Week 13: Galaxies

HW10 due now
HW11 (last one!) posted on the website, due Dec. 3rd

Read Ch. 23 for next Tuesday

Project Presentations week after Thanksgiving!!!

Communicating Science Project Evaluations

Project Grade
(Worth 20% of course grade)

50 points for accuracy
20 points for clarity
20 points for presentation
10 points for creativity
100 points total

Based on *submitted* project, due by 10:45am on Tuesday, Dec. 8th

Course Participation Grade
(Worth 10% of course grade)

Will be available as a google form

Interpreting & Communicating Science: Peer Feedback

Provide constructive criticism on your peers' projects. Feedback will be distributed anonymously.

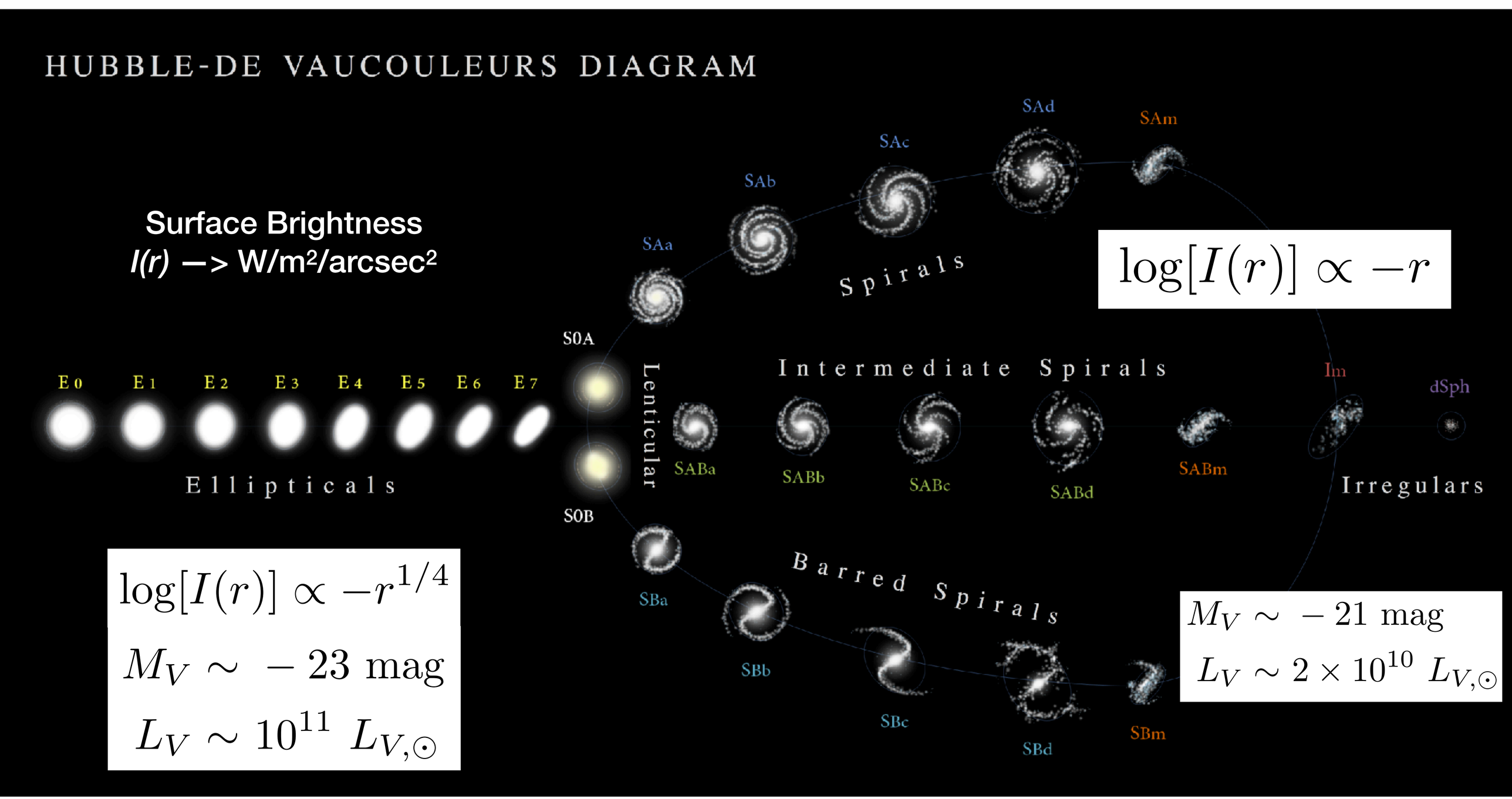
Presenter Name(s): _____

Did the project and presentation improve your understanding of the concept?

