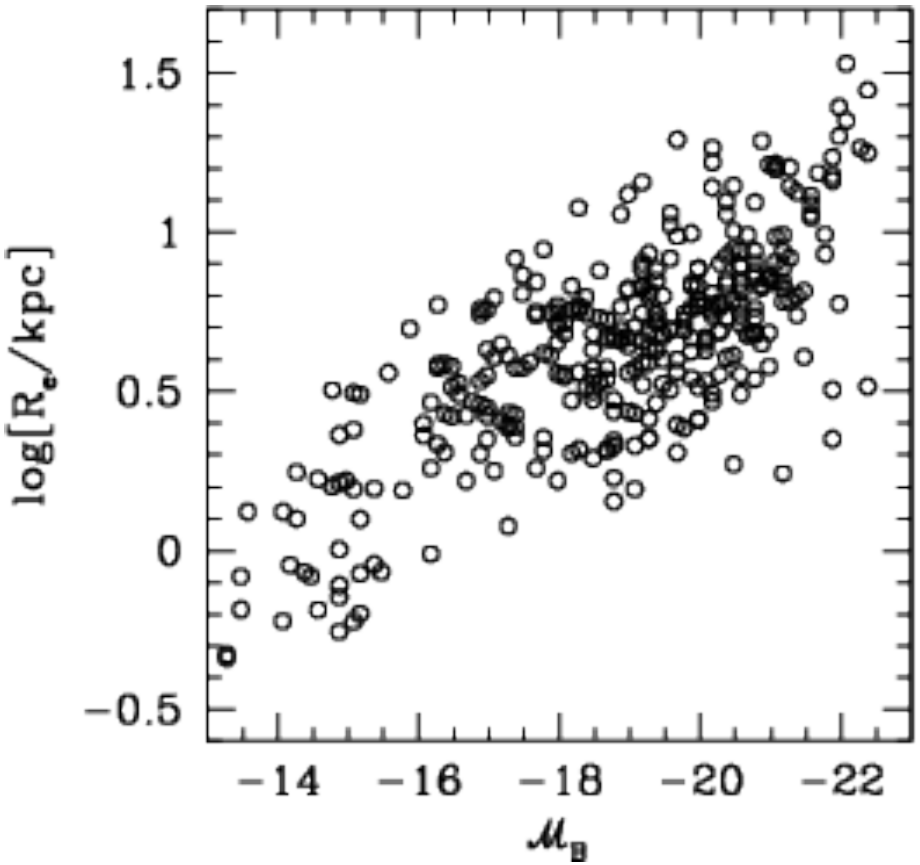
$I_0 = L/2\pi R_d^2$; central luminosity surface density

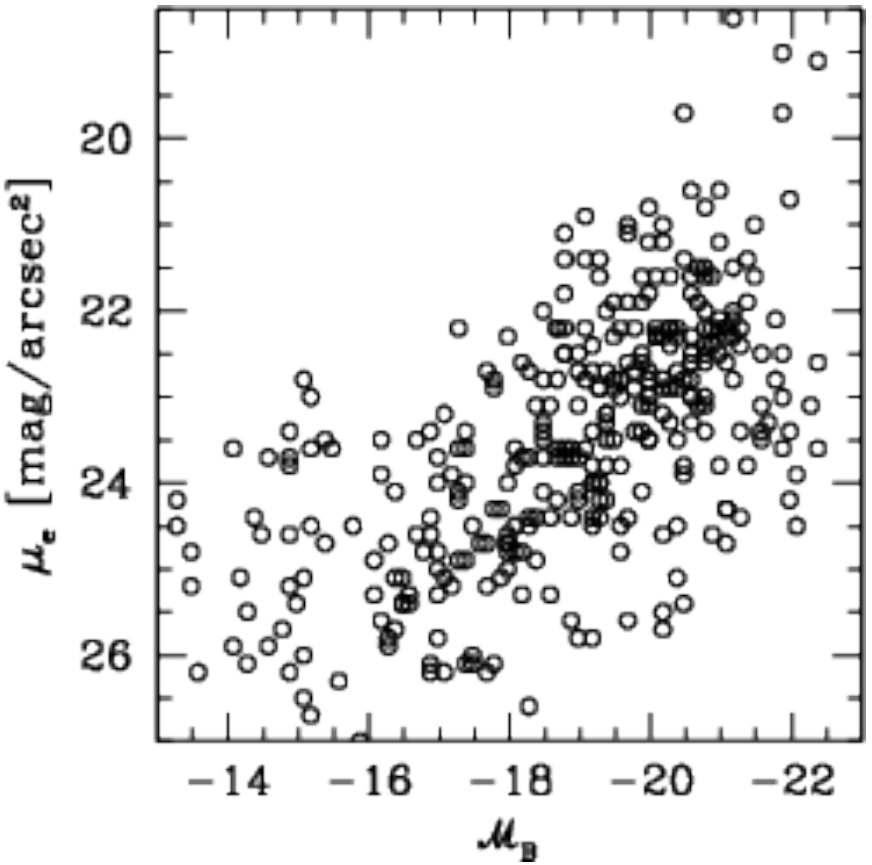
$R \equiv$ cylindrical radius

$R_d \equiv$ exponential scale length

$L \equiv$ total luminosity

Spiral galaxy trends





Vertical luminosity profile

The surface brightness distribution in the vertical direction is independent of the distance from the center.

$$\nu(R,z) = \nu_0 e^{-R/R_d} f(z) \qquad f_n(z) = \mathrm{sech}^{2/n}\left(\frac{n|z|}{2z_d}\right)$$

where

- ν $\equiv$ luminosity density in 3D
- n controls the shape of the profile near $z = 0$ ($n = 1$ corresponds to a self-gravitating isothermal disk)
- z_d $\equiv$ vertical scale height of the disk