Dark Matter

ASTR 333/433
Fall 2013
M T 4:00-5:15pm
Sears 552

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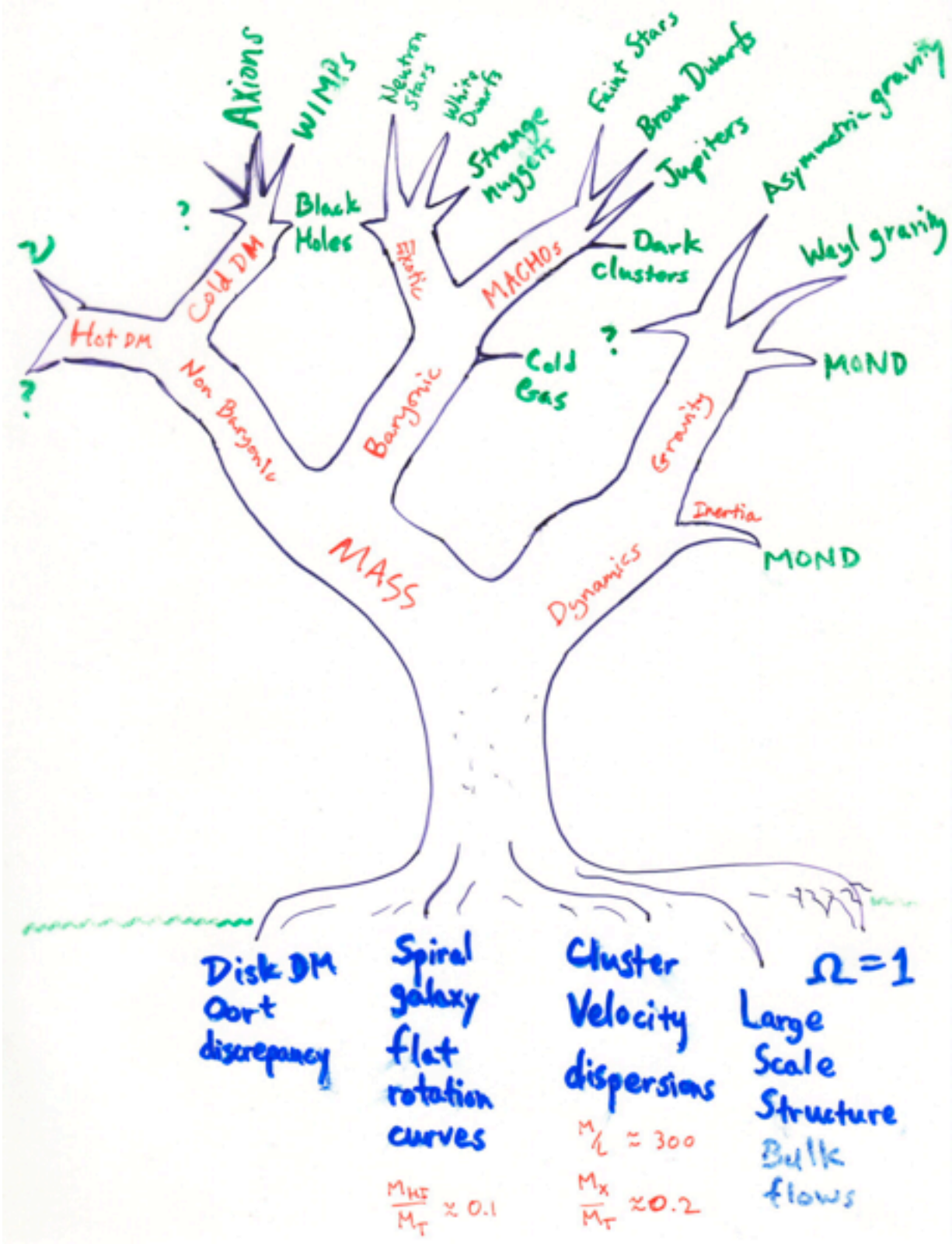
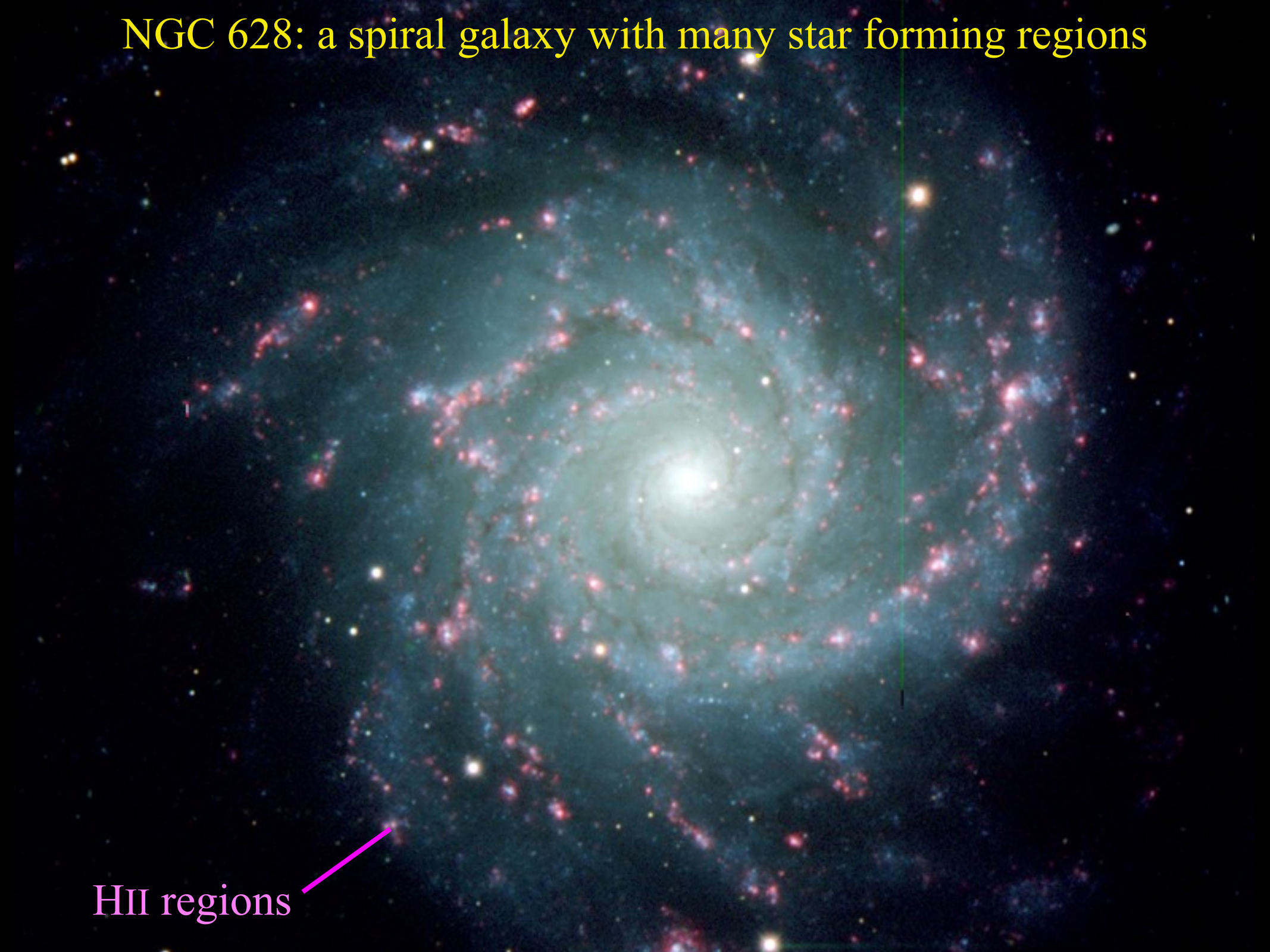