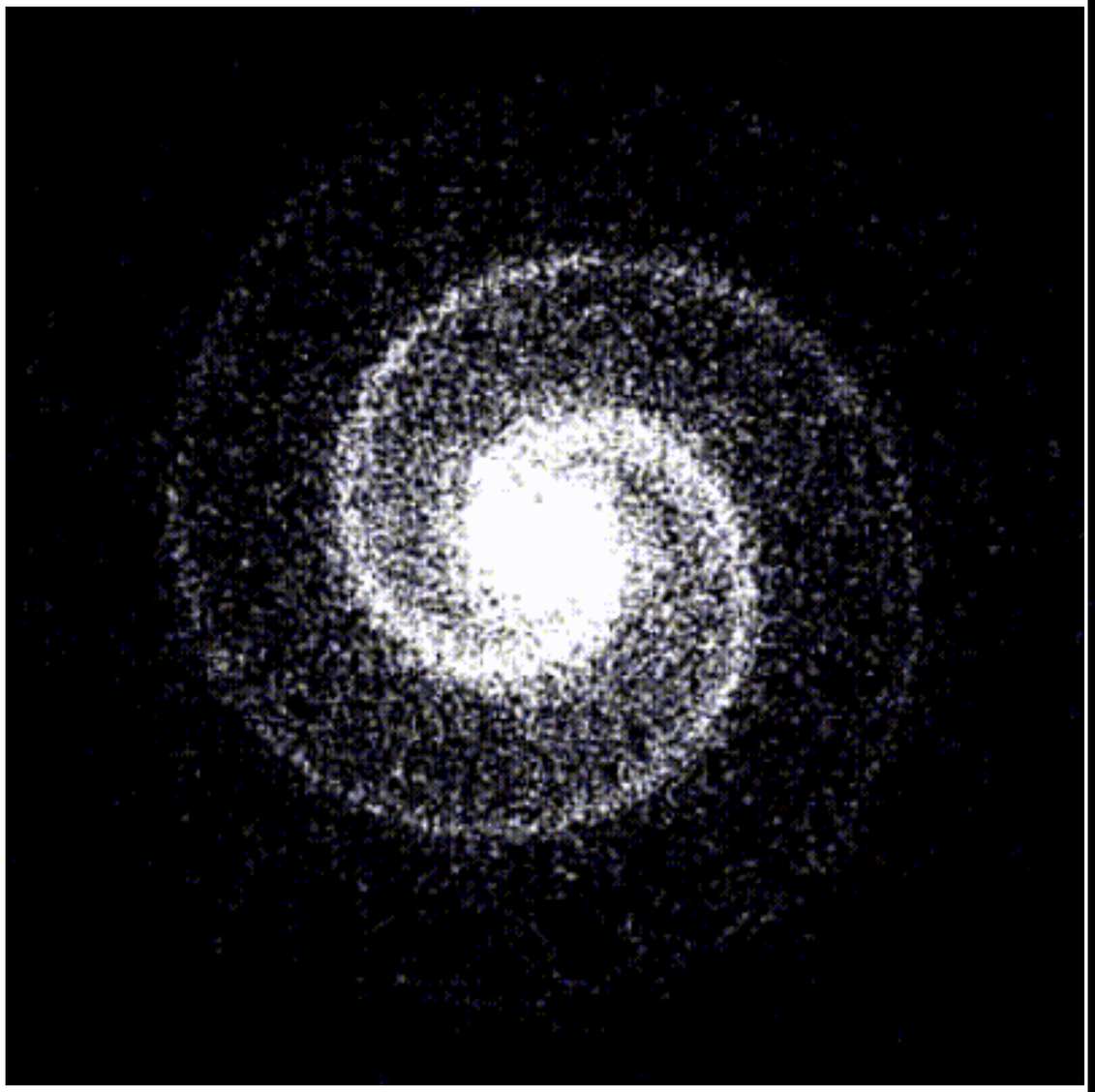
_____

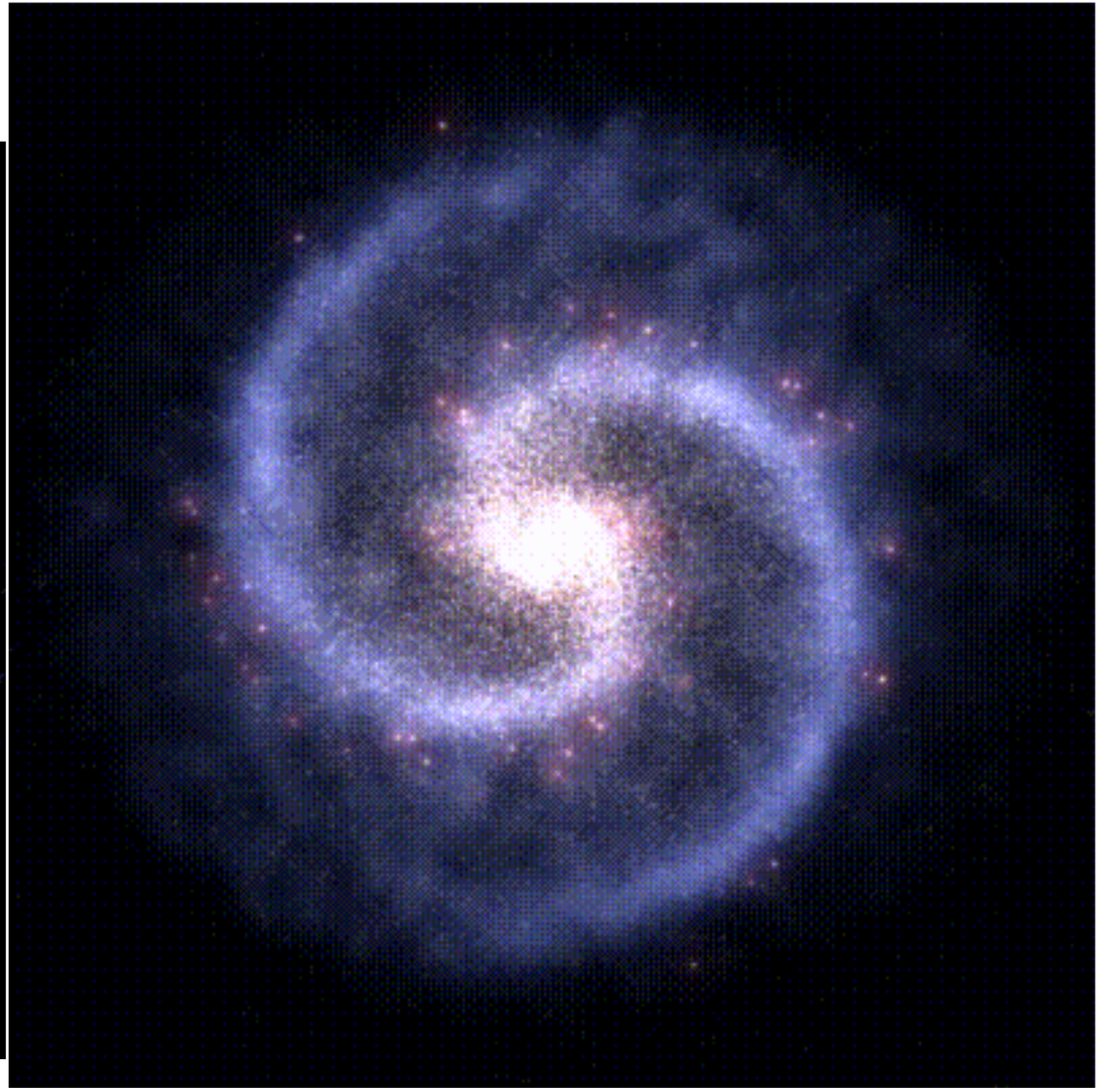
Which aspect did you feel was most instructive?
Project Presentation Both were equally useful Neither were useful

Any suggestions for how the final copy could be improved before it is submitted:


HUBBLE-DE VAUCOULEURS DIAGRAM
Surface Brightness
I(r) —> W/m²/arcsec²
$\log[I(r)] \propto -r$
E0 E1 E2 E3 E4 E5 E6 E7
Ellipticals
S0A
S0B
Lenticular
SAa
SAb
SAc
SAd
SAm
Spirals
Intermediate Spirals
SABa
SABb
SABc
SABd
SABm
Im
dSph
Irregulars
SBa
SBb
SBc
SBd
SBm
Barred Spirals
$\log[I(r)] \propto -r^{1/4}$
$M_V \sim -23$ mag
$L_V \sim 10^{11}\ L_{V,\odot}$
$M_V \sim -21$ mag
$L_V \sim 2 \times 10^{10}\ L_{V,\odot}$

Spiral Arms





Galaxies are not isolated

and R frames. After sky subtraction, the coadded frames were then normalized to their respective exposure times, resulting in pixel values in ADUs/second.

