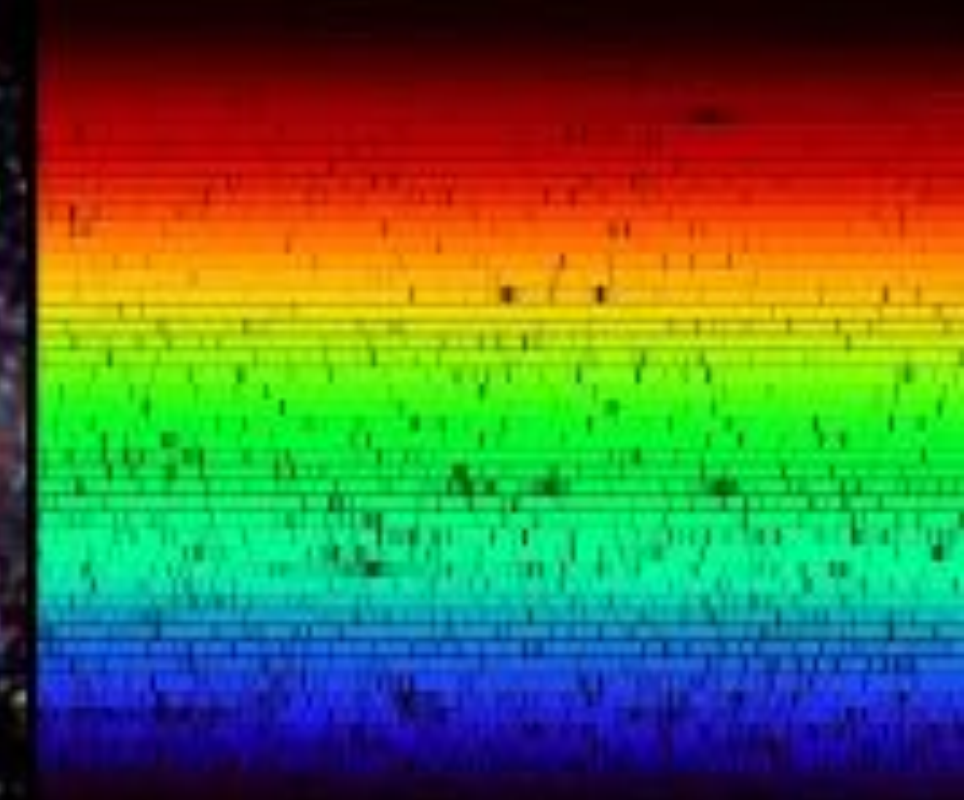




ASTR/PHYS 2500: Foundations Astronomy



Week 12: Galaxies

HW10 due Thursday

Read Ch. 20 (possibly some into Ch. 22)

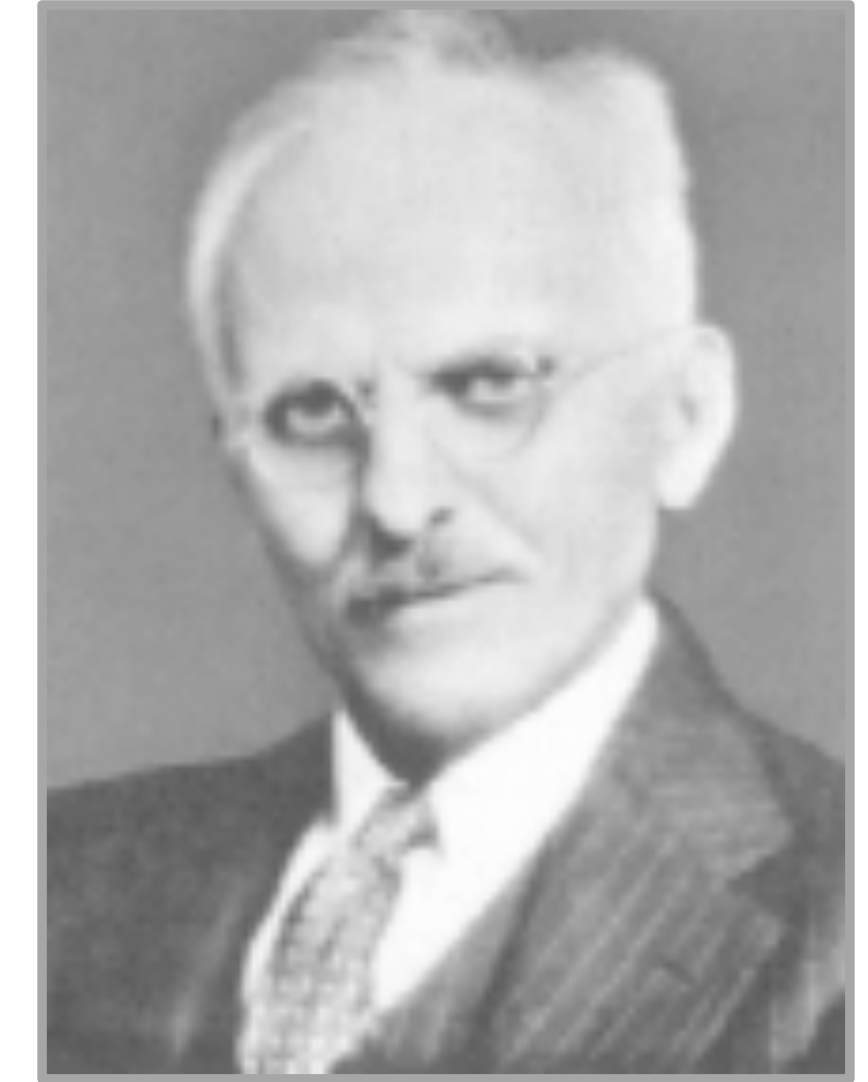
Project Presentations week after Thanksgiving!!!

What are the spiral nebulae?

The great debate of 1920



Harlow Shapley



Herber Curtis

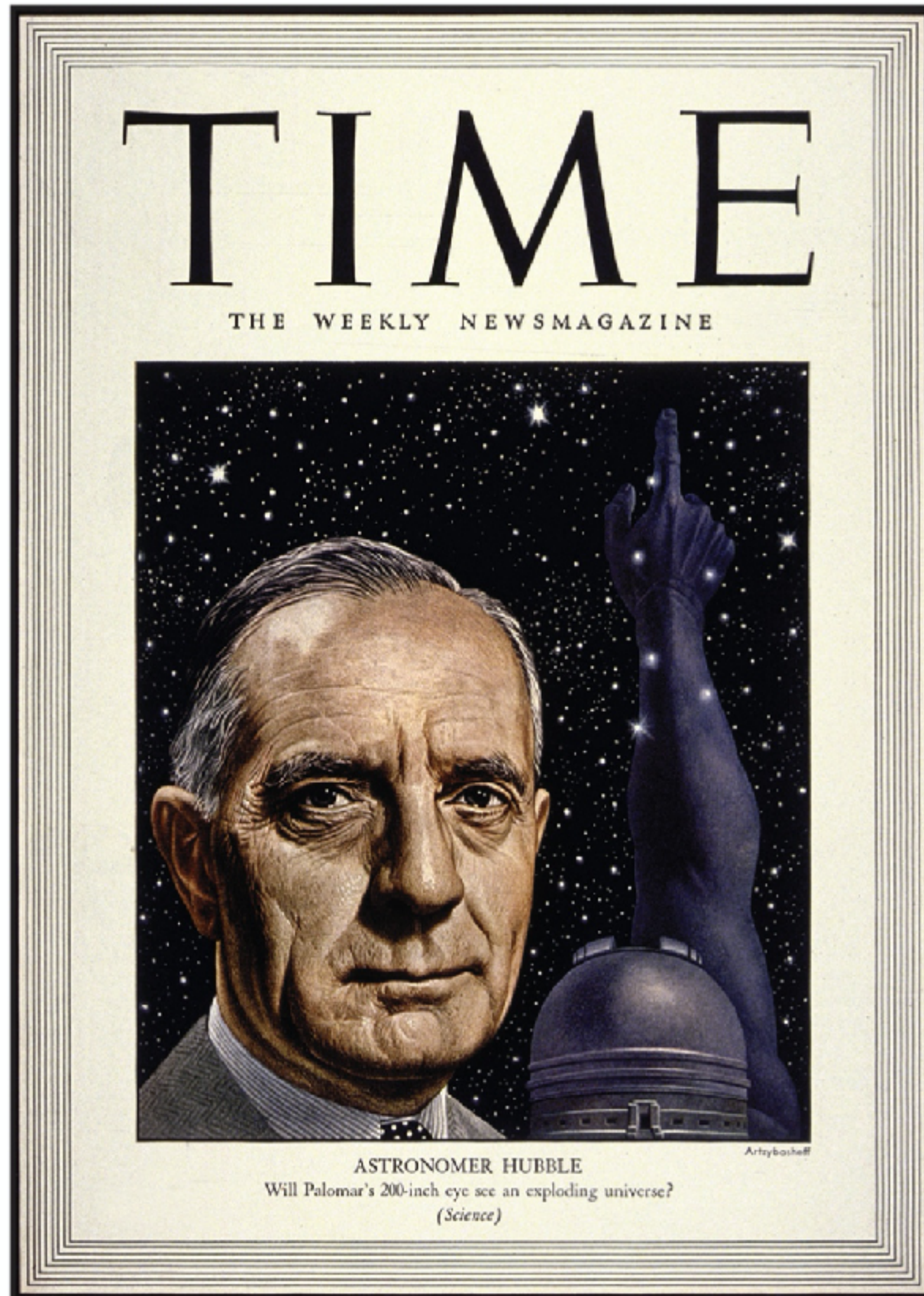
MW is whole Universe

- ✓ • Sun is in outer part of the MW
- ✗ • M31 would have to be at an insane distance to be similar
- ✗ • we can see rotation in the Pinwheel
- ✓✗ • this one nova in M31 would have been impossibly bright