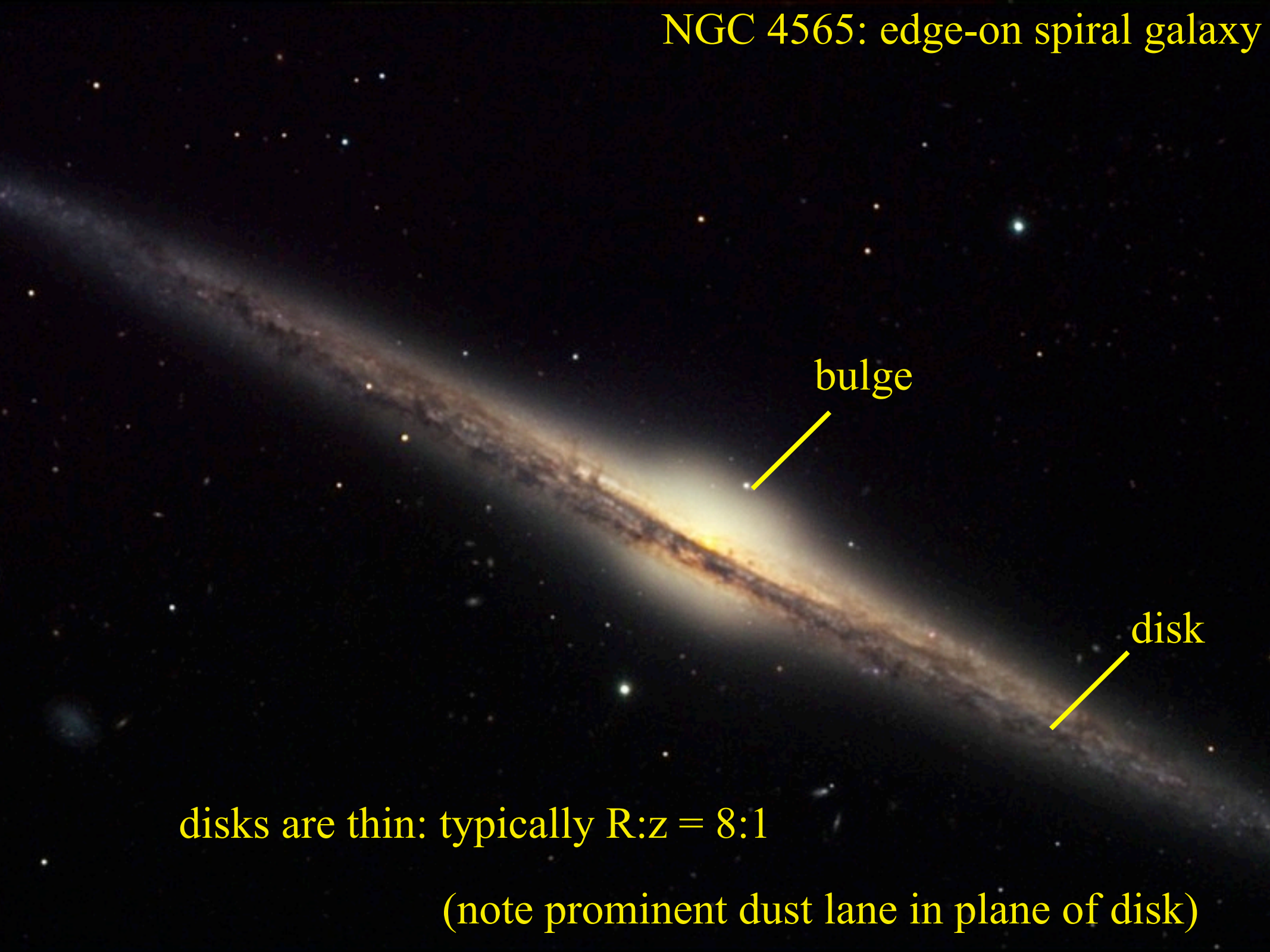
Case Western Reserve University EST. 1826

