Introduction & Basic Concepts

Karina Caputi

Physics of Galaxies 2019-2020 Q4
Rijksuniversiteit Groningen

Course Information

Teachers: Prof. Karina Caputi (lectures)
Anqi Li (tutorials)
Giulio Rosani (tutorials)

Timetable: Lectures on Wed (11-13 h) and Fridays (9-11 h)
Tutorials Thursdays (9-11 h)
Check schedule *

Course Assessment:

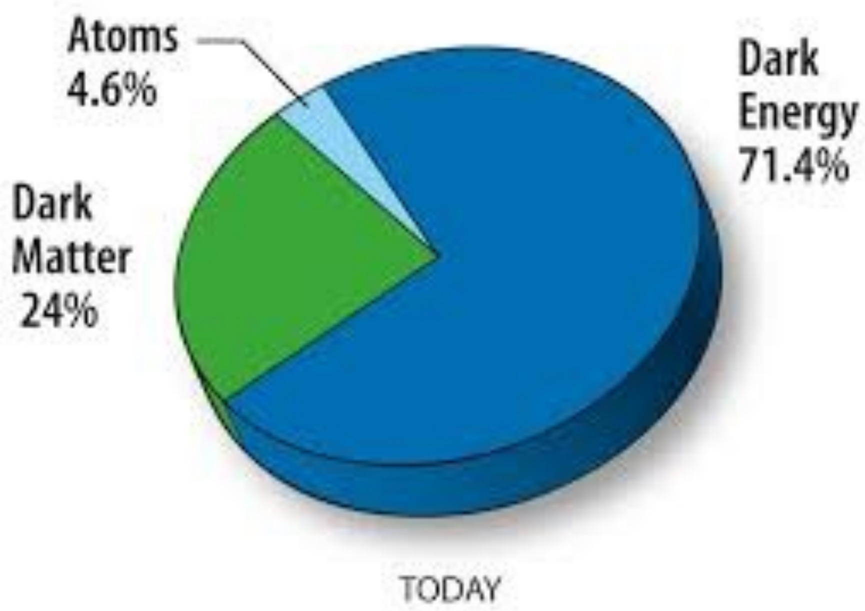
Special Assignment (30%)	Deadline: 22 May 2020
Final Exam (70%)	17 June 2020 (resit 8 July 2020)

All necessary info available at:

* https://www.astro.rug.nl/~karina/pog_schedule.html

This Course in Context

The Universe we live in

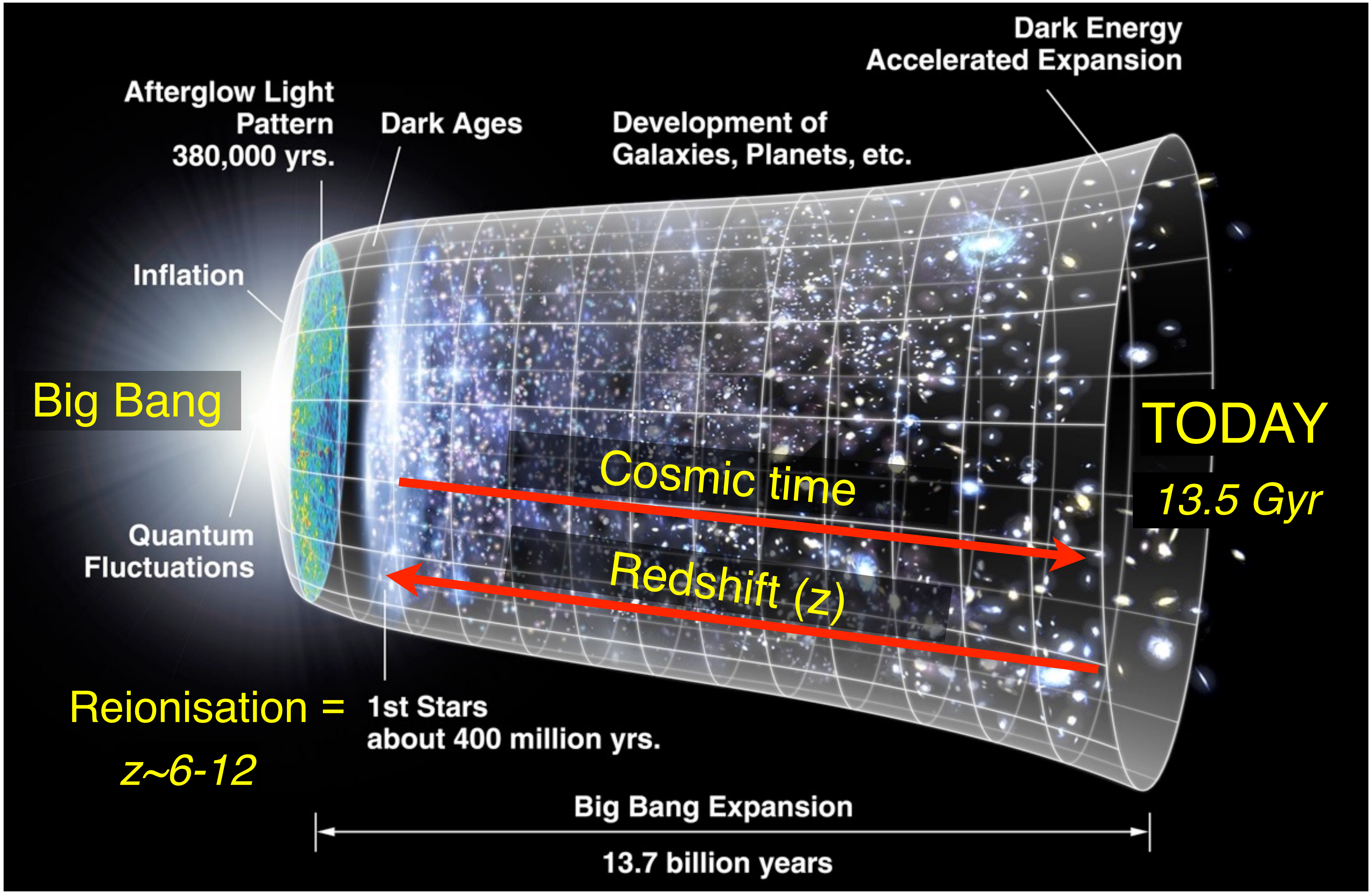


In this course we will mostly deal with baryonic matter

Gravitational collapse makes that most baryons are aggregated in stars and galaxies

Galaxies are gravitational bound units composed of stars, gas and dust, which live in dark matter haloes