Figure 1.1

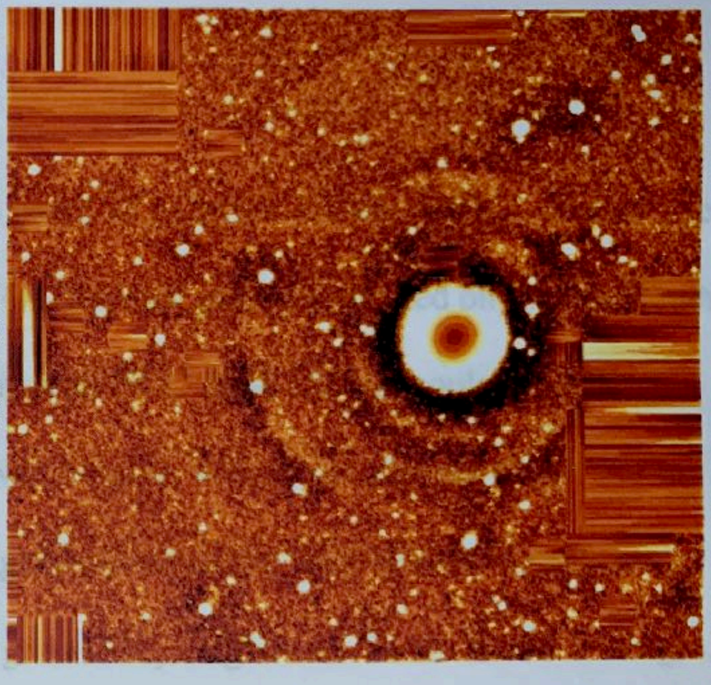
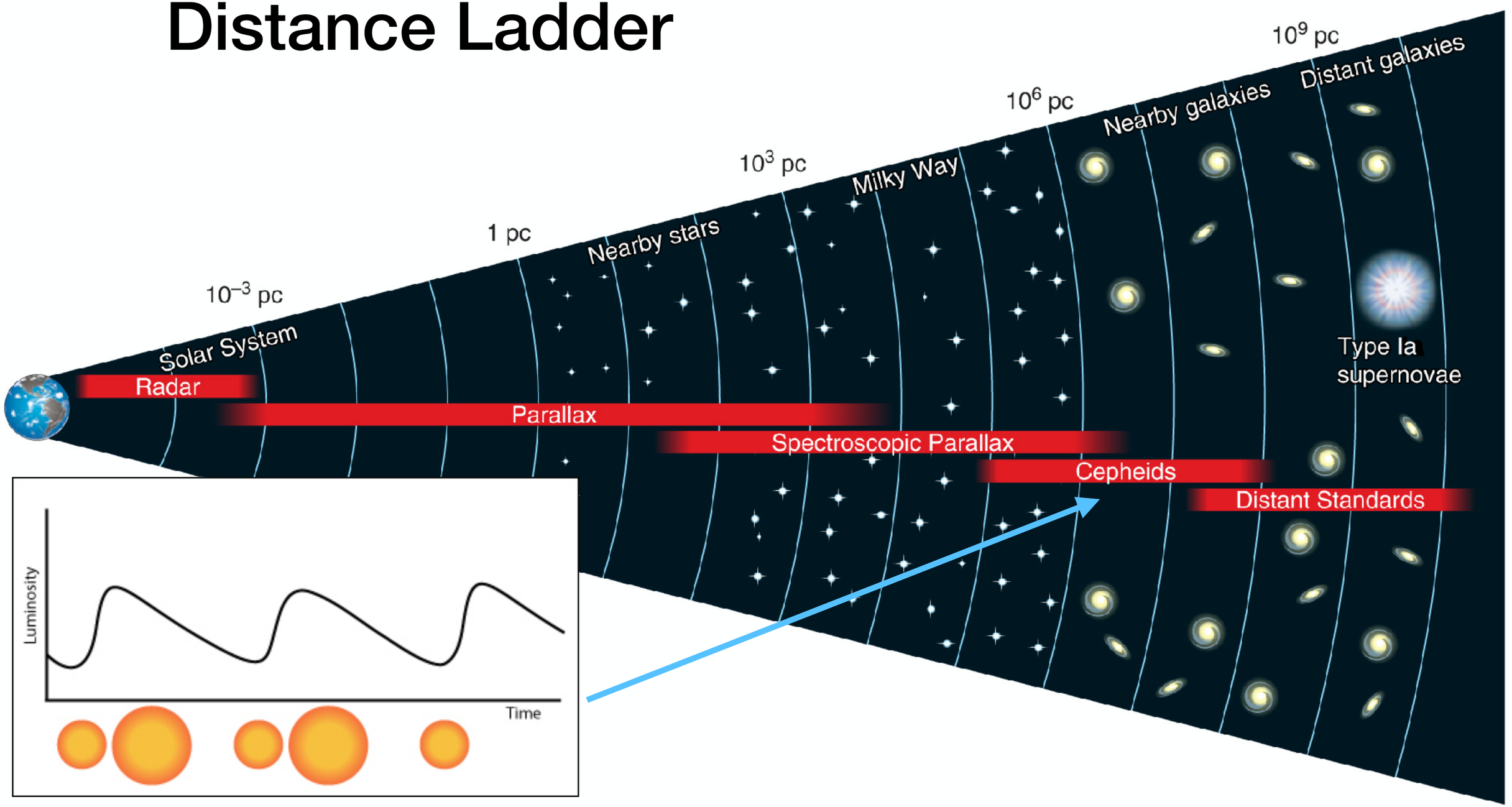
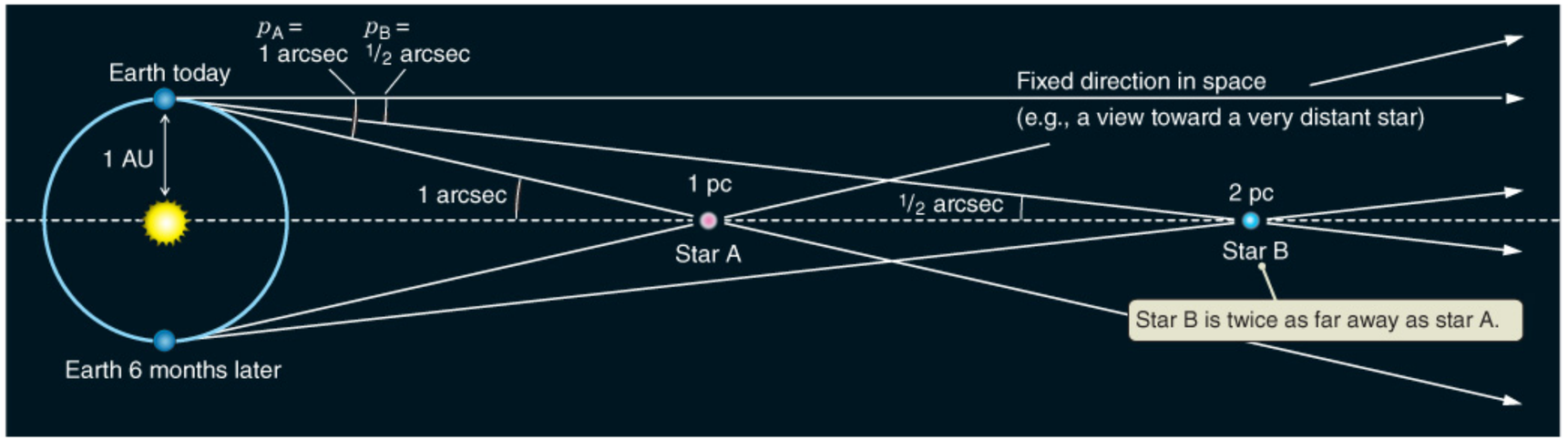