NGC 6946: a spiral galaxy

NGC 628: a spiral galaxy with many star forming regions



NGC 1300: a barred spiral galaxy


NGC 4565: edge-on spiral galaxy
bulge
disk
disks are thin: typically R:z = 8:1
(note prominent dust lane in plane of disk)

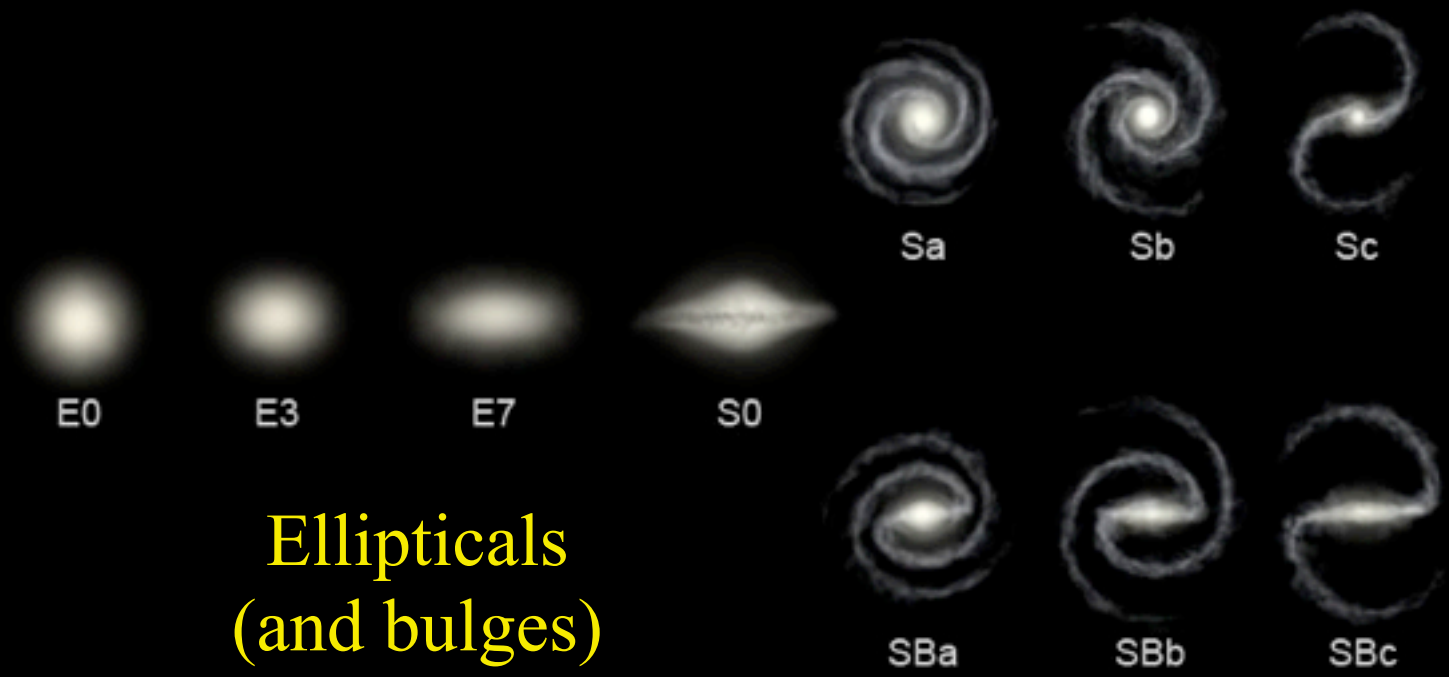
M87: a giant Elliptical galaxy

M87 © Anglo-Australian Observatory