MW is one of many galaxies

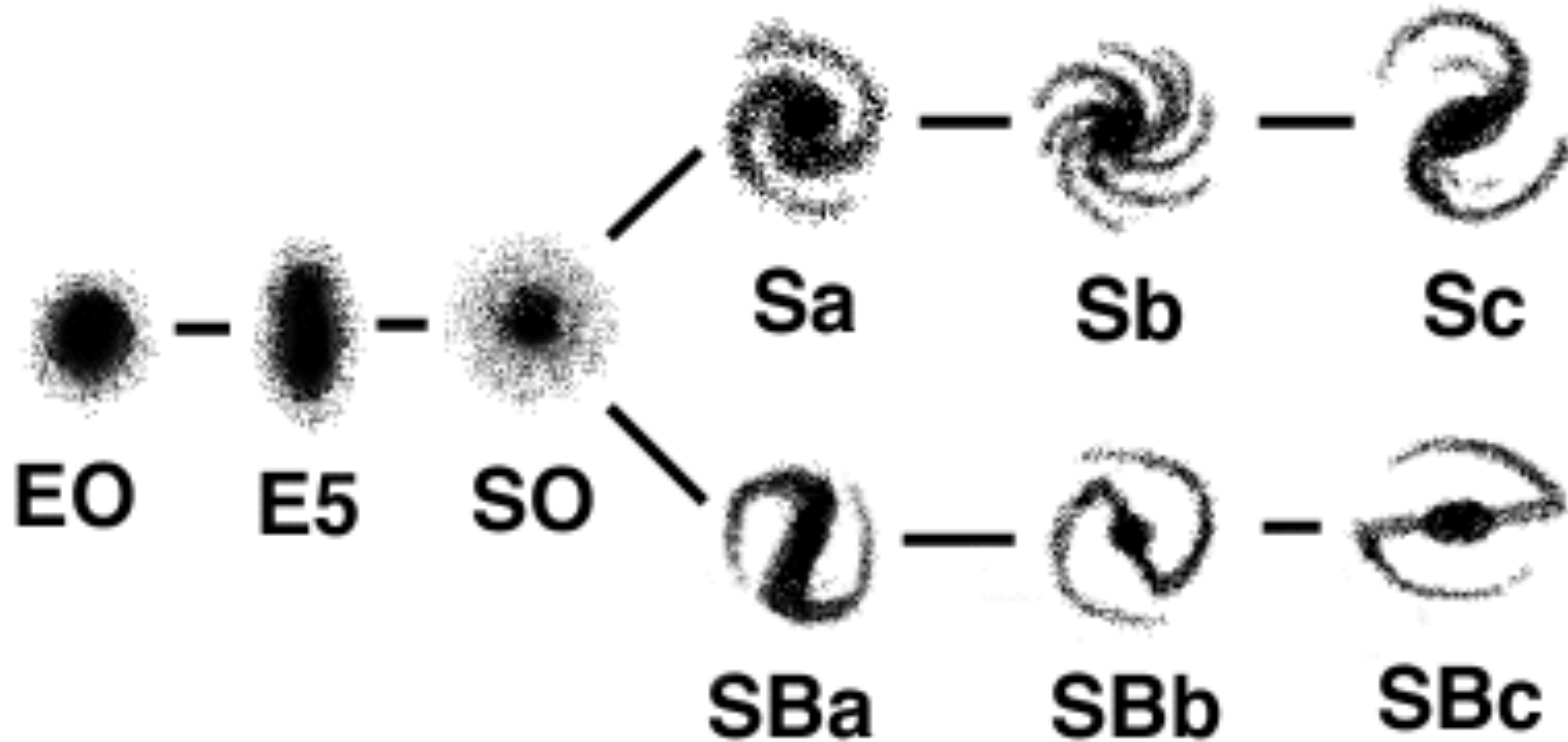
- ✗ • Sun is at the center of MW
- ✓ • M31 has too many novae to be just a galactic nebula
- ✓ • we see dust lanes in other nebulae, like the MW's