The Universe timeline

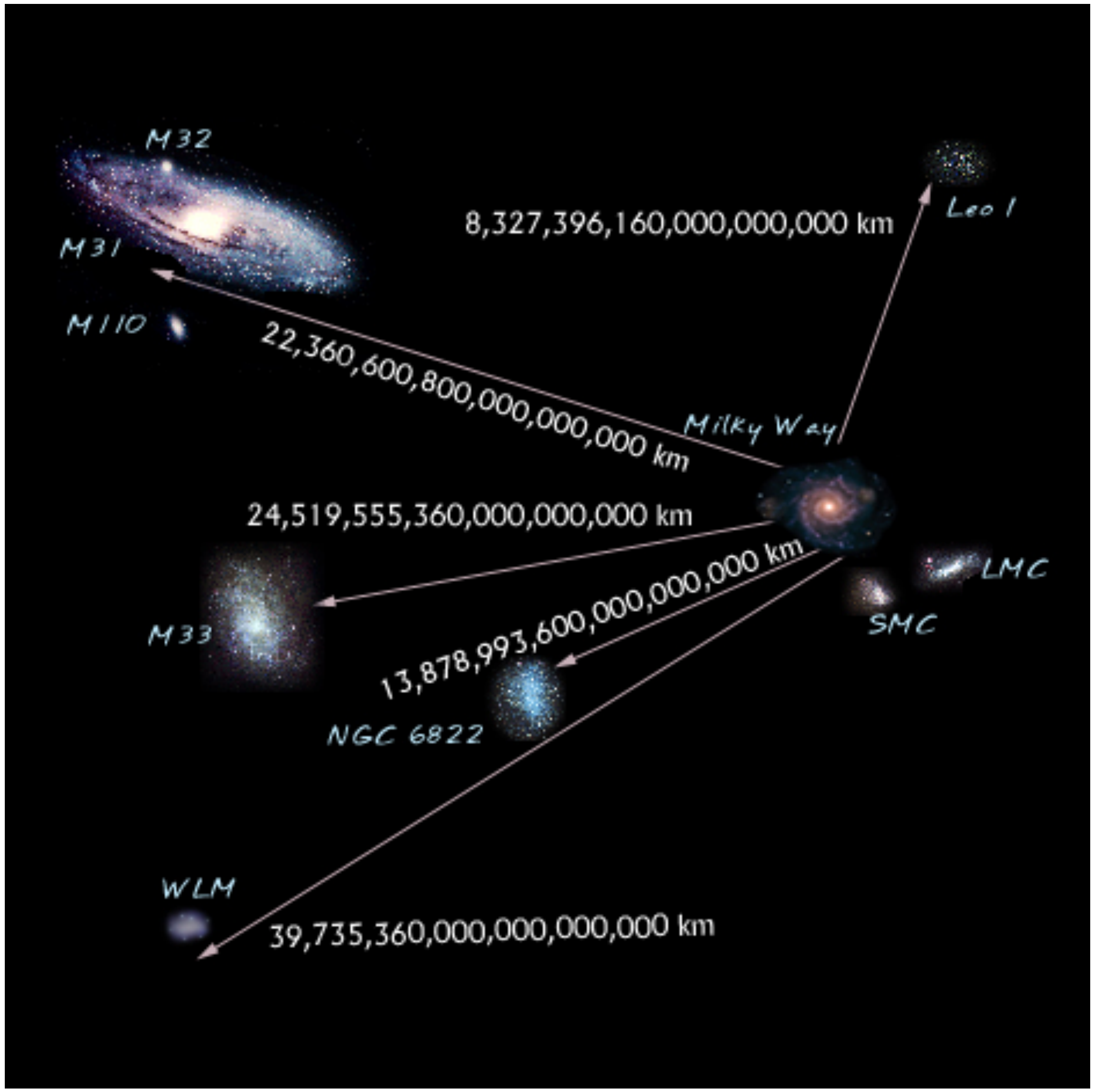


Galaxies in the Universe

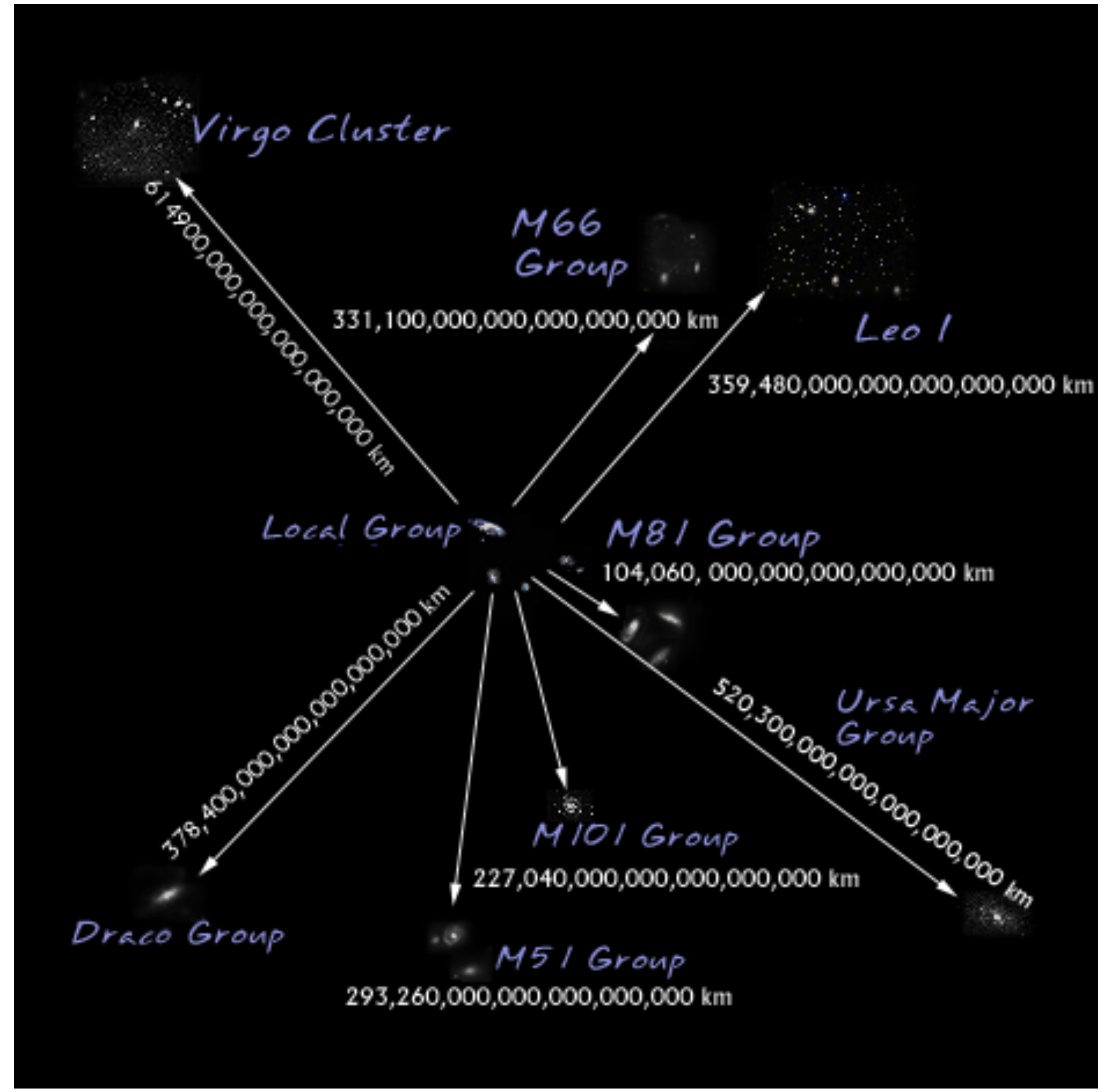
Our own Galaxy: the Milky Way

The Milky Way’s neighbourhood

The Local Group



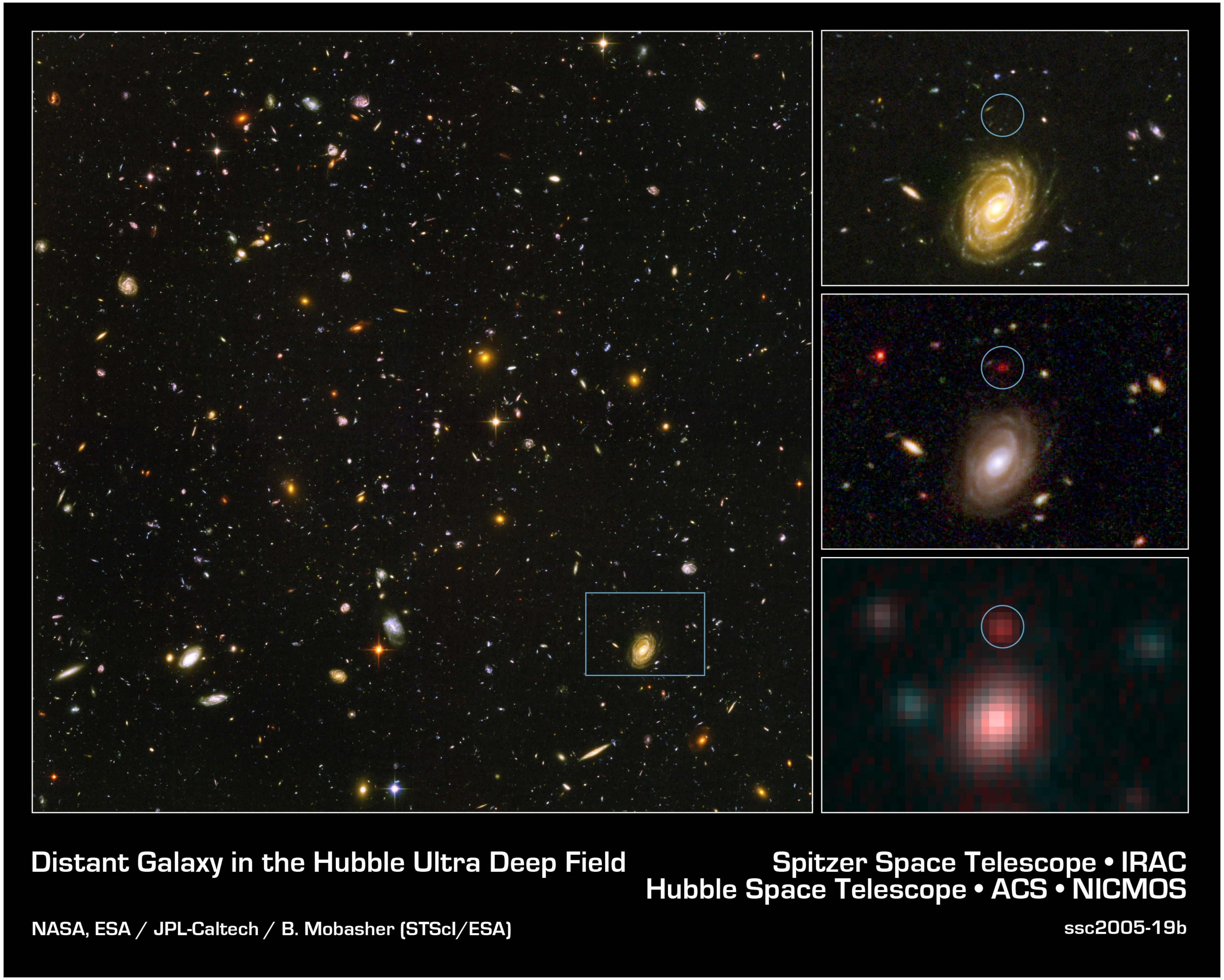
The Local Supercluster



1 light year = 9.461 x 10^{15} m

Picture credit: NASA

Distant Galaxies

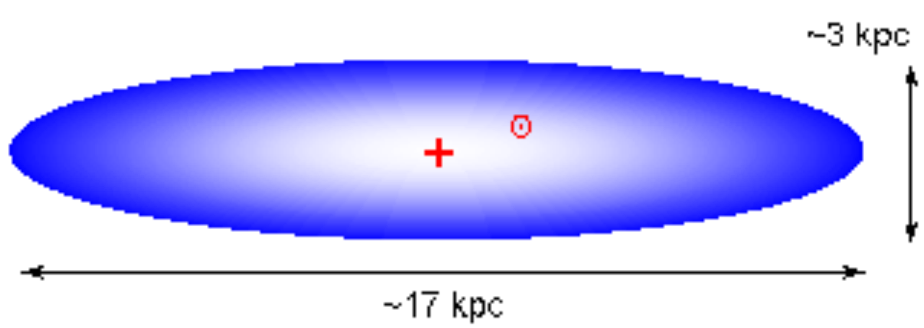


$1 \text{ Mpc} = 3.086 \times 10^{22} \text{ m}$

A bit of history…

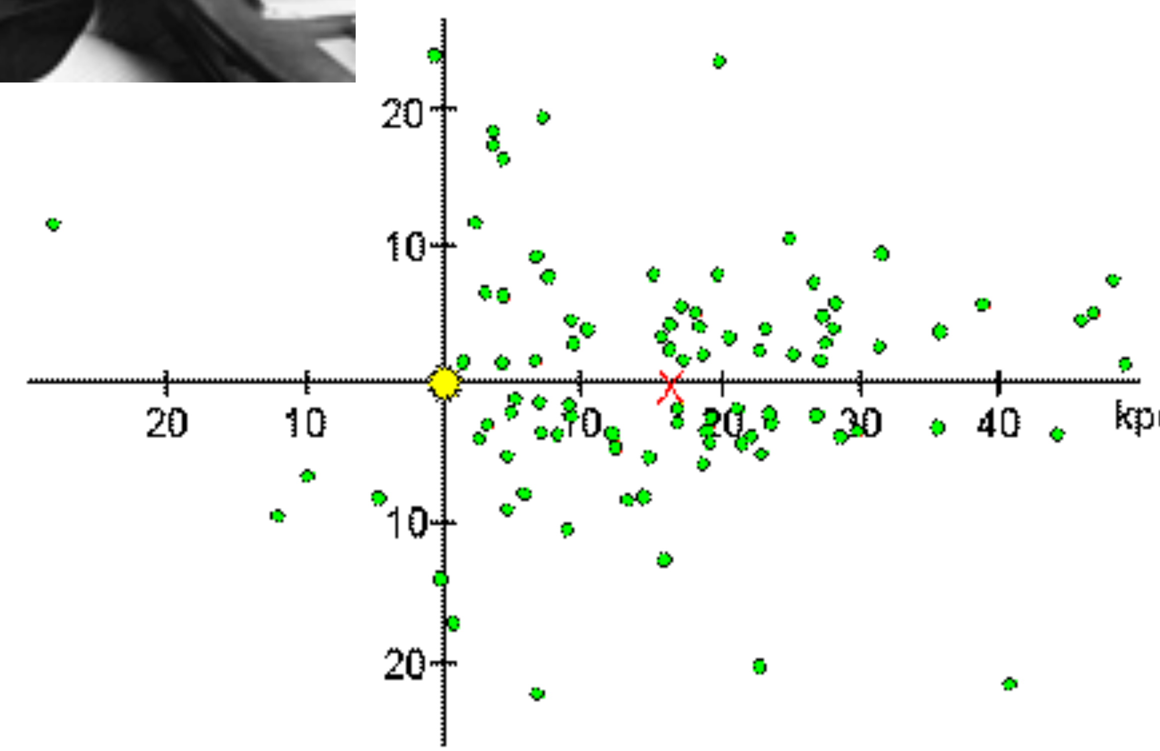
The Universe's view a century ago

Kapteyn Model (1922)



kpc = kiloparsec = 1000 pc

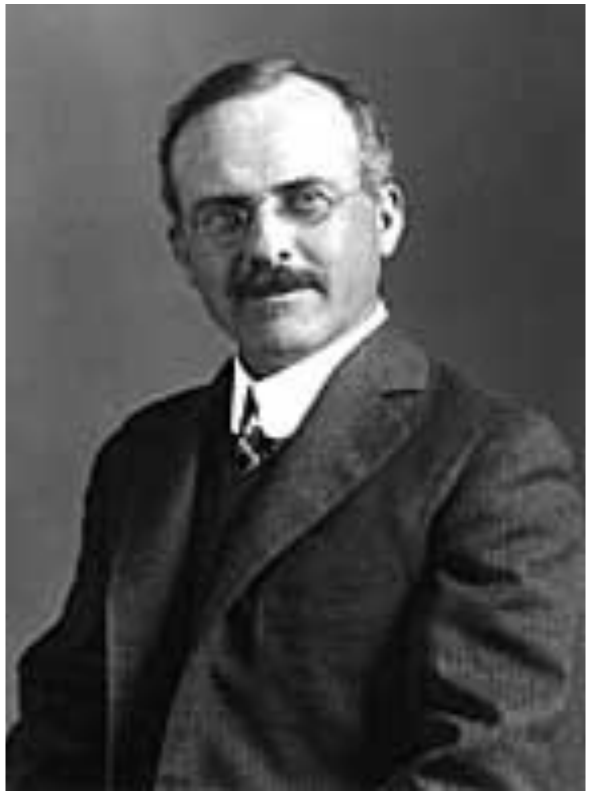
Shapley's model



Picture credit: *http://www.astronomy.ohio-state.edu/~pogge/Ast162/Unit4/milkyway.html*

The Great Debate (1920)

Harlow Shapley

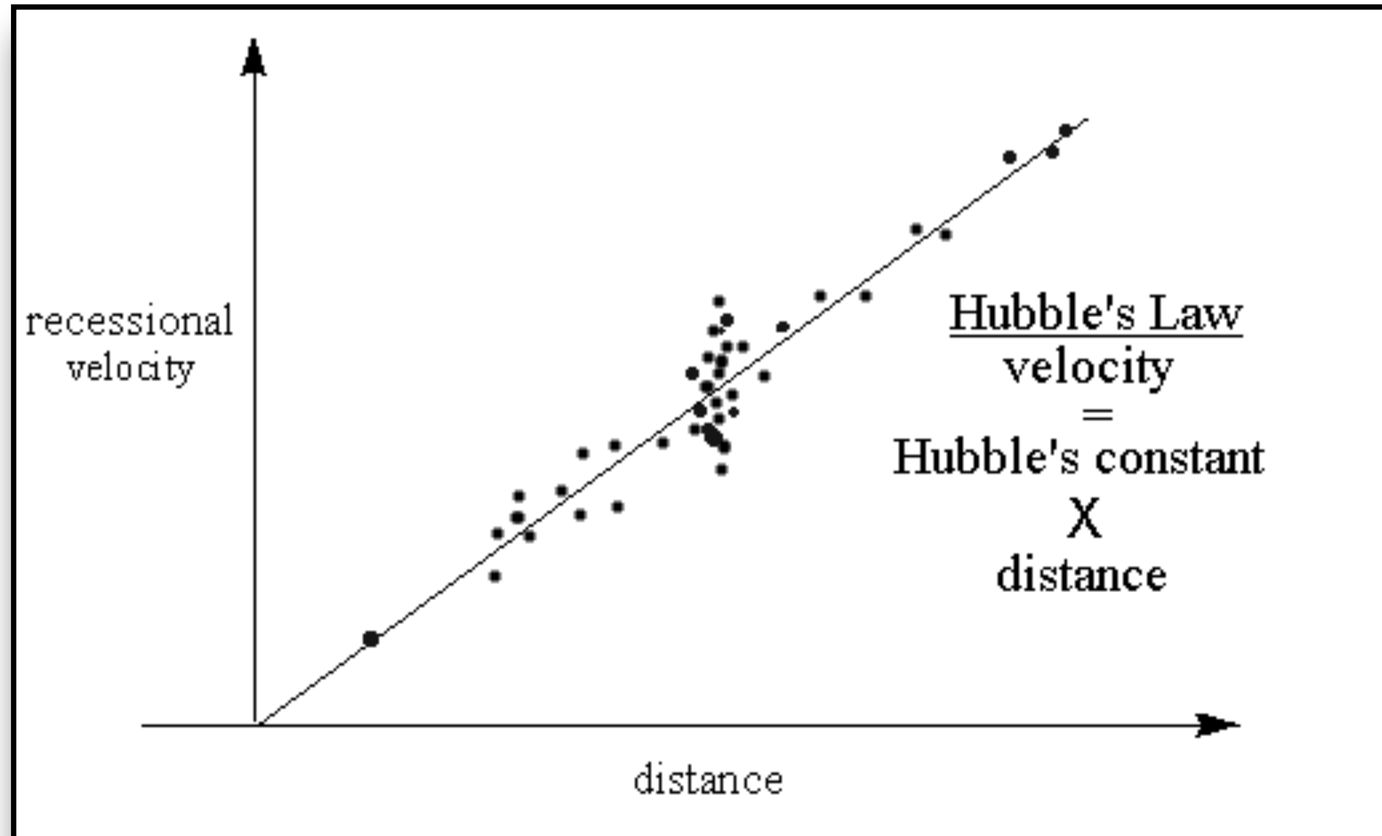


Heber Curtis

<u>Point of conflict:</u> the nature of observed 'spiral nebulae'

The cosmology revolution

Edwin Hubble



Hubble's Law:

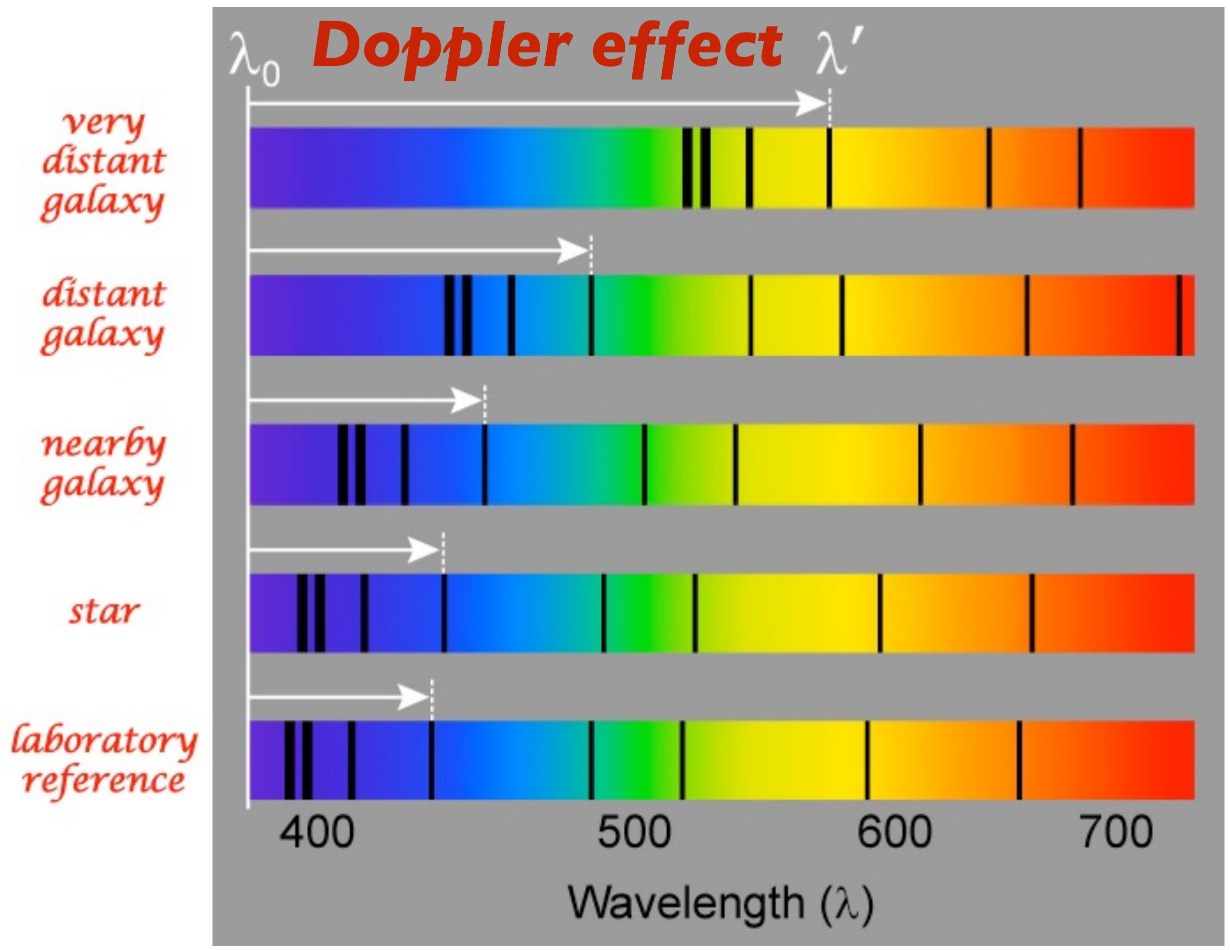
$v = H0 \times d$

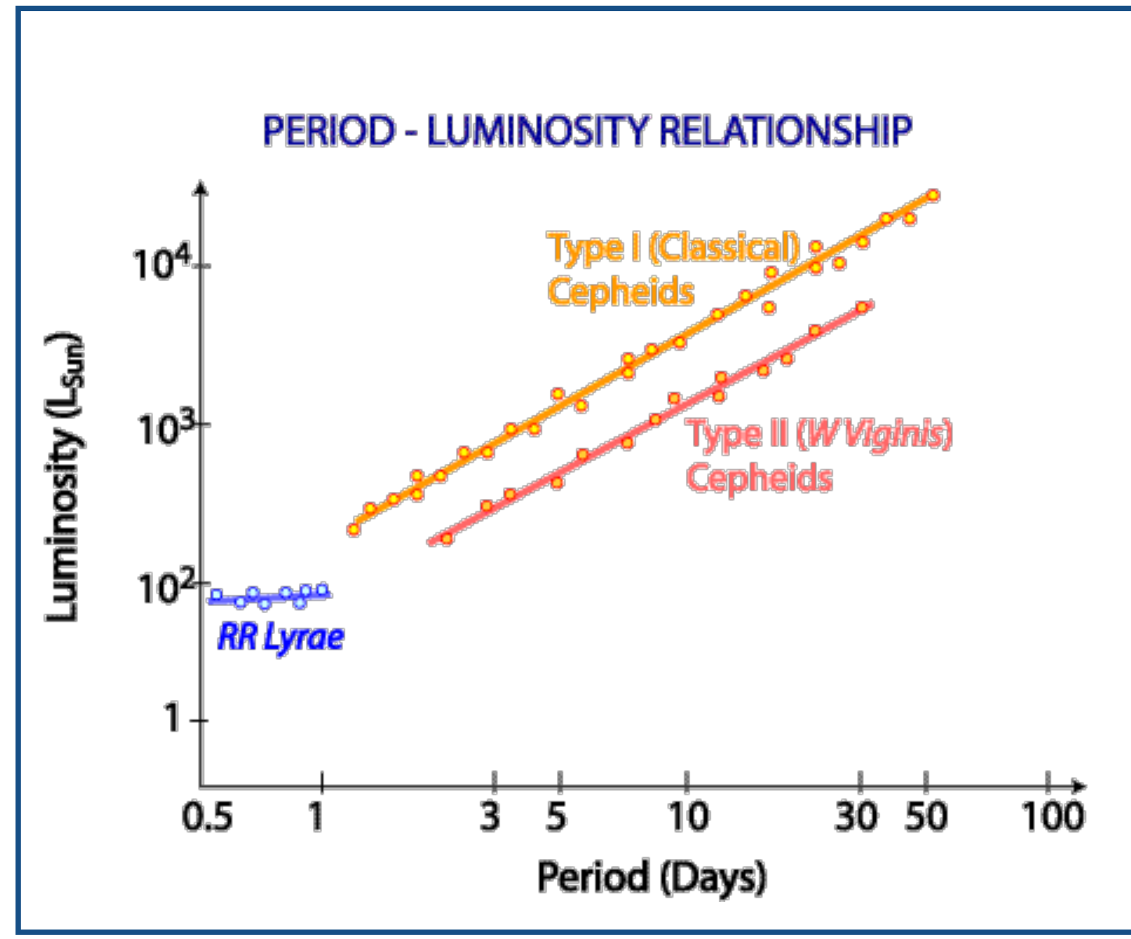
The Universe is expanding!

Karina Caputi 15 Feb 2017, 22:09
Typical distances on x axis up to 100 Mpc ~ 10^21 km. This is the typical maximum scale in which distances can be measured through Cepheids. Supernovae type I can be used up to at least 1000 Mpc.

How we measure distances

In the nearby Universe, we calibrate Hubble's Law $v = H0 \times d$





In the distant Universe, we only measure spectral line shifts (*redshifts*) and infer distances

$\boxed{z = (\lambda o - \lambda e) / \lambda e}$ $\boxed{v_r = c\,(\lambda o - \lambda e) / \lambda e}$ (if $v_r << c$)

Basic Concepts

Measuring the light of a point-like source

$$L = 4\pi d_L^2 f$$

$$f \equiv \int f_\nu(\nu) d\nu = \int f_\lambda(\lambda) d\lambda$$

Angular separation of two sources at the radial distance from us:

$\alpha = D/d$ with α in radians.

Telescope diffraction limit:

$\theta = 1.22 \times \lambda/D$ with θ in radians.

Stefan-Boltzmann:

$$L = 4\pi R^2 \sigma_{SB} T^4$$

The magnitude system

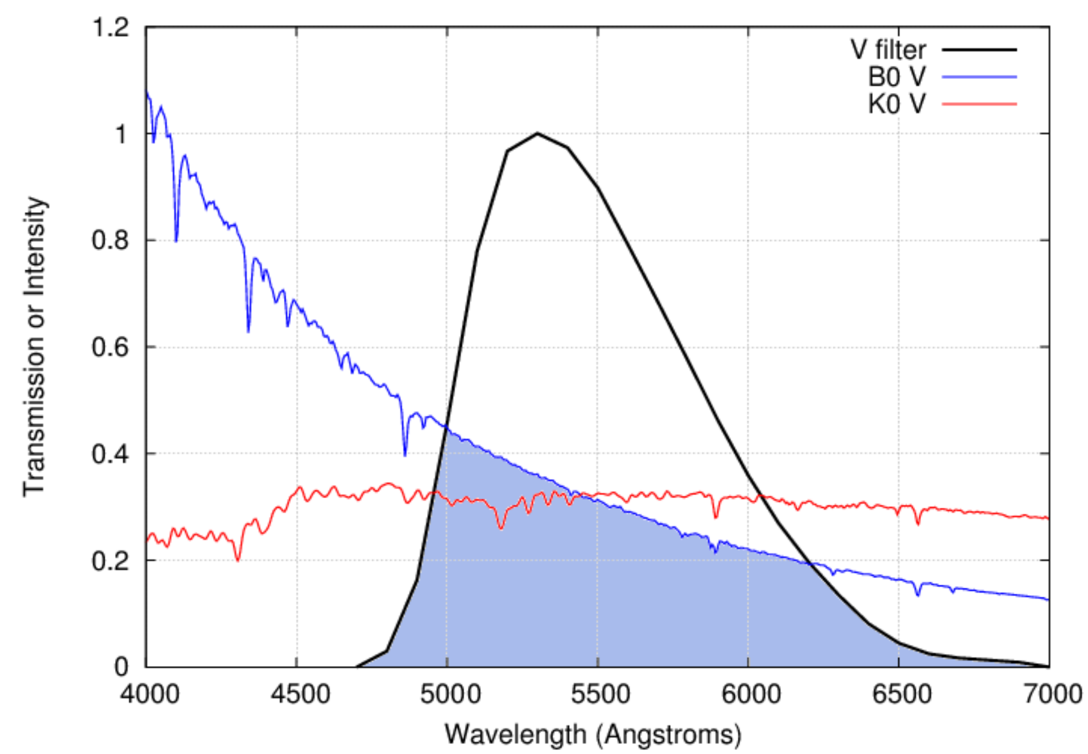
$$m = -2.5\, log_{10}(f_\nu/f_0) = -2.5\, log_{10}(f_\nu) + ZP$$

f_ν -> flux density, per unit of frequency
(c.g.s. units: erg s-1 cm-2 Hz-1)

Flux density measured with a filter in a passband:

$$f_\nu(\lambda_{eff}) \equiv \frac{\int_0^\infty f_\nu(\lambda)\, T(\lambda) d\lambda}{\int_0^\infty T(\lambda) d\lambda}$$

$$\lambda_{eff} \equiv \frac{\int_0^\infty \lambda\, T(\lambda) d\lambda}{\int_0^\infty T(\lambda) d\lambda}$$



Picture credit: spiff.rit.edu

More photometry

Source (A-B) colour:

$$m_A - m_B = -2.5\, log_{10}(f_\nu^A / f_\nu^B)$$

If λ_A < λ_B then:
negative colour -> “blue” source
positive colour -> “red” source

Effect of dust extinction (uniform distribution):

$$f_{obs} = f_{em}\, e^{-\tau_\lambda}$$

optical depth

Absolute magnitudes:

$$m - M = -2.5\, log_{10}(f/F) = 5\, log_{10}(d/D)$$

distance modulus