Photo by David Malin

Galaxy Classification
The Hubble Tuning-fork sequence

increasing disk

increasing bulge



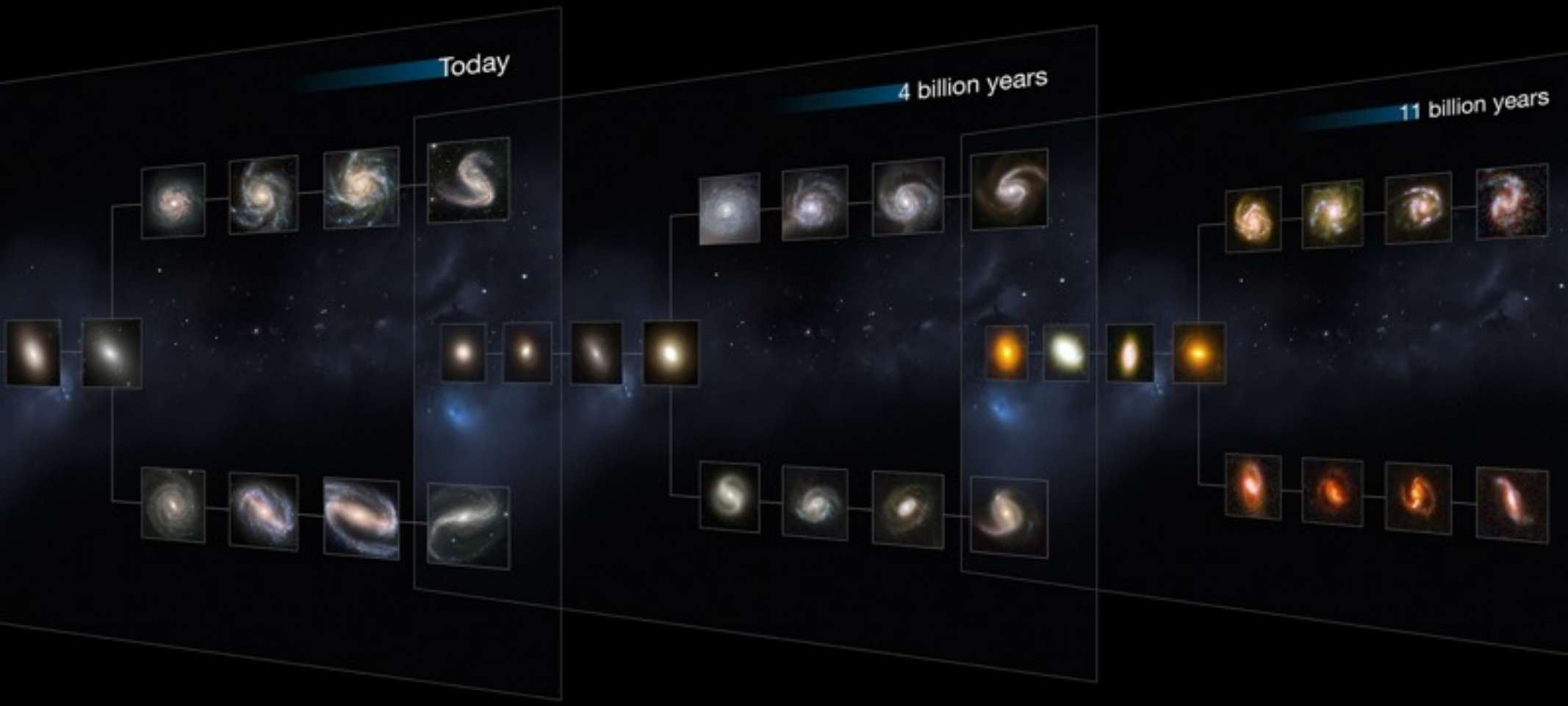
regular spirals

barred spirals

Ellipticals
(and bulges)
3D ellipsoids
pressure support
V/σ small

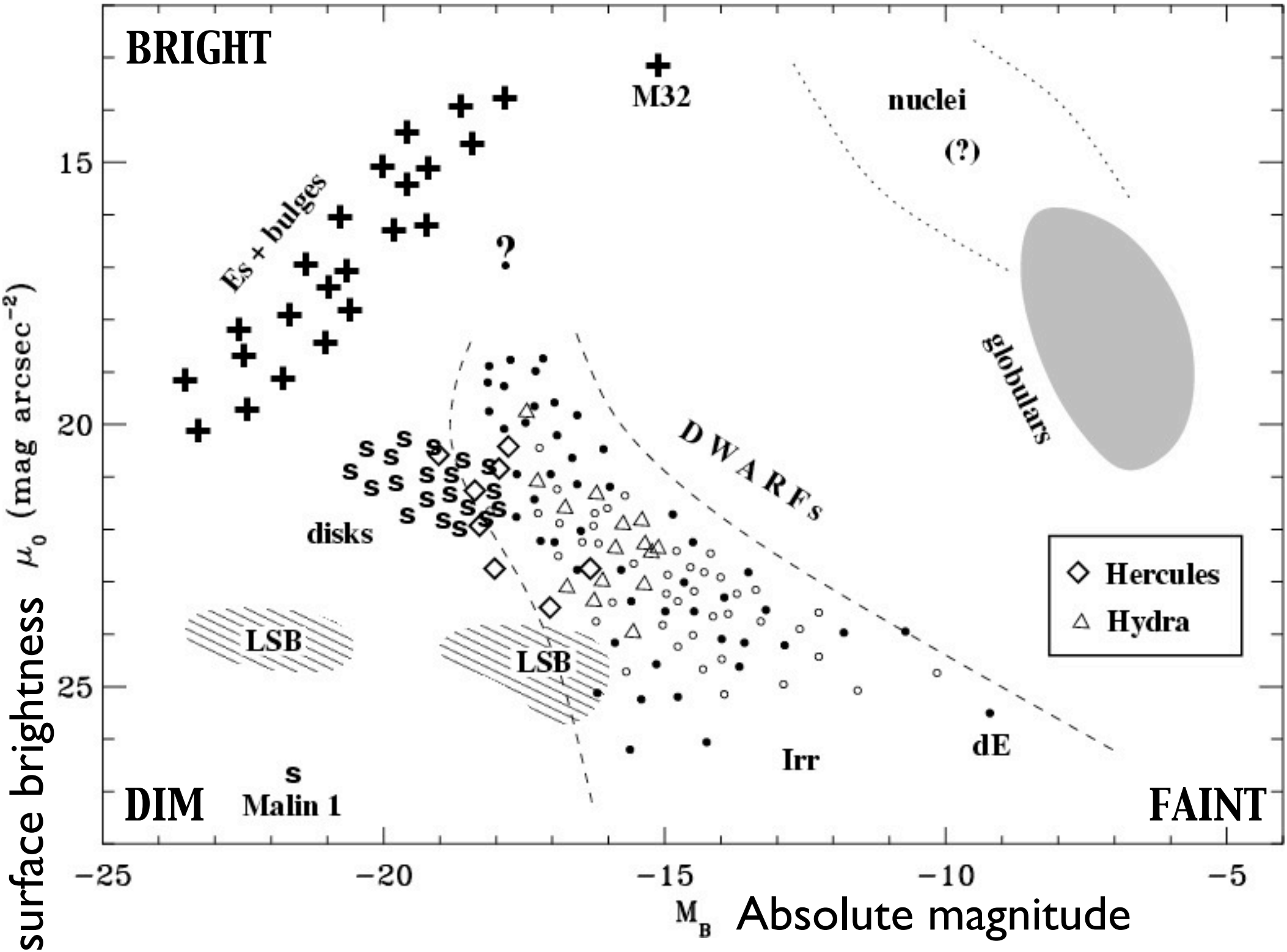
Spirals
2D disks
rotational support
V/σ large