Edwin Hubble settles the debate

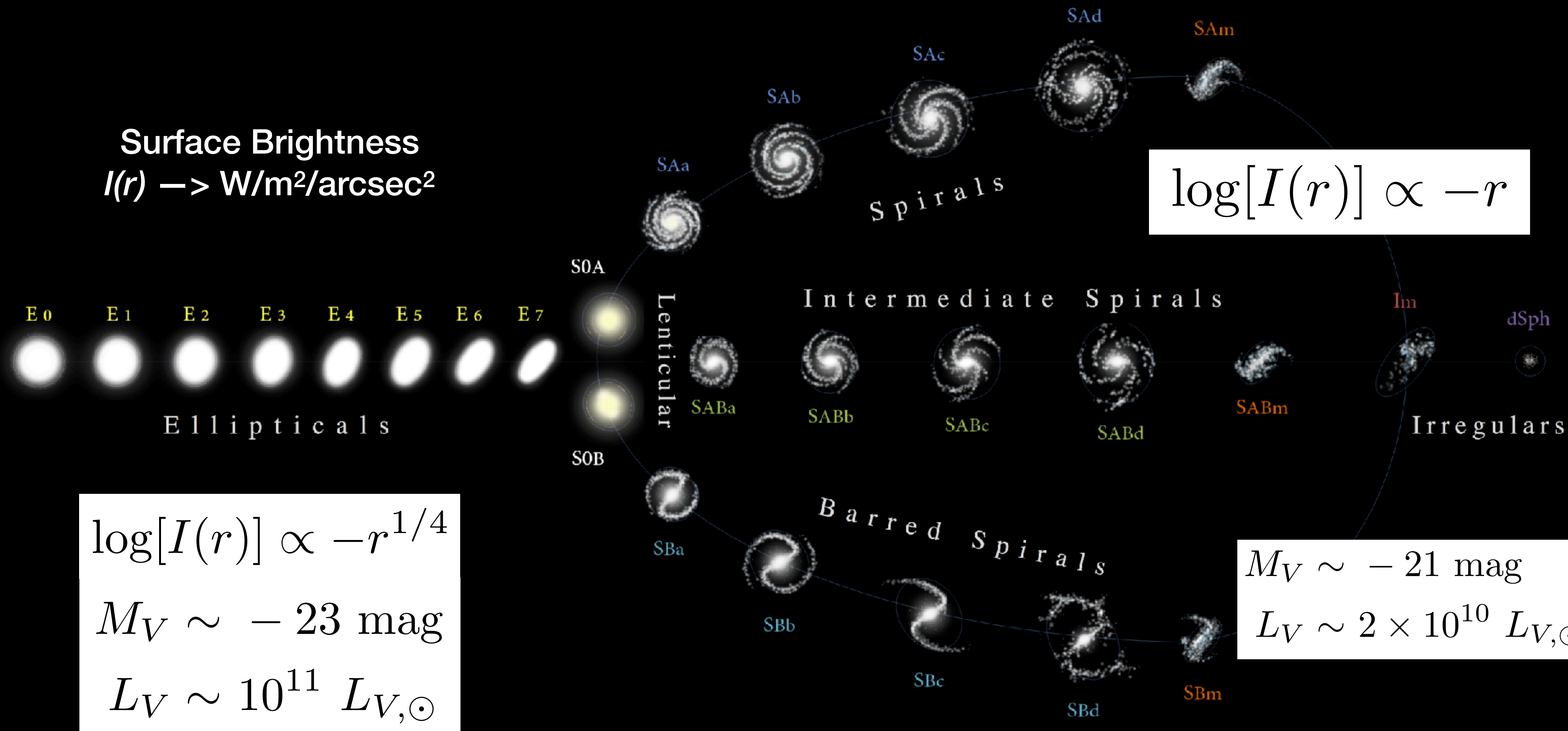


M31: Andromeda Galaxy

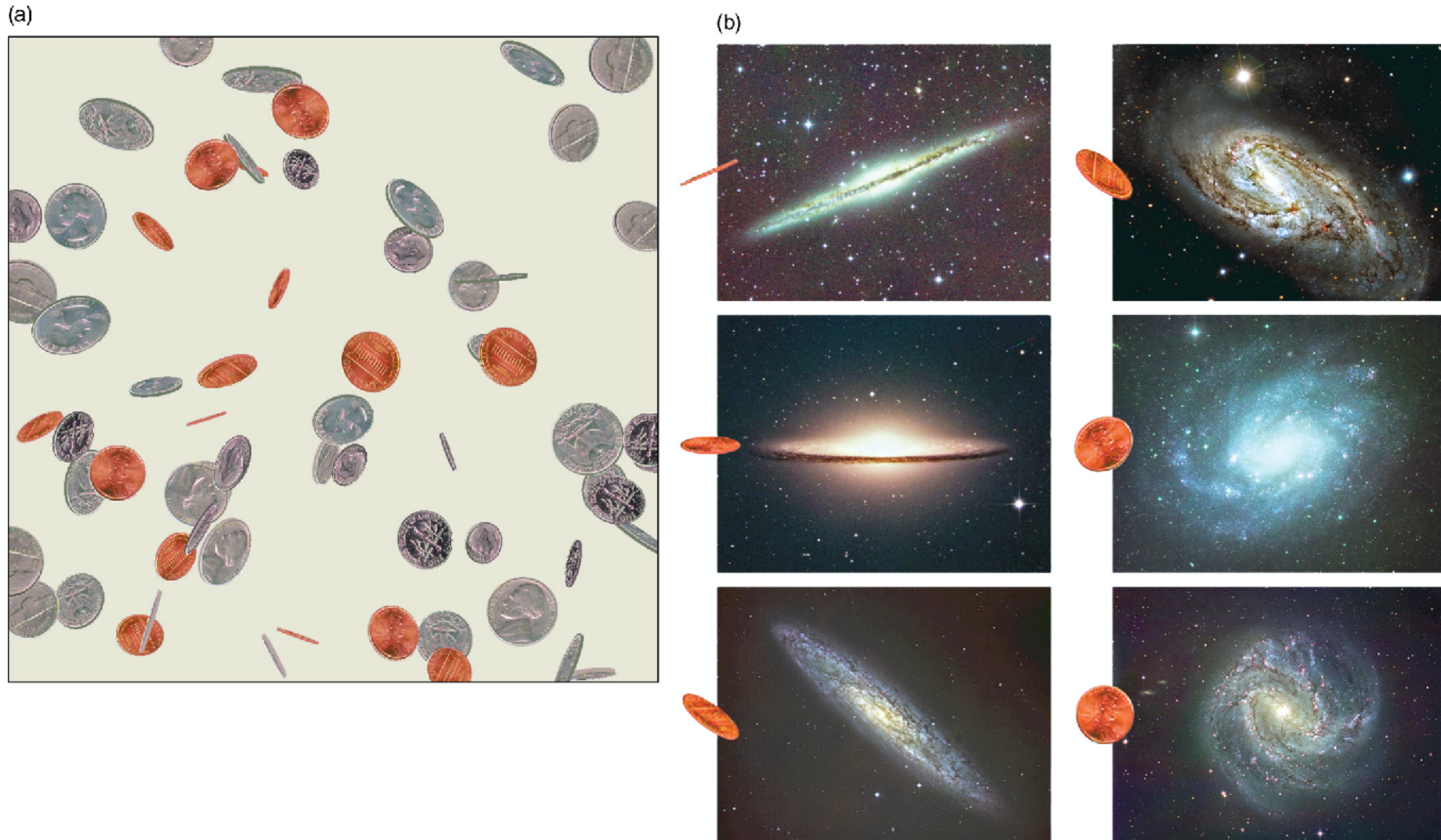
Hubble's Classification Scheme: Tuning Fork Diagram