Figure 1.2

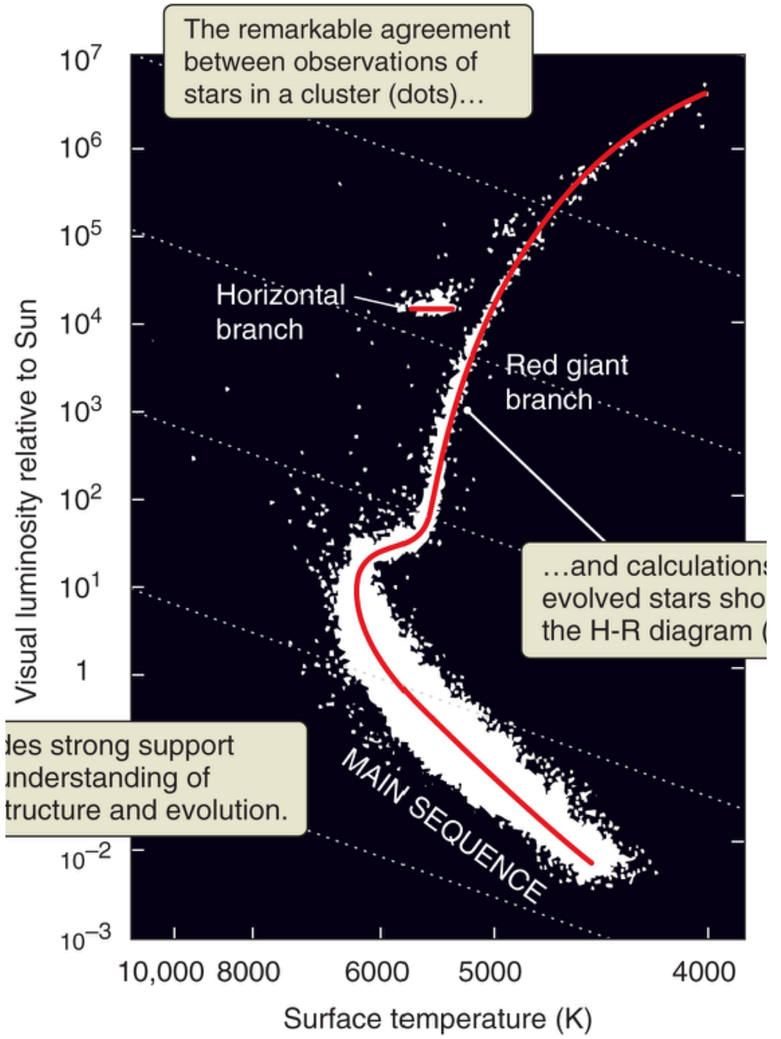
Distance Ladder



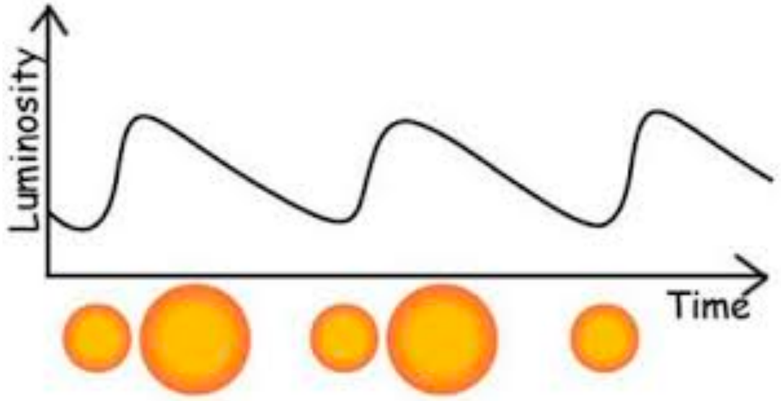
Parallax



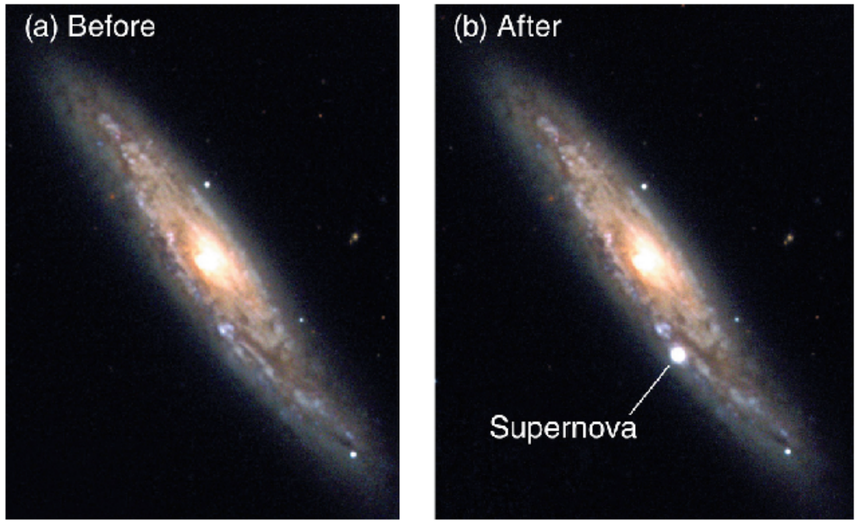
Spectroscopic Parallax



Cepheid Variables

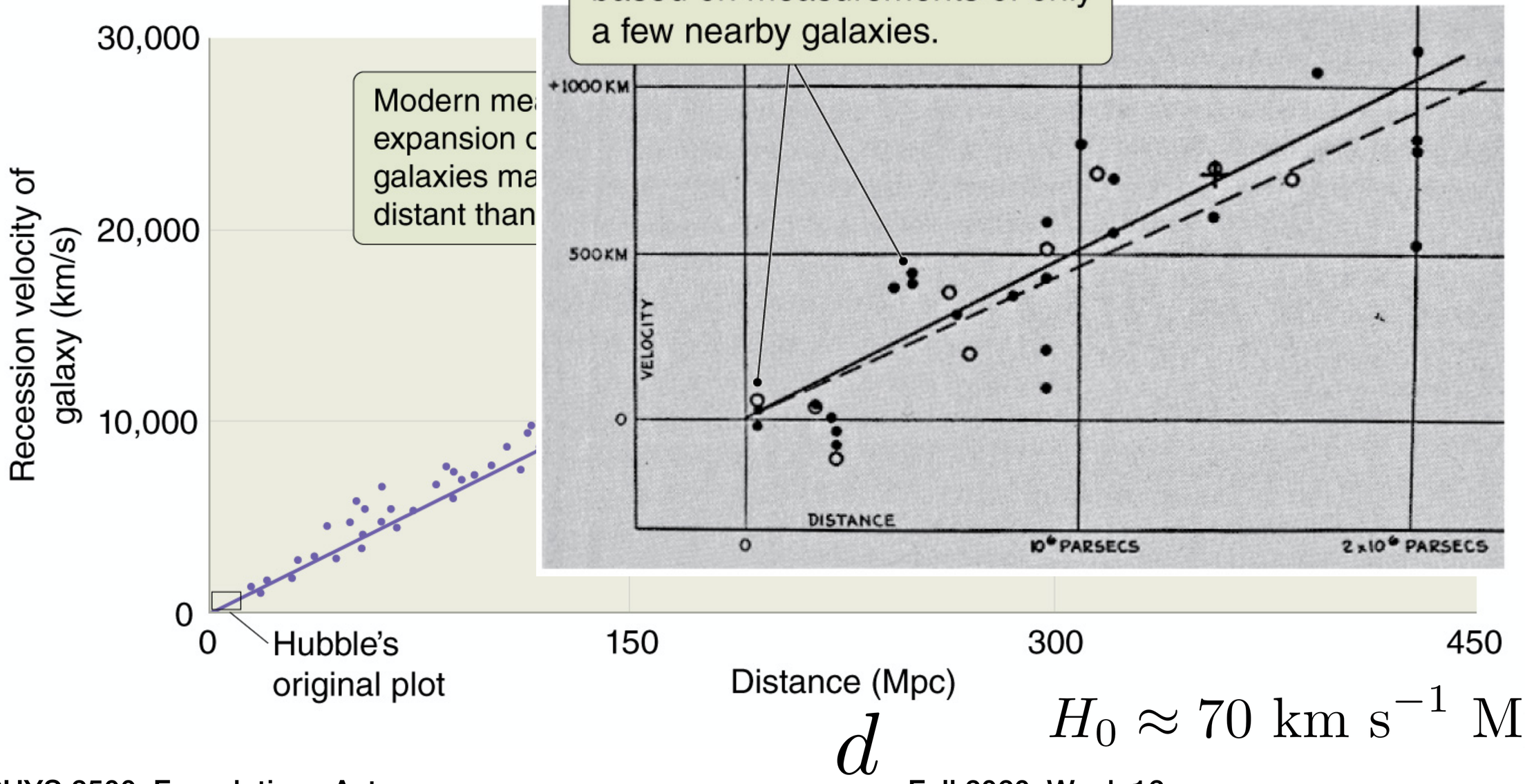


Type Ia SNe



Hubble's Law

$$cz = H_0 d$$

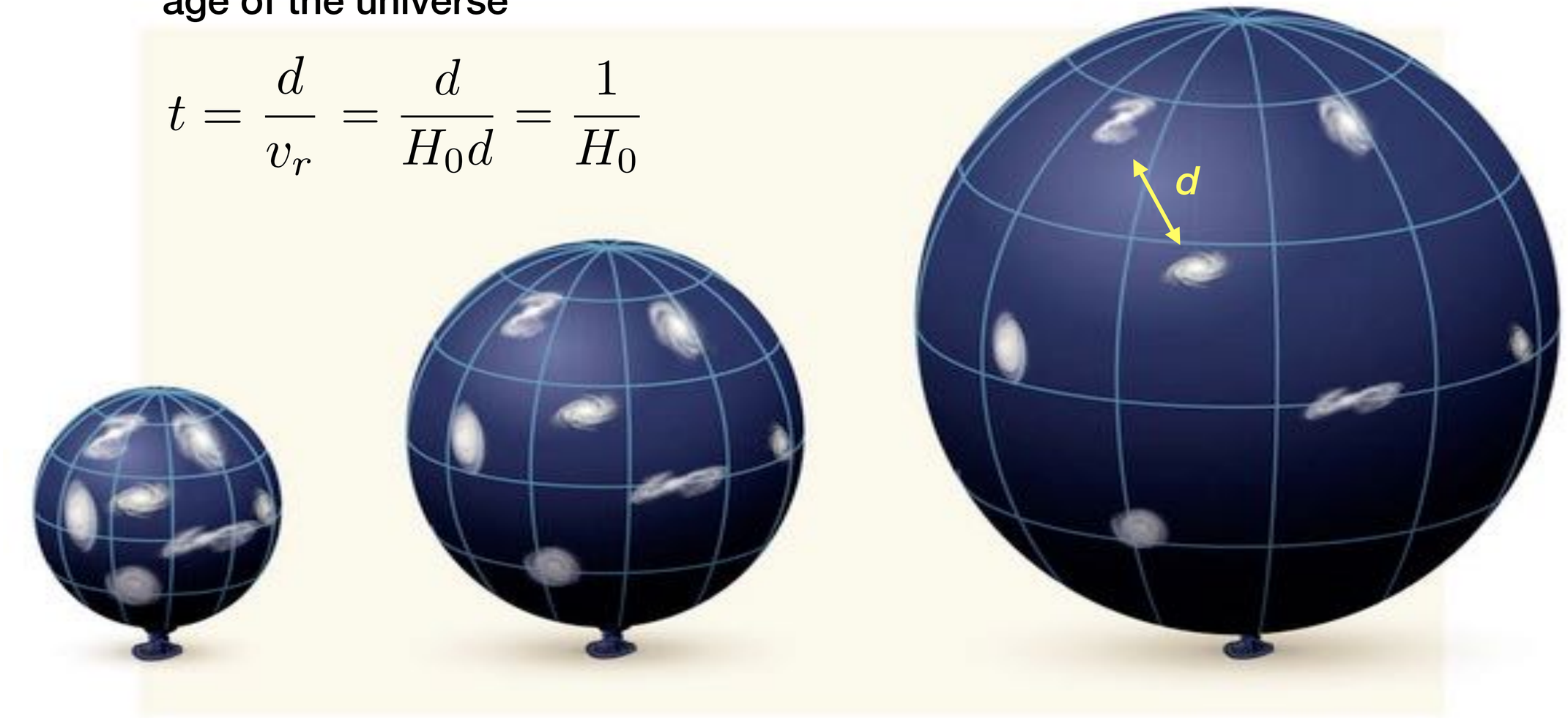


$$H_0 \approx 70 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

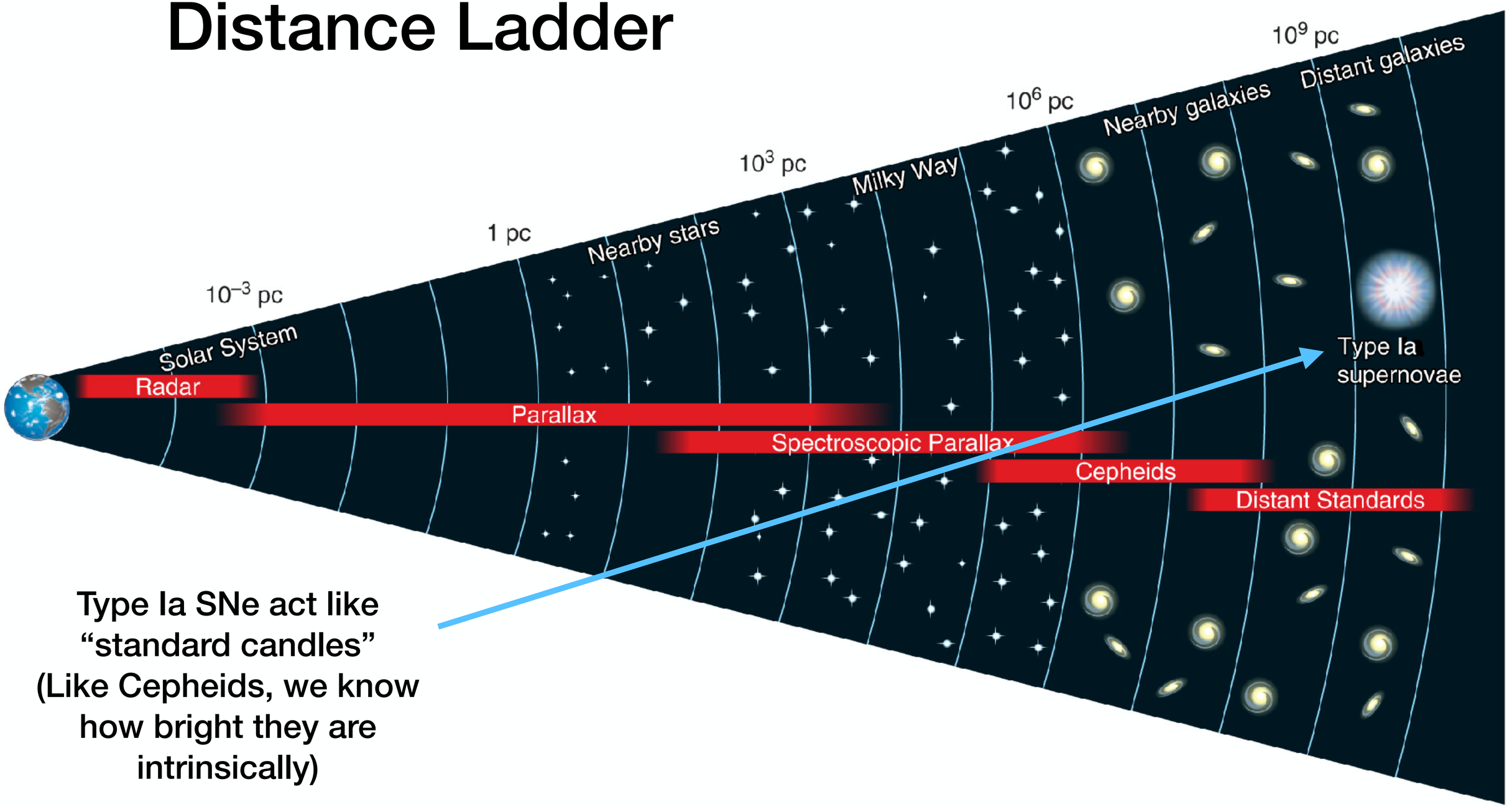
We live in an expanding “balloon universe”

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

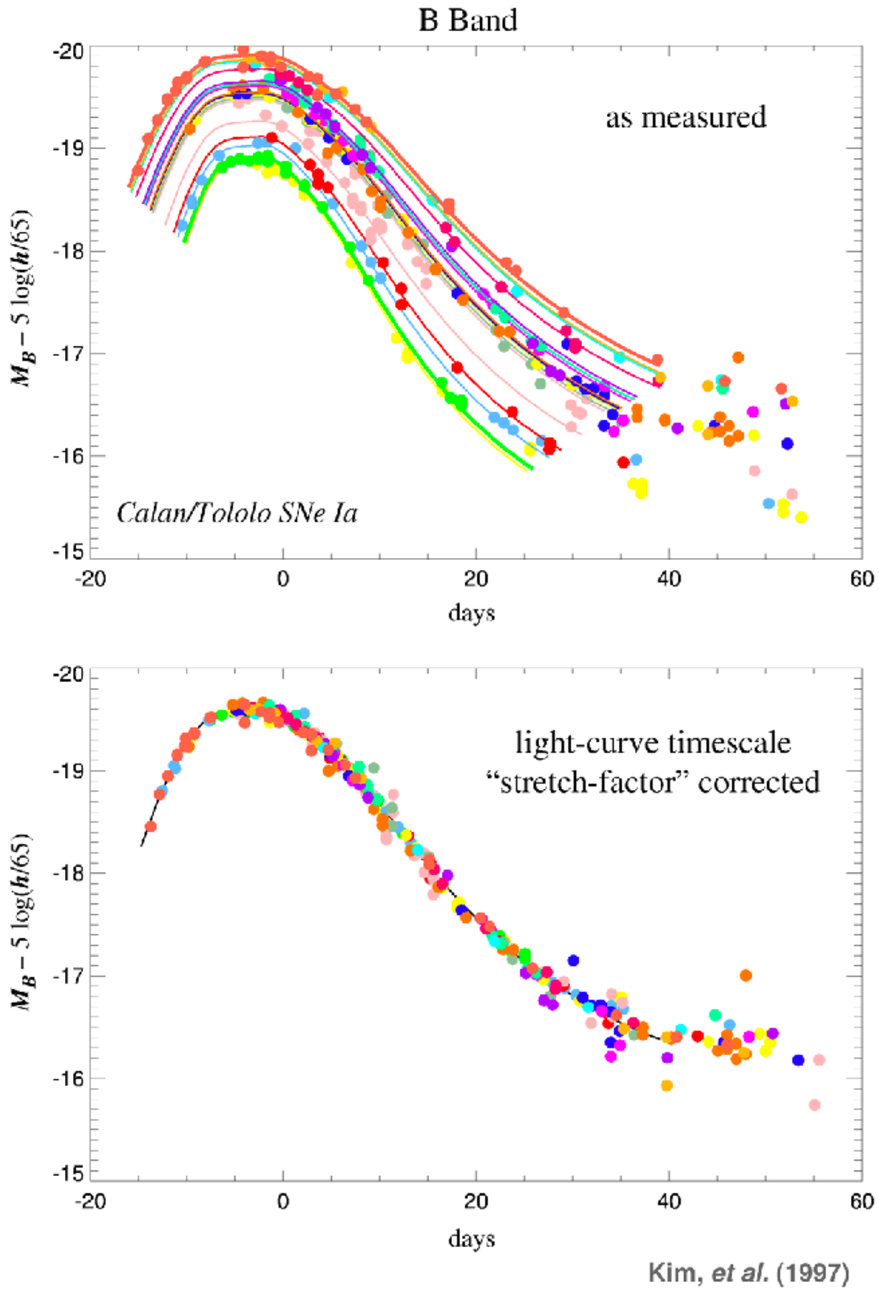
$$t = \frac{d}{v_r} = \frac{d}{H_0 d} = \frac{1}{H_0}$$

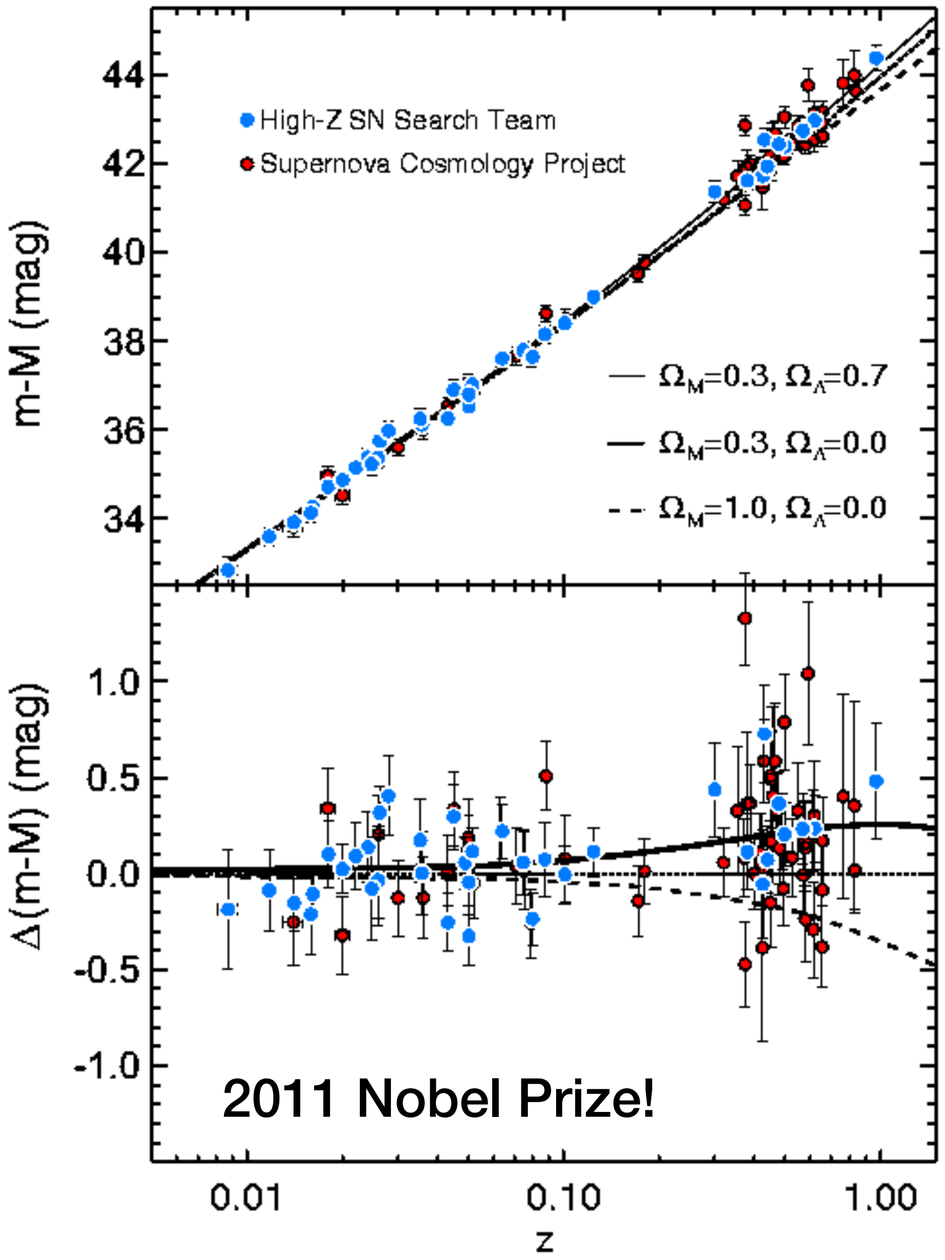


Distance Ladder

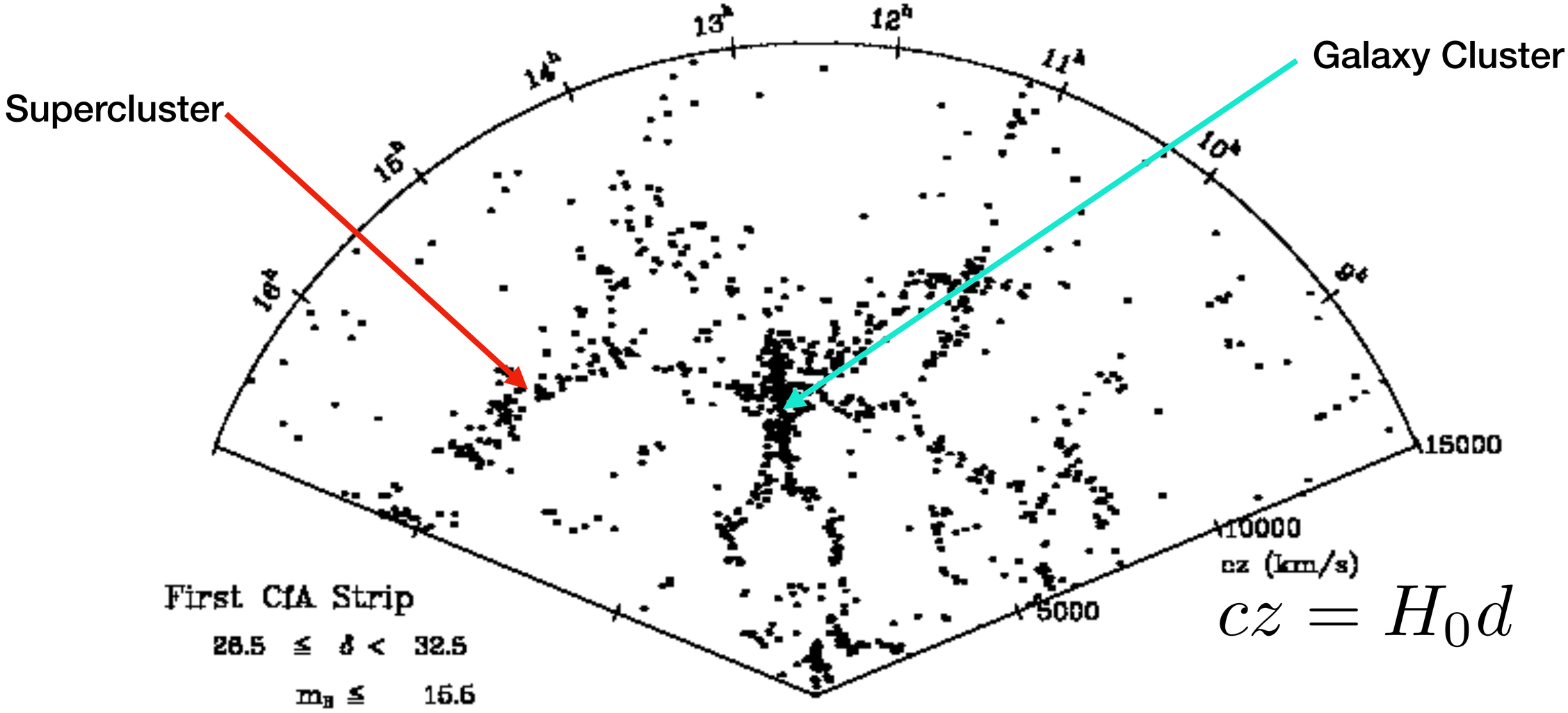


Type Ia SNe act like "standard candles" (Like Cepheids, we know how bright they are intrinsically)


B Band
as measured
Calan/Tololo SNe Ia
$M_B - 5\log(h/65)$
days
light-curve timescale
"stretch-factor" corrected
$M_B - 5\log(h/65)$
days
Kim, *et al.* (1997)