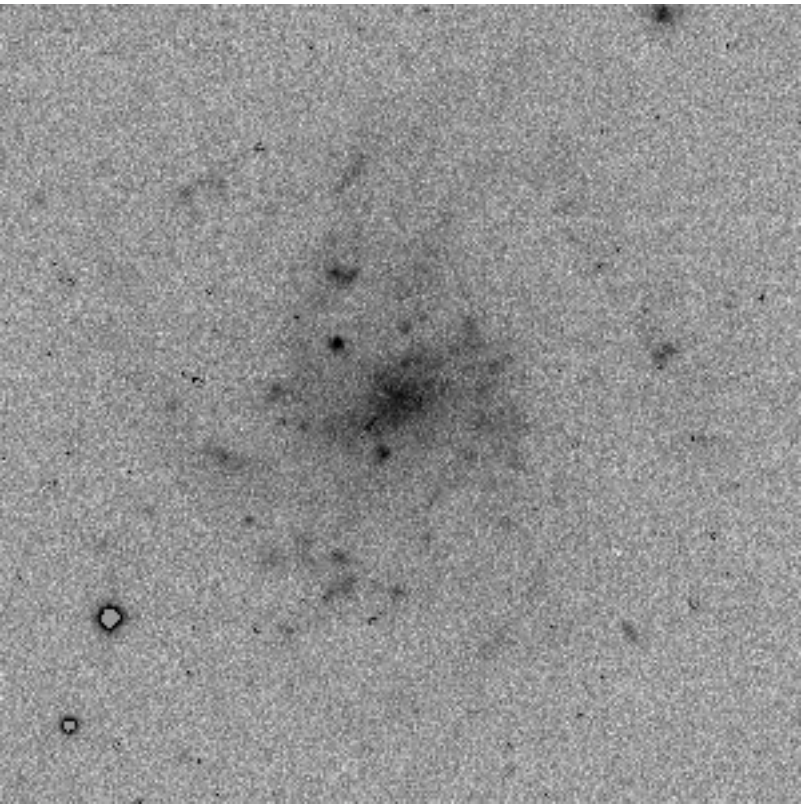
The Hubble sequence in place at high redshift

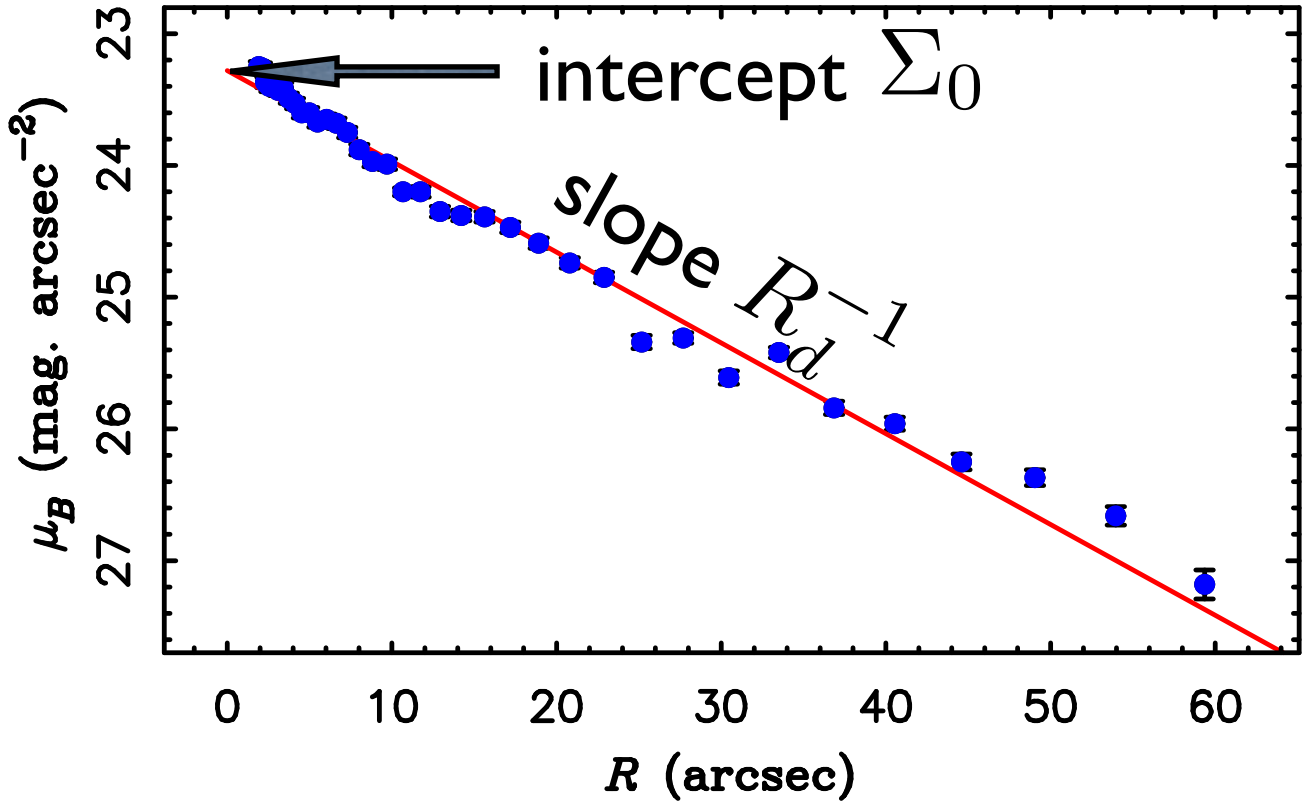


but lots of non-conforming things out there...