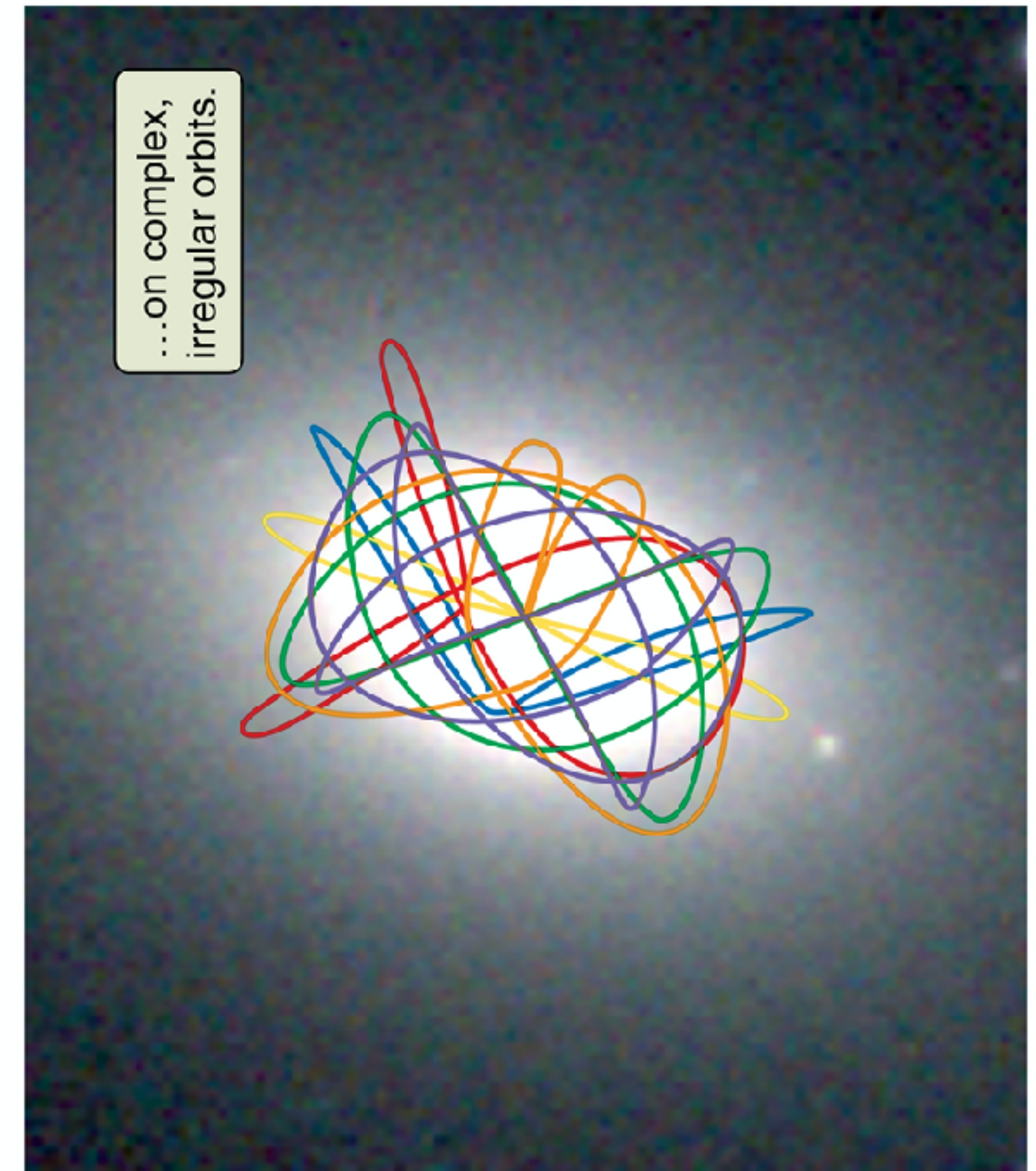
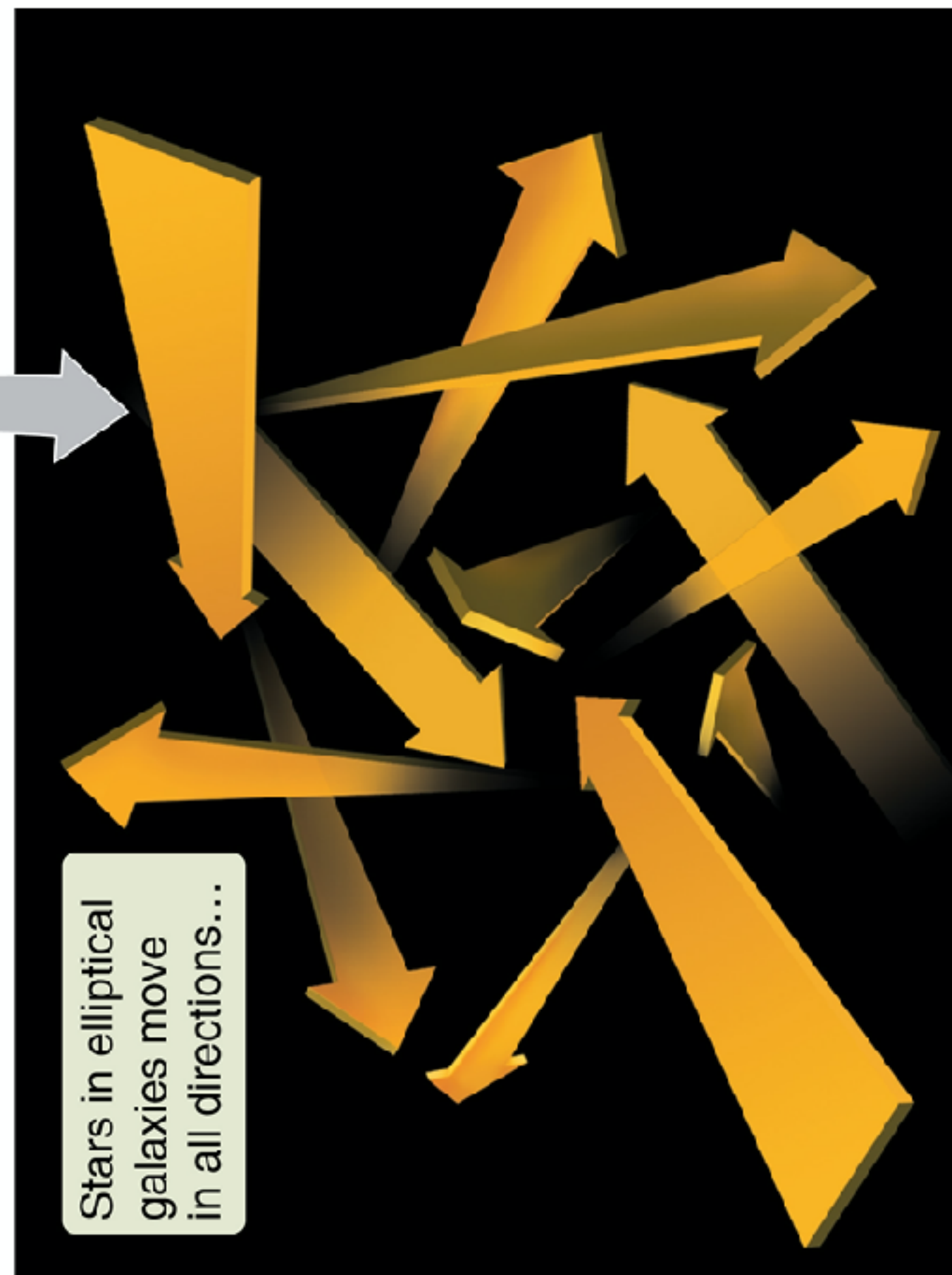
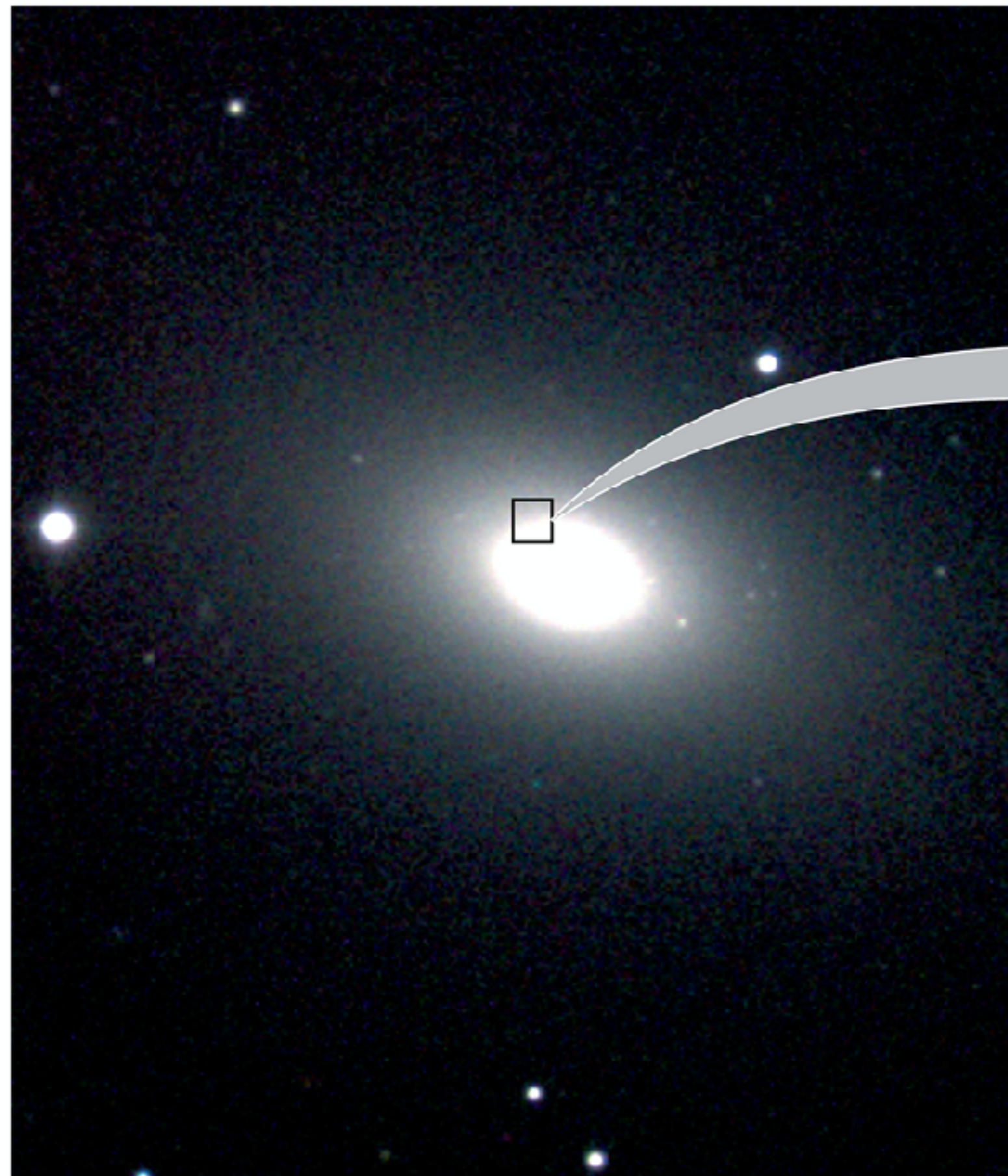
HUBBLE-DE VAUCOULEURS DIAGRAM



Appearance depends on orientation...

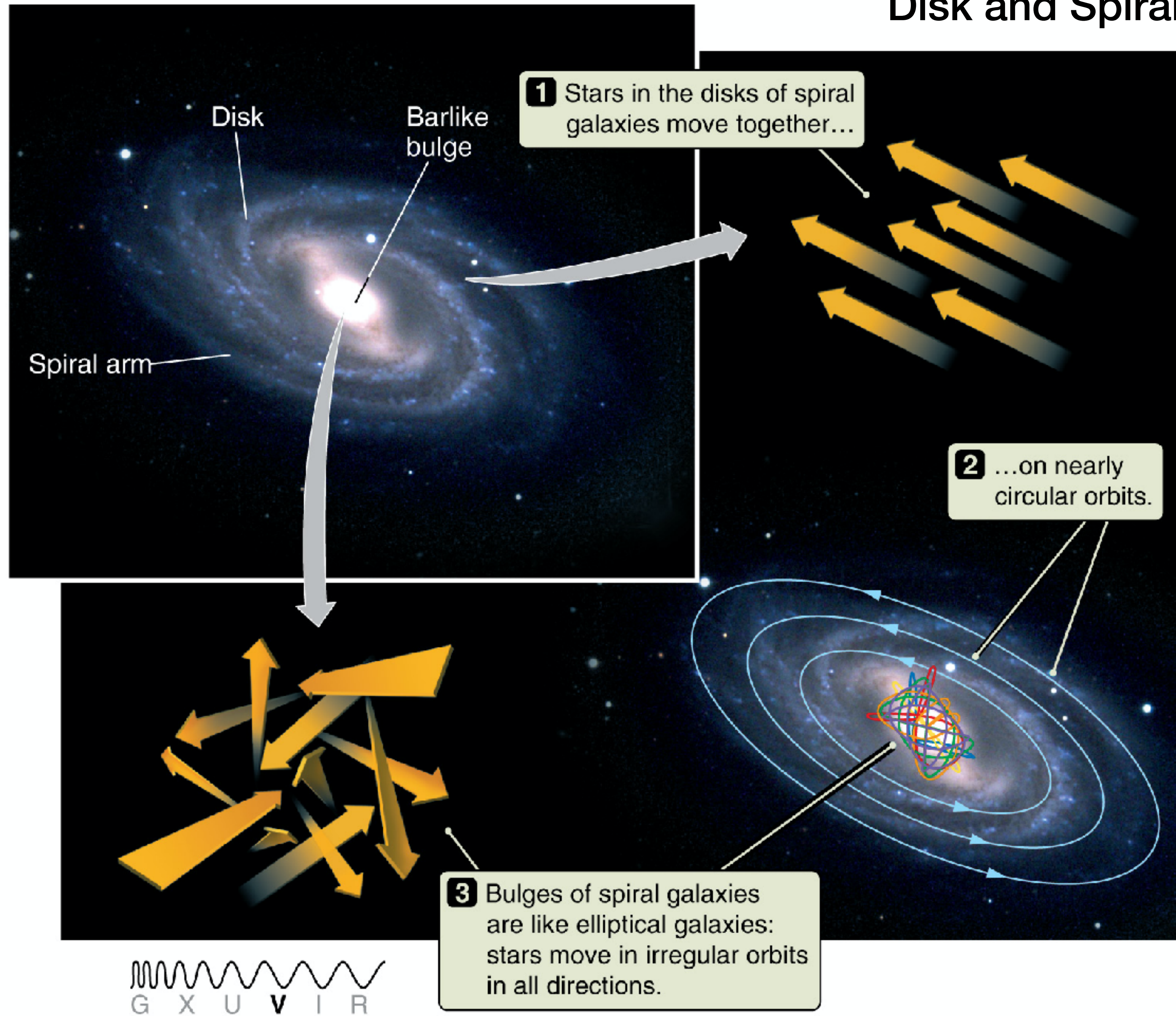


...and the motions of stars



Bulges and Ellipticals

Disk and Spiral Galaxies



Which part of a disk galaxy is the "oldest"?

Why do you think so?

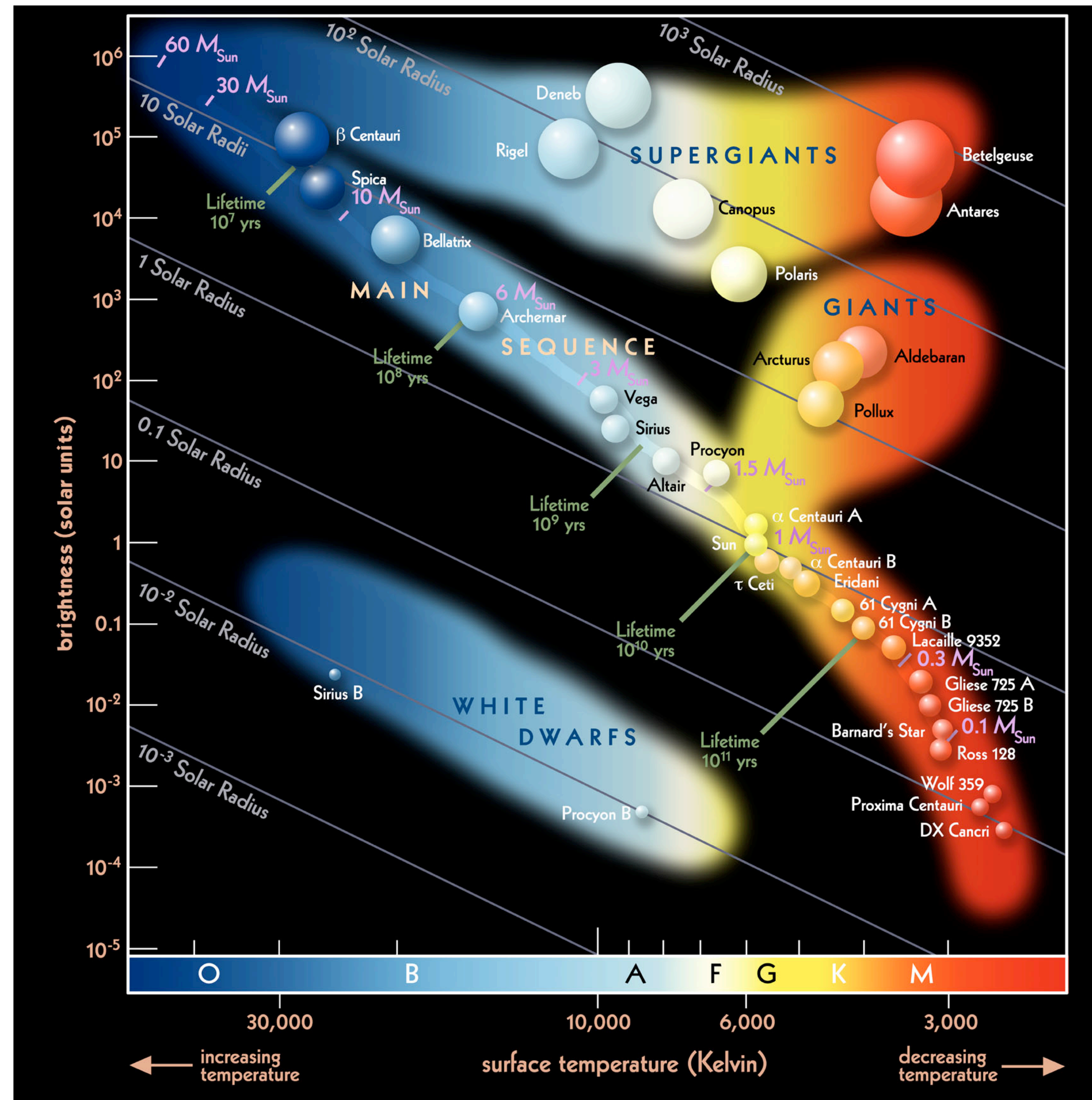
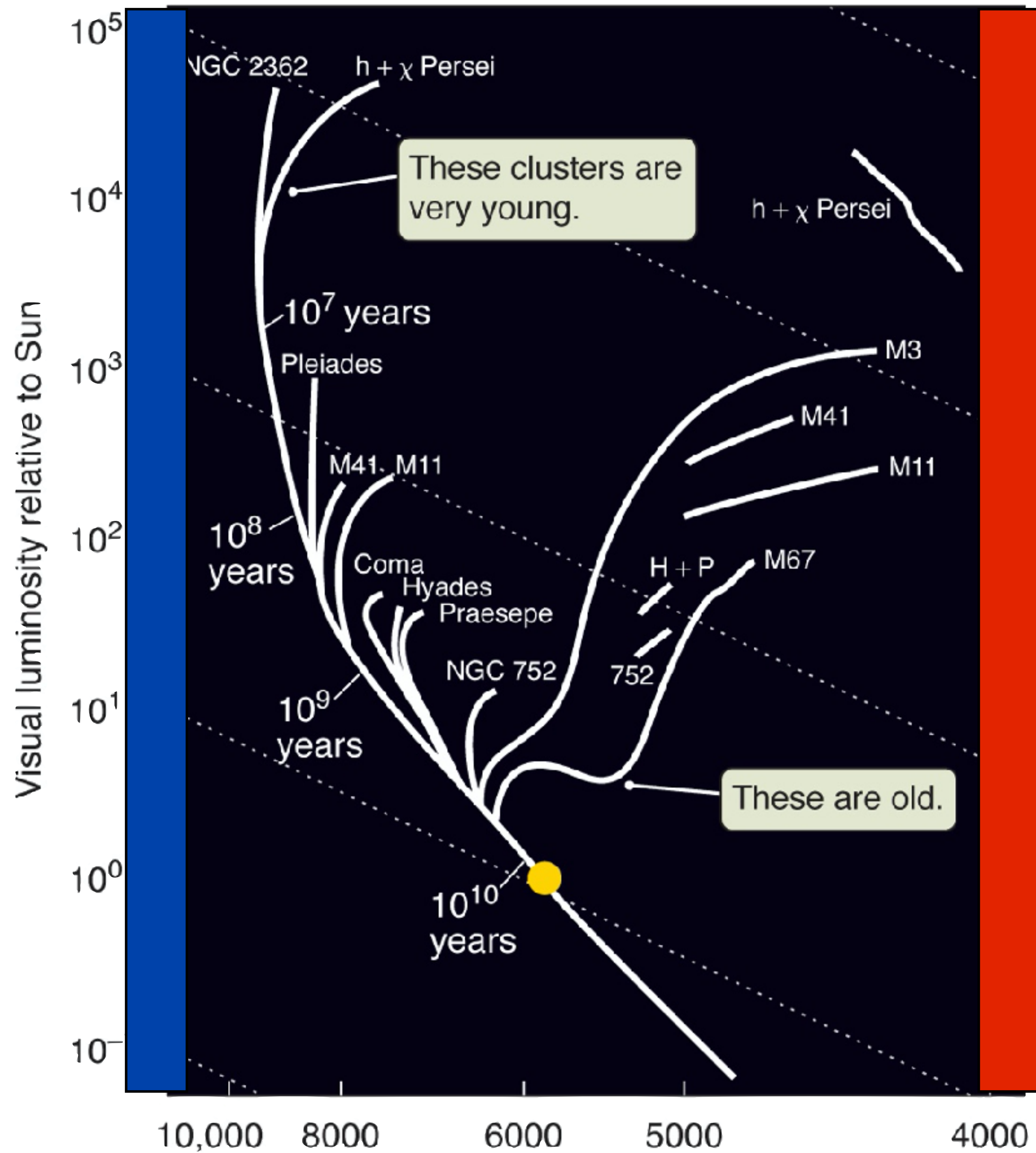


Which is oldest?

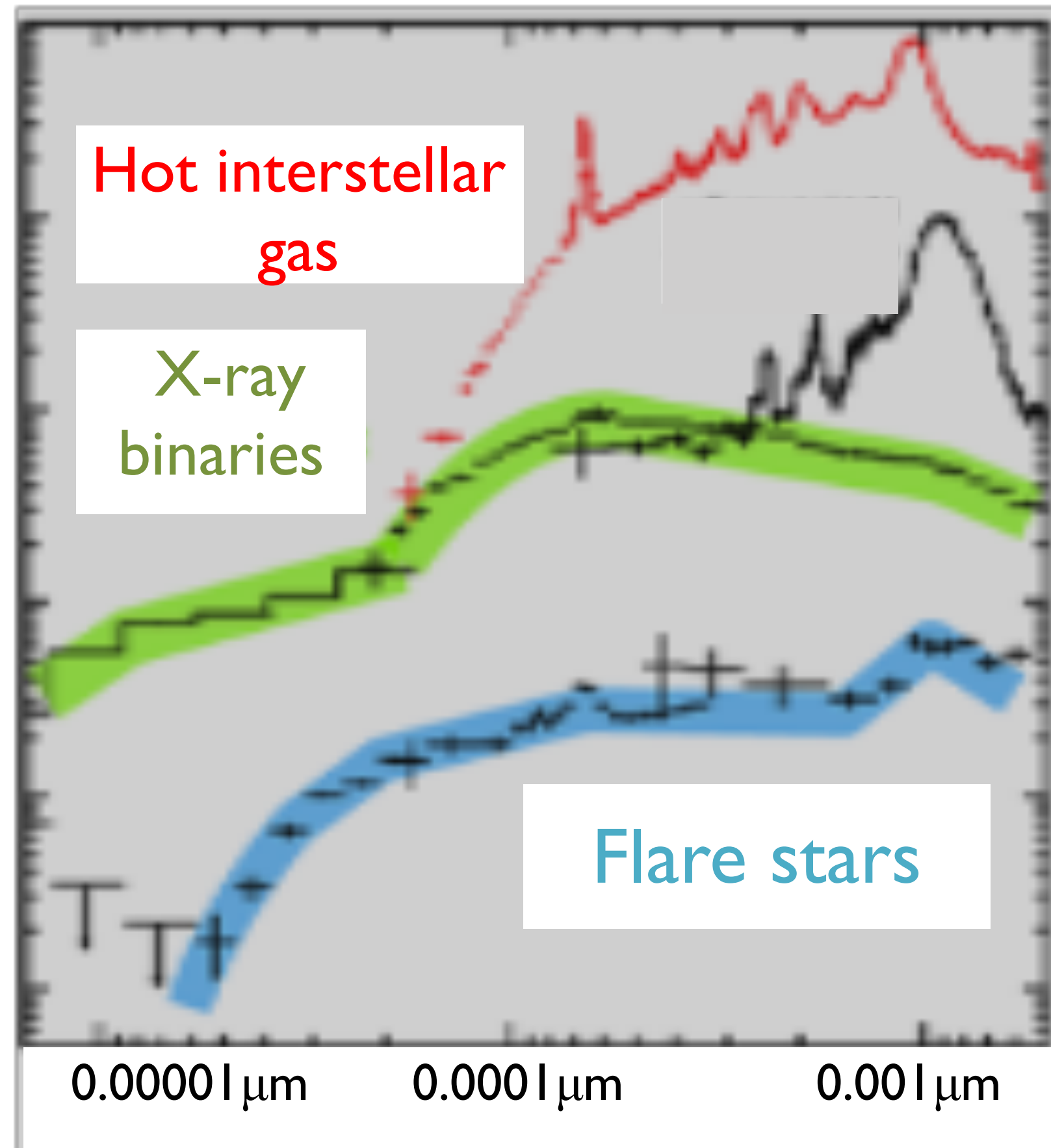
(Or, which has the youngest stars? Why?)



Star Clusters



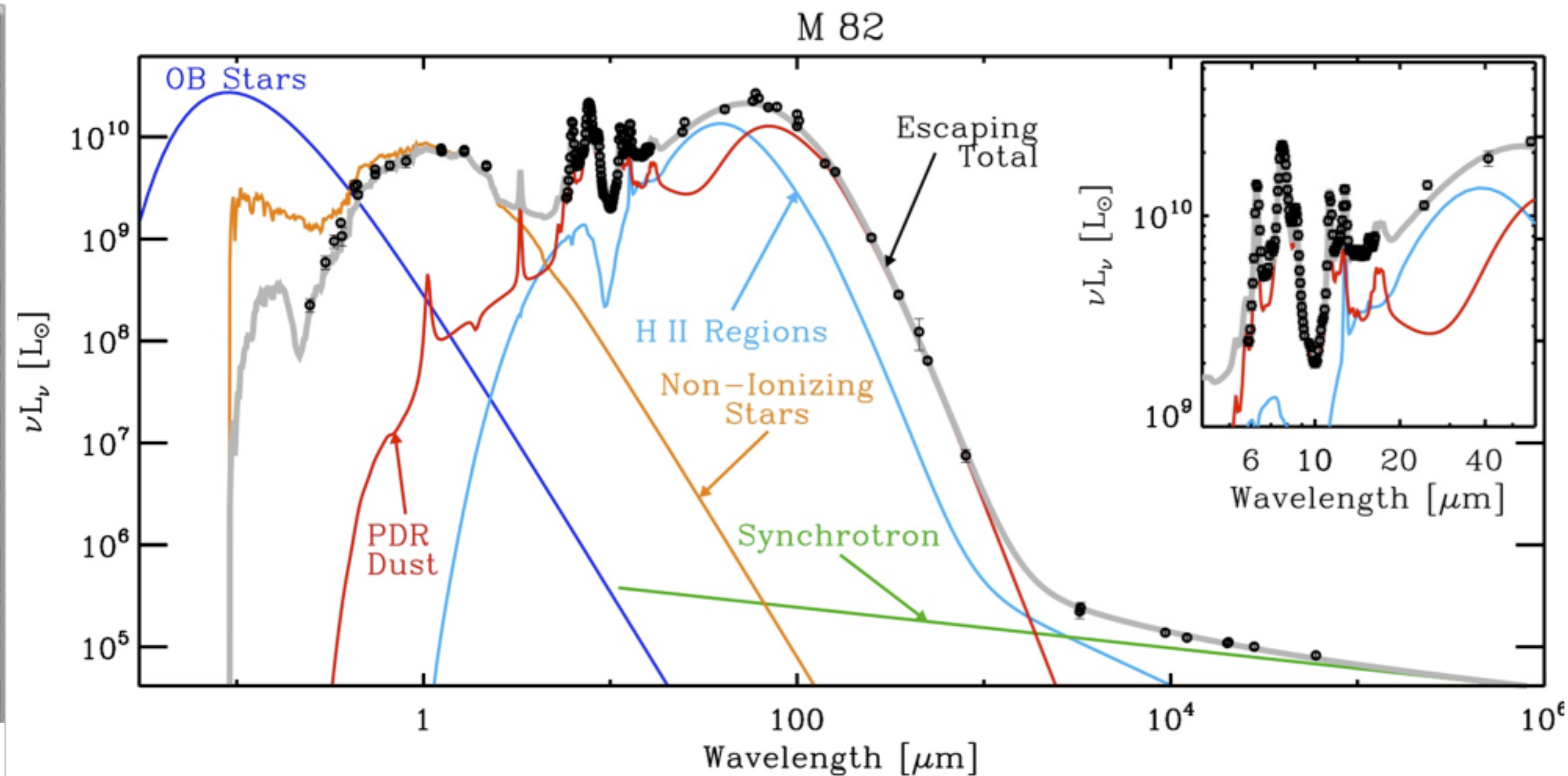
Galaxy Spectra



High E

Low E

X-ray



500 nm

1 m

UV

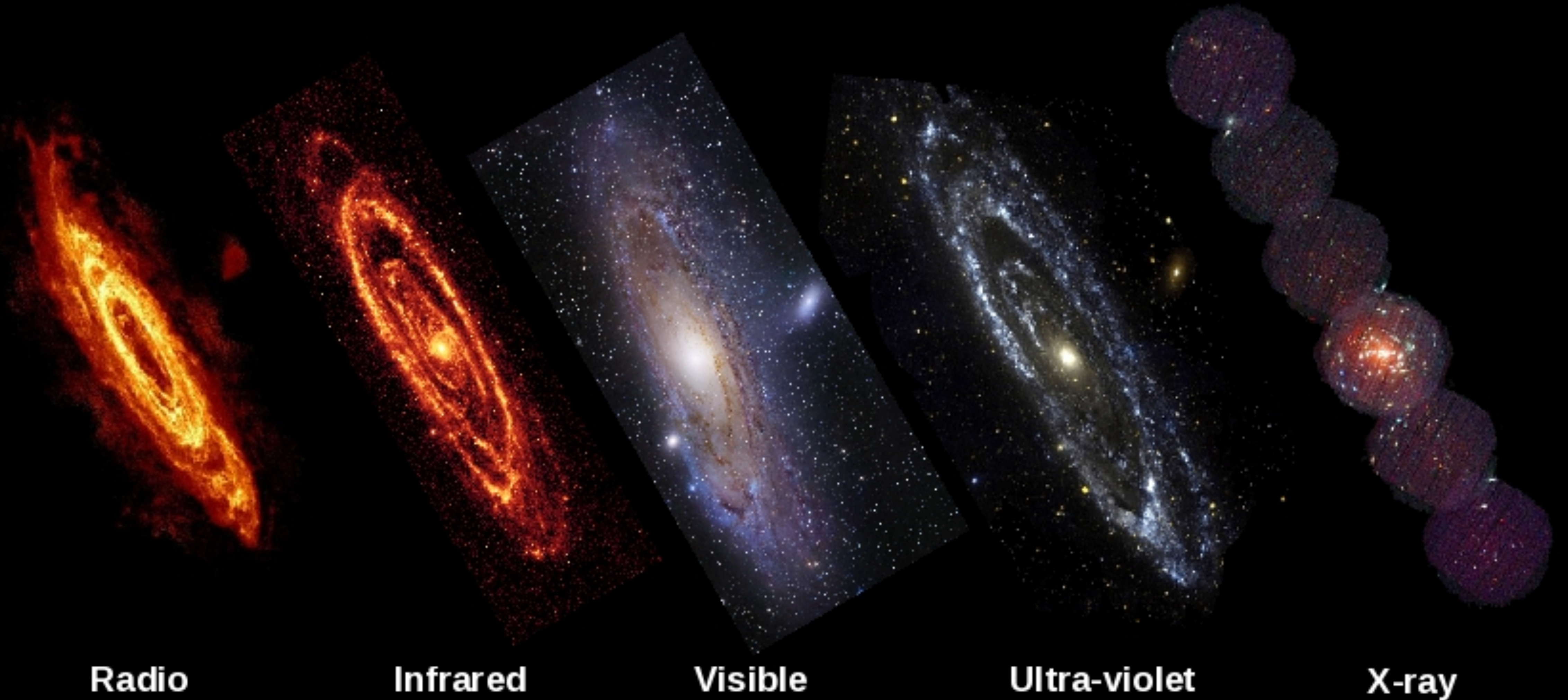
Optical

IR

Microwave

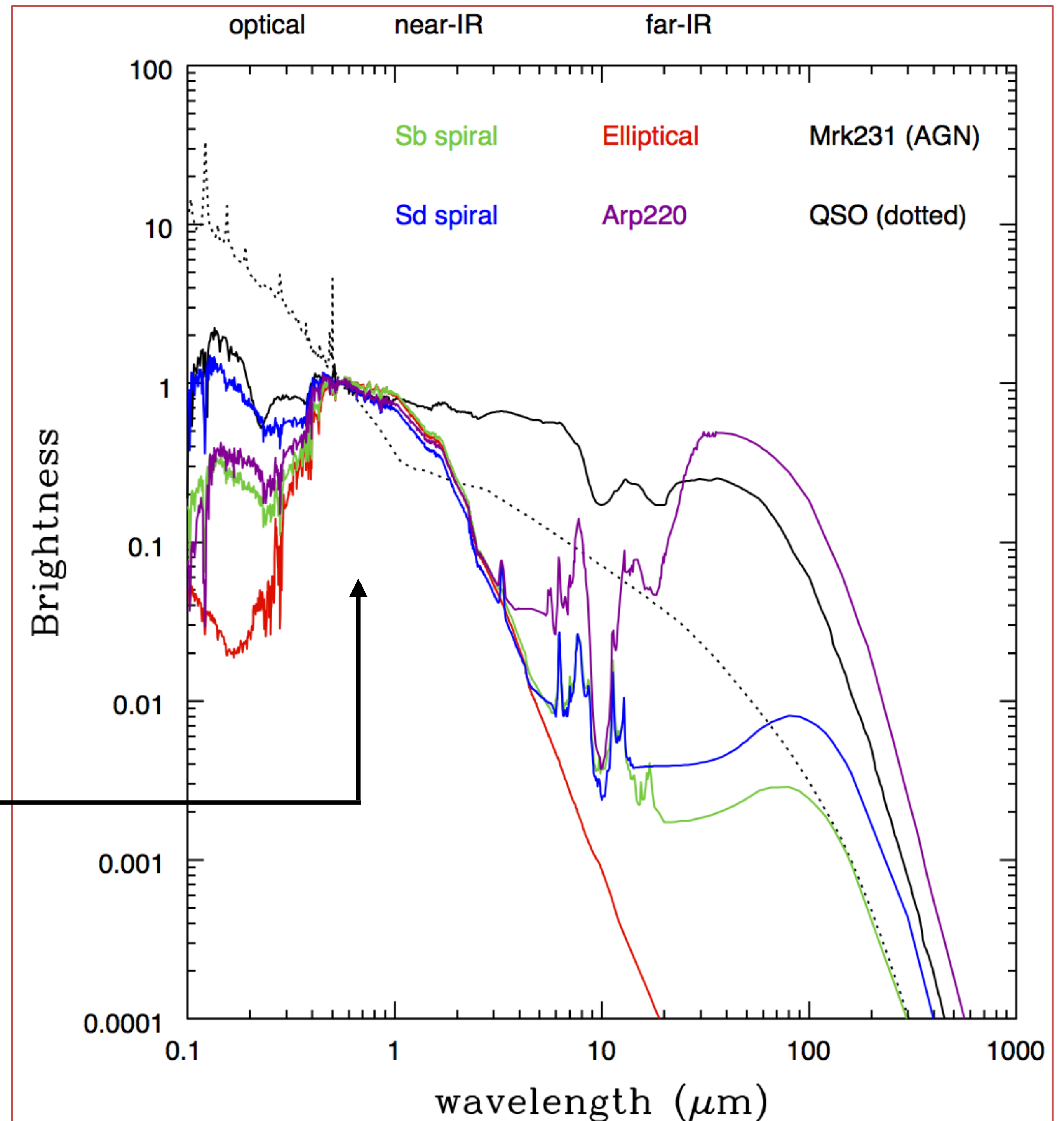
Radio

M31 at different frequencies

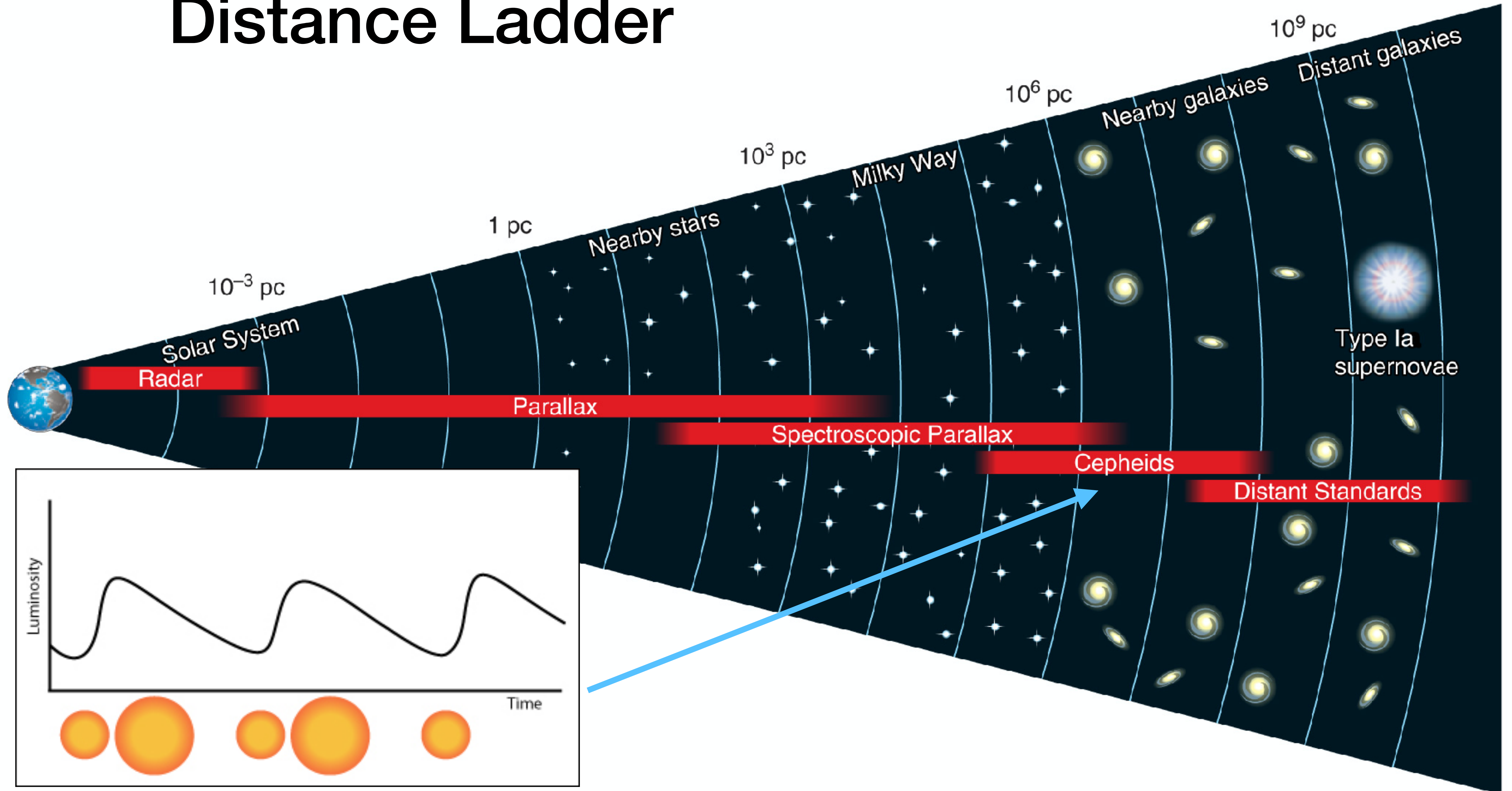


Spectra of galaxies of different types are, well, different

Why do they look the same here though?

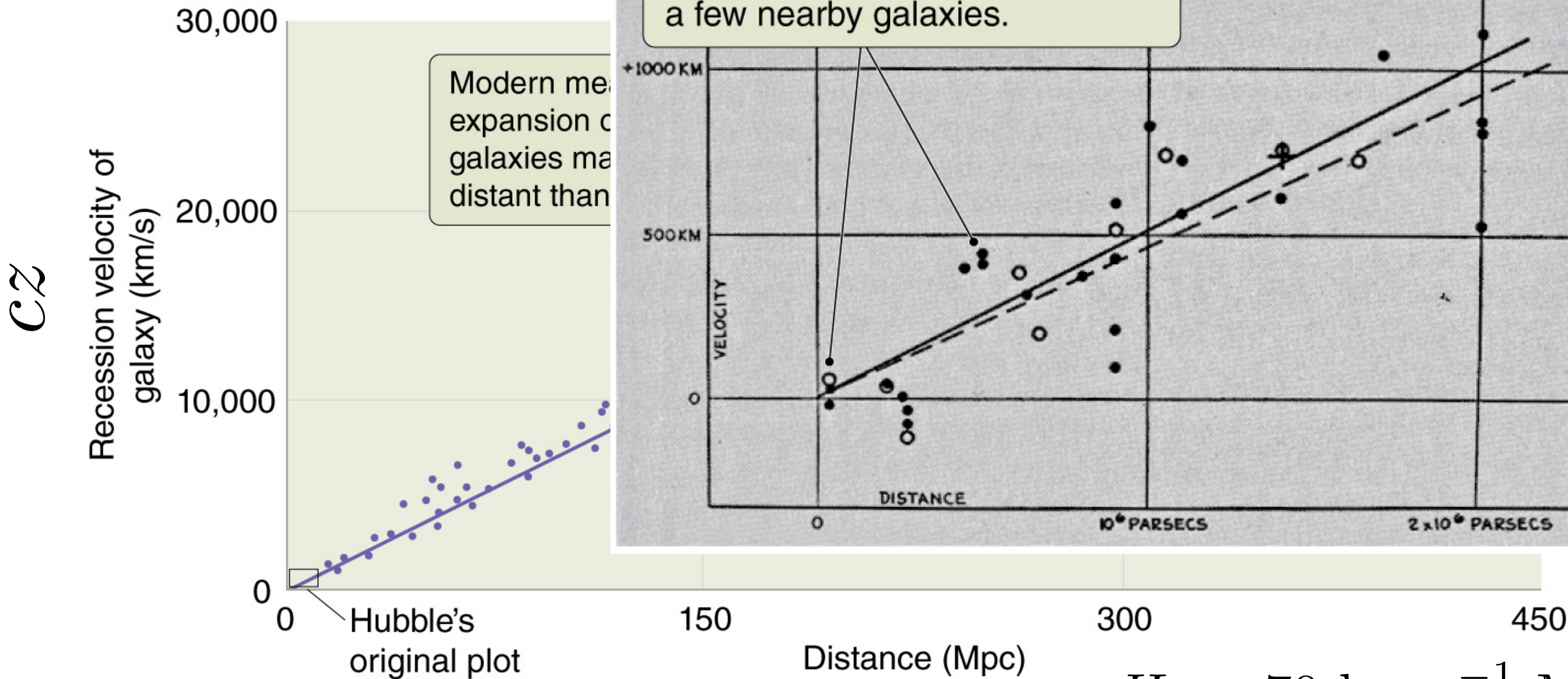


Distance Ladder



Hubble's Law

$$cz = H_0 d$$

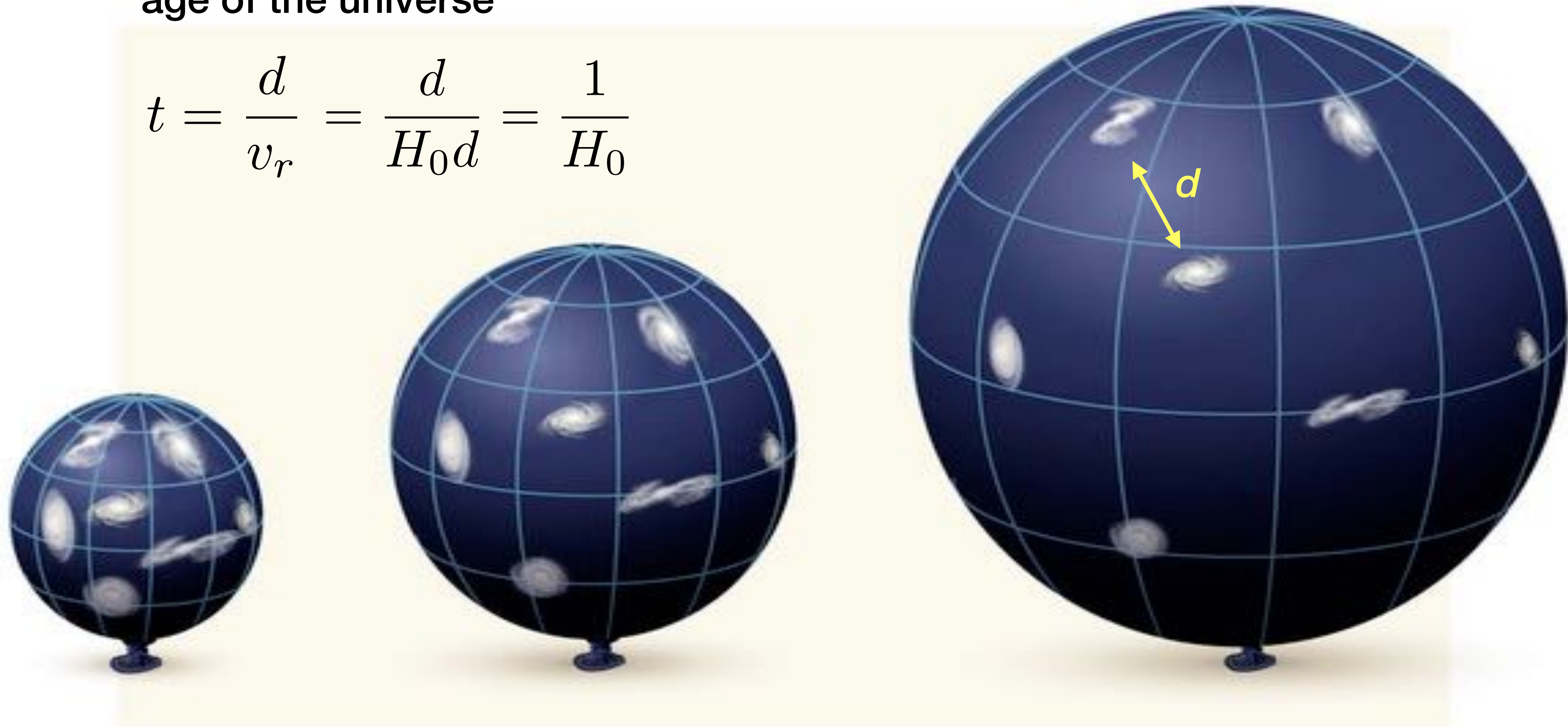


$$H_0 \approx 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

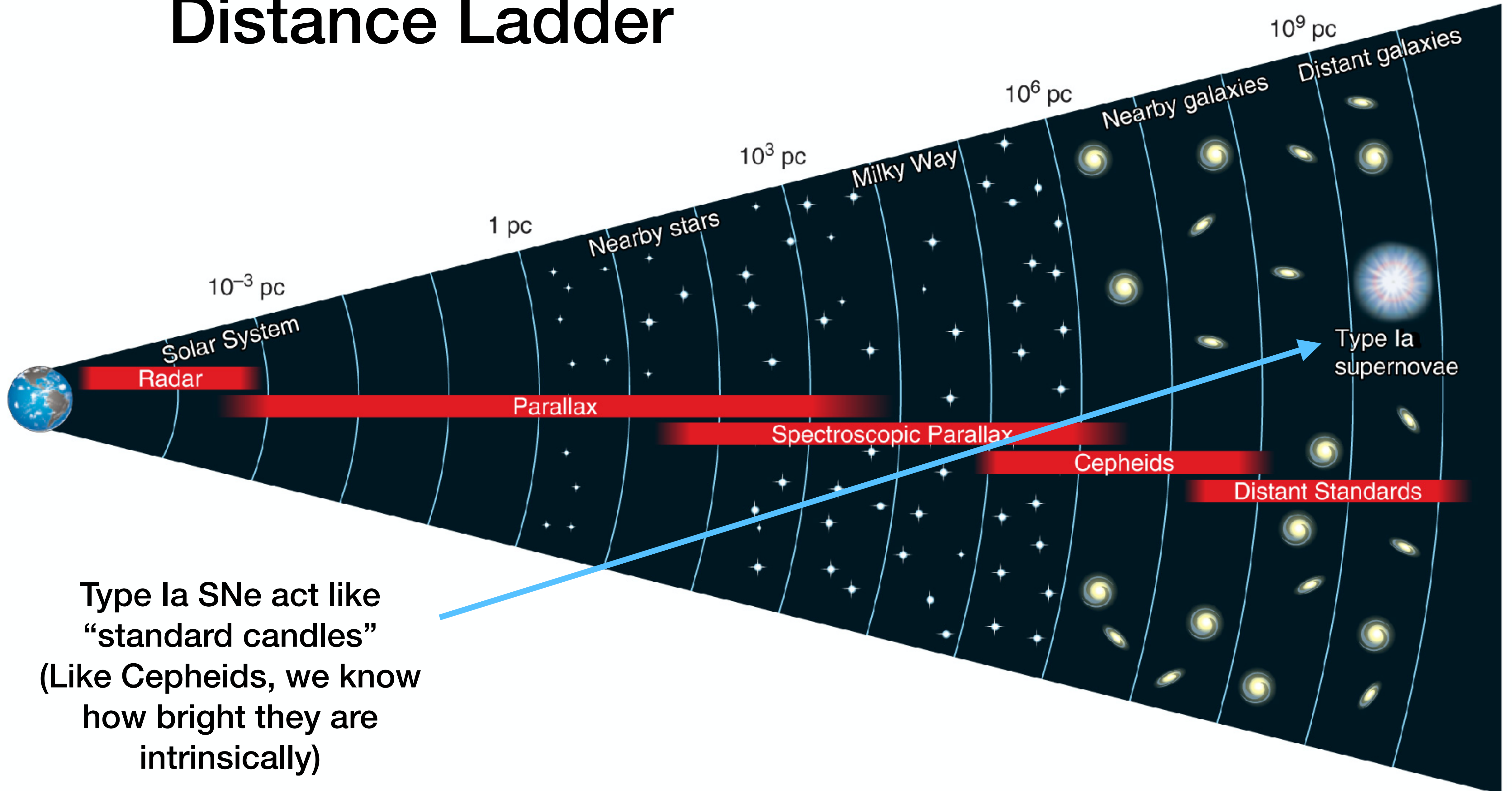
We live in an expanding “balloon universe”

If expansion constant, then can estimate the age of the universe

$$t = \frac{d}{v_r} = \frac{d}{H_0 d} = \frac{1}{H_0}$$



Distance Ladder



Type Ia SNe act like “standard candles”
(Like Cepheids, we know how bright they are intrinsically)