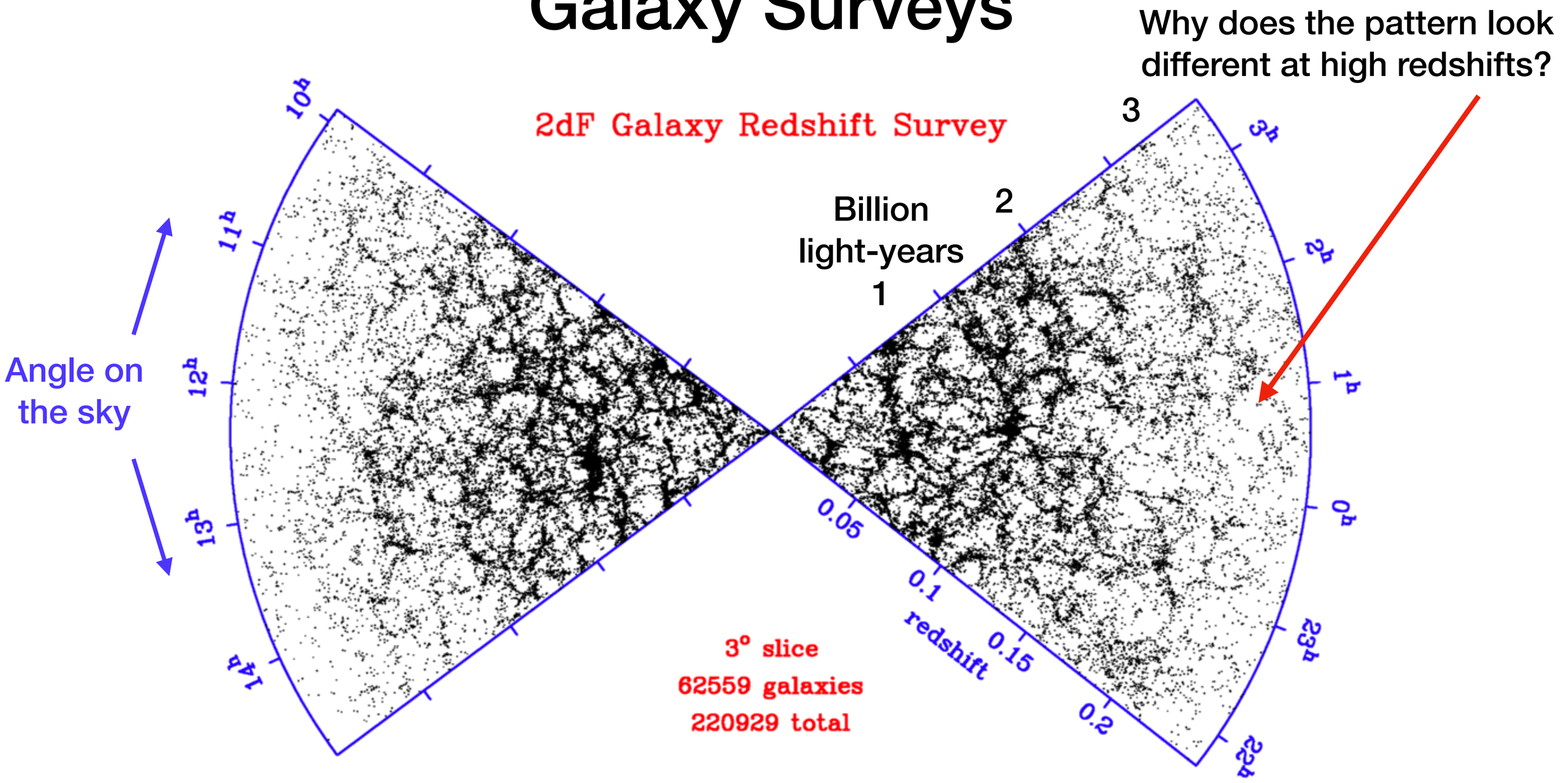

High-Z SN Search Team
Supernova Cosmology Project
Ω_M=0.3, Ω_Λ=0.7
Ω_M=0.3, Ω_Λ=0.0
Ω_M=1.0, Ω_Λ=0.0
m-M (mag)
Δ(m-M) (mag)
z
2011 Nobel Prize!

Finger of God: the Coma Cluster



$$cz = H_0 d$$

Galaxy Surveys

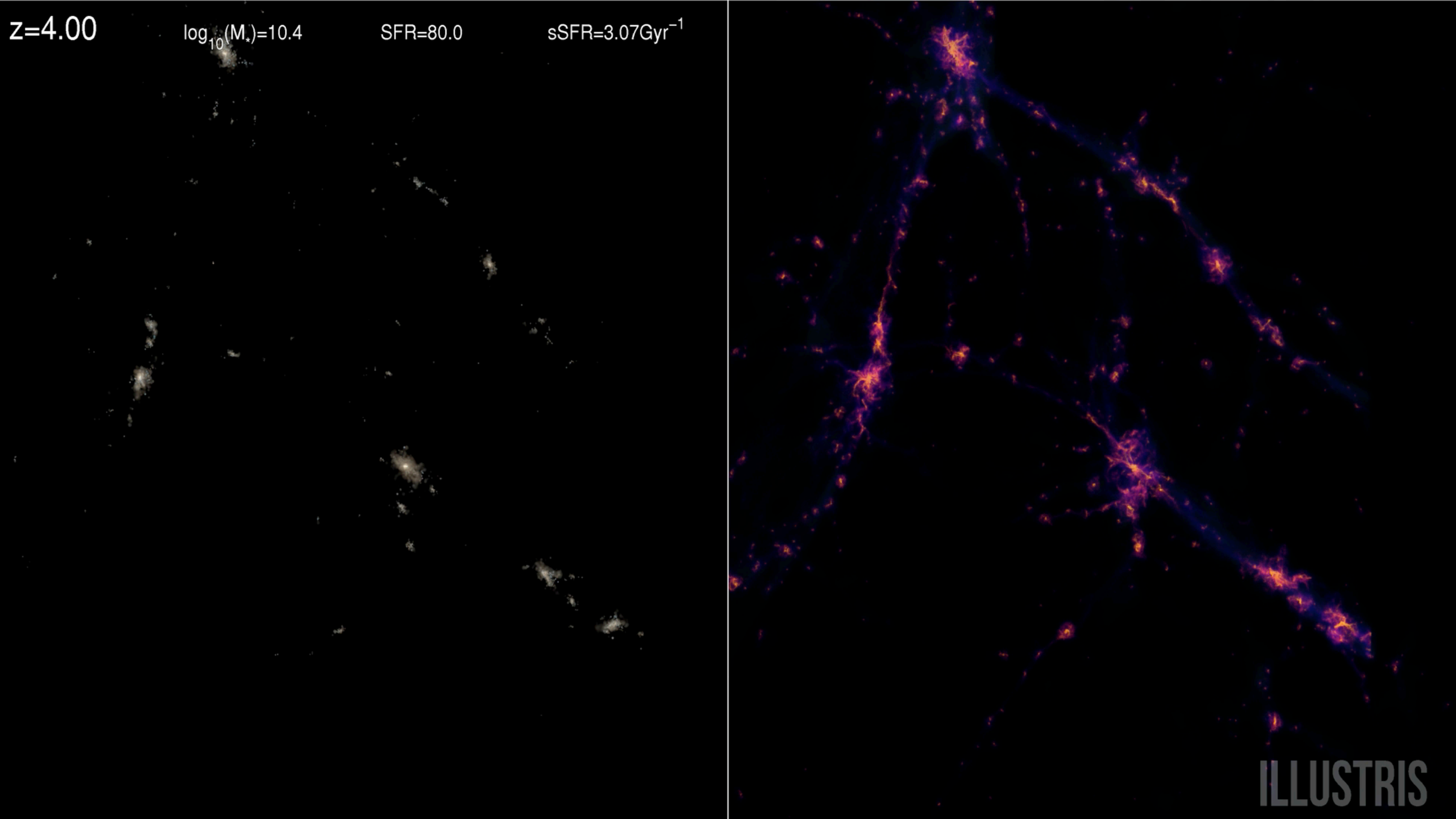


Computer Simulations of Structure Formation

https://www.illustris-project.org/media/

10 Mpc box showing the formation of galaxies in filaments from 0.5 Gyr to the present:
https://www.illustris-project.org/movies/illustris_movie_cube_sub_frame.mp4

1 Mpc box showing the formation of an elliptical galaxy:
https://www.illustris-project.org/movies/illustris_movie_elliptical_formation_1pMpc.mp4


z=4.00
log10(M*)=10.4
SFR=80.0
sSFR=3.07Gyr−1
ILLUSTRIS