More recent observations require extension to later types


BRIGHT
DIM
FAINT
M32
nuclei
(?)
Es + bulges
?
globulars
DWARFs
disks
LSB
LSB
Malin 1
Irr
dE
Hercules
Hydra
15
20
25
−25
−20
−15
−10
−5
μ_0 (mag arcsec^{-2})
M_B
surface brightness
Absolute magnitude

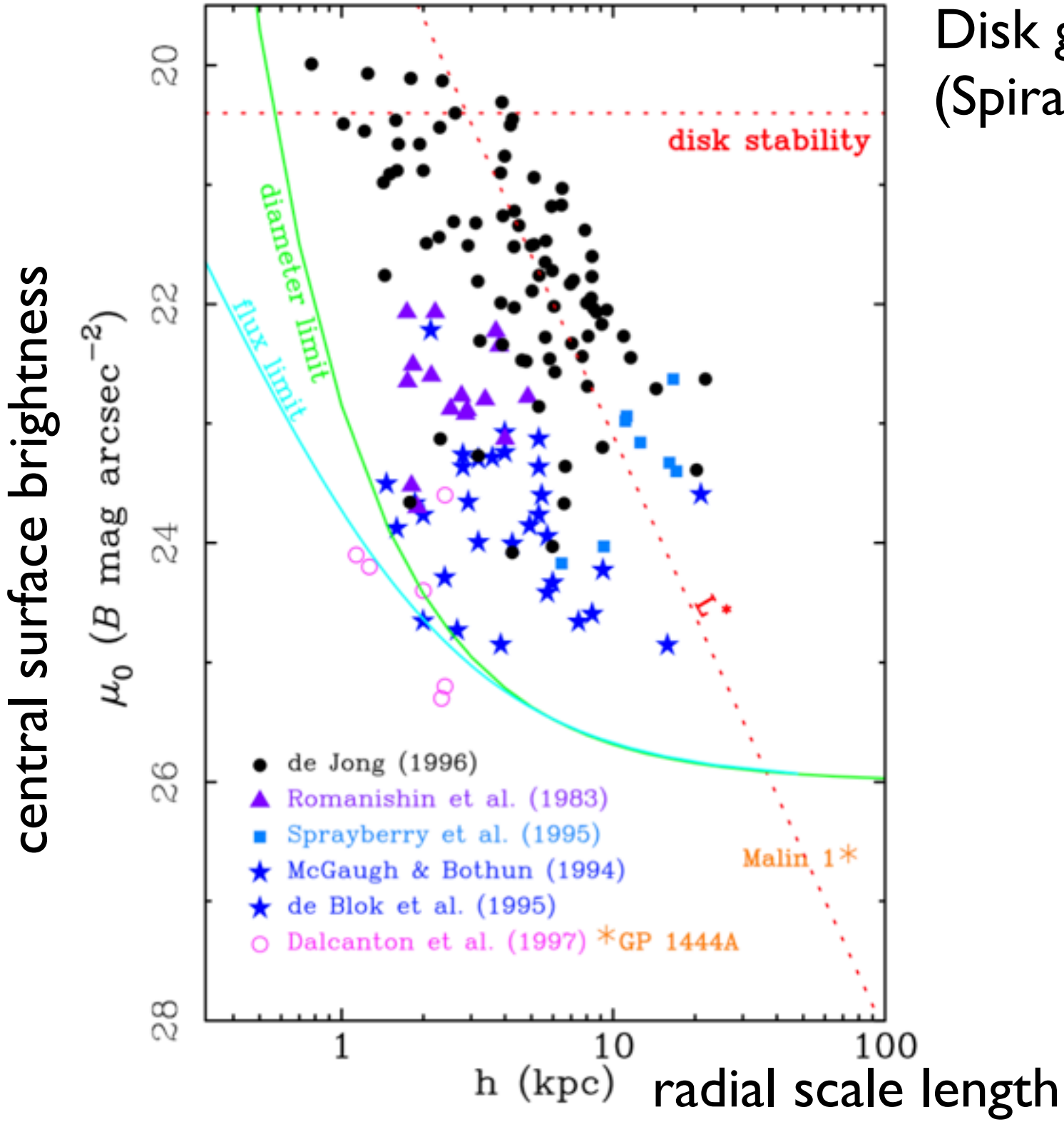


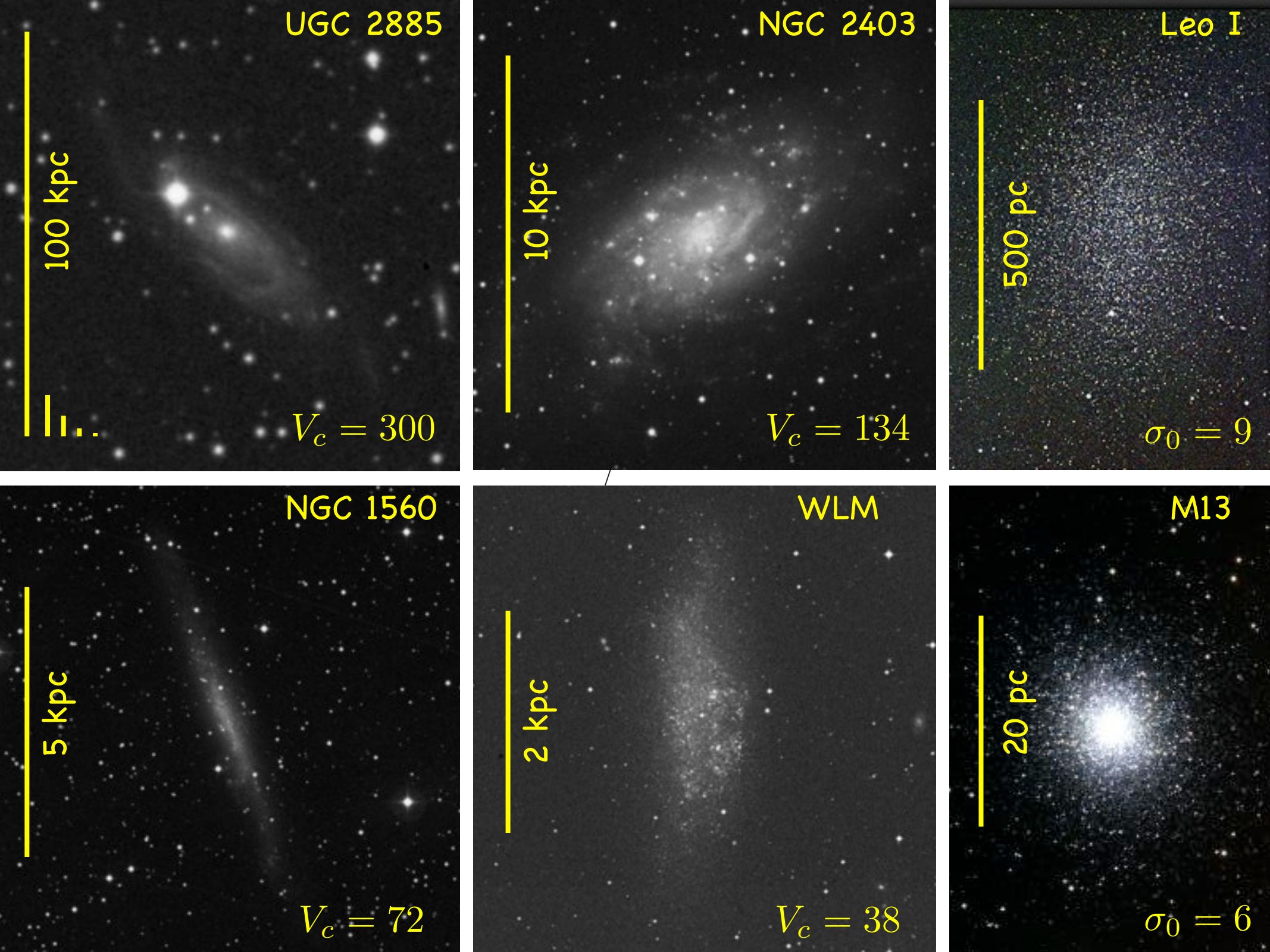


$$\Sigma(R) = \Sigma_0 e^{-R/R_d}$$

Azimuthally averaged light distribution approximately exponential for spiral disks.

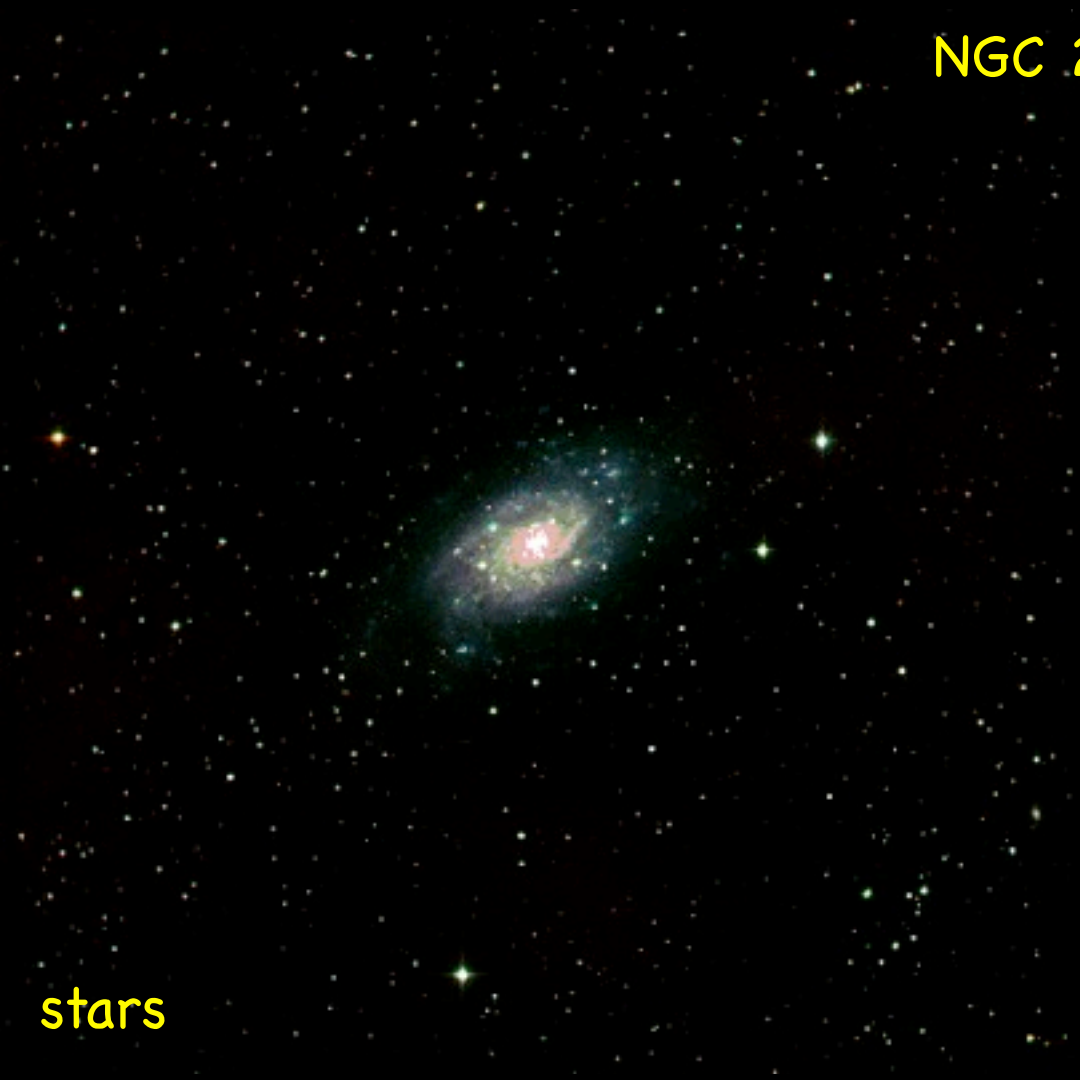
Disk galaxies
(Spirals+Irrs)




UGC 2885
100 kpc
$V_c = 300$
NGC 2403
10 kpc
$V_c = 134$
Leo I
500 pc
$\sigma_0 = 9$
NGC 1560
5 kpc
$V_c = 72$
WLM
2 kpc
$V_c = 38$
M13
20 pc
$\sigma_0 = 6$

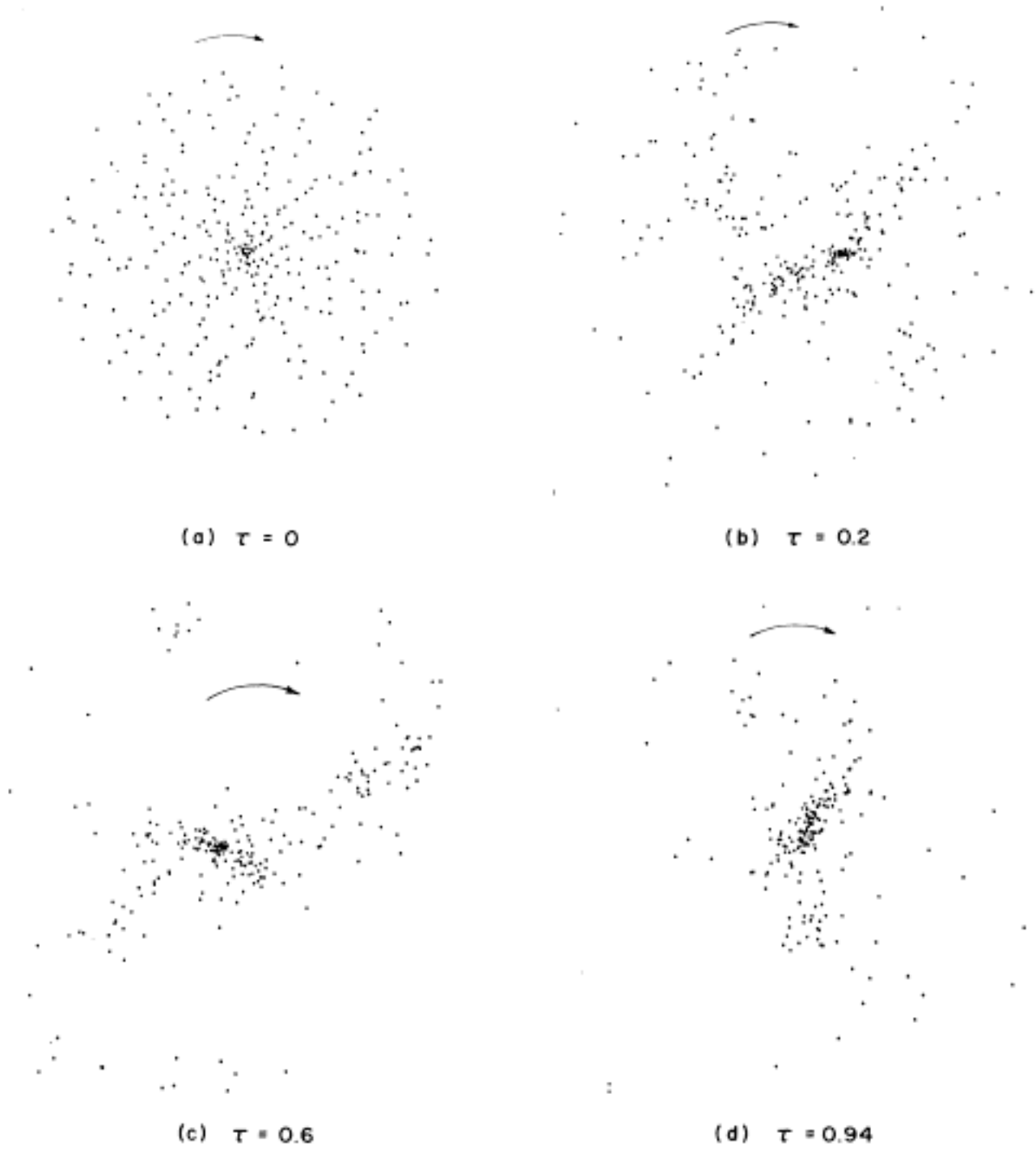
The atomic gas of the ISM is often more extended than the stars

NGC 2403



Fraternali, F., Oosterloo, T., Sancisi, R., van Moorsel, G.A. 2001, ApJ, 562, L47

The bar instability


(a) τ = 0
(b) τ = 0.2
(c) τ = 0.6
(d) τ = 0.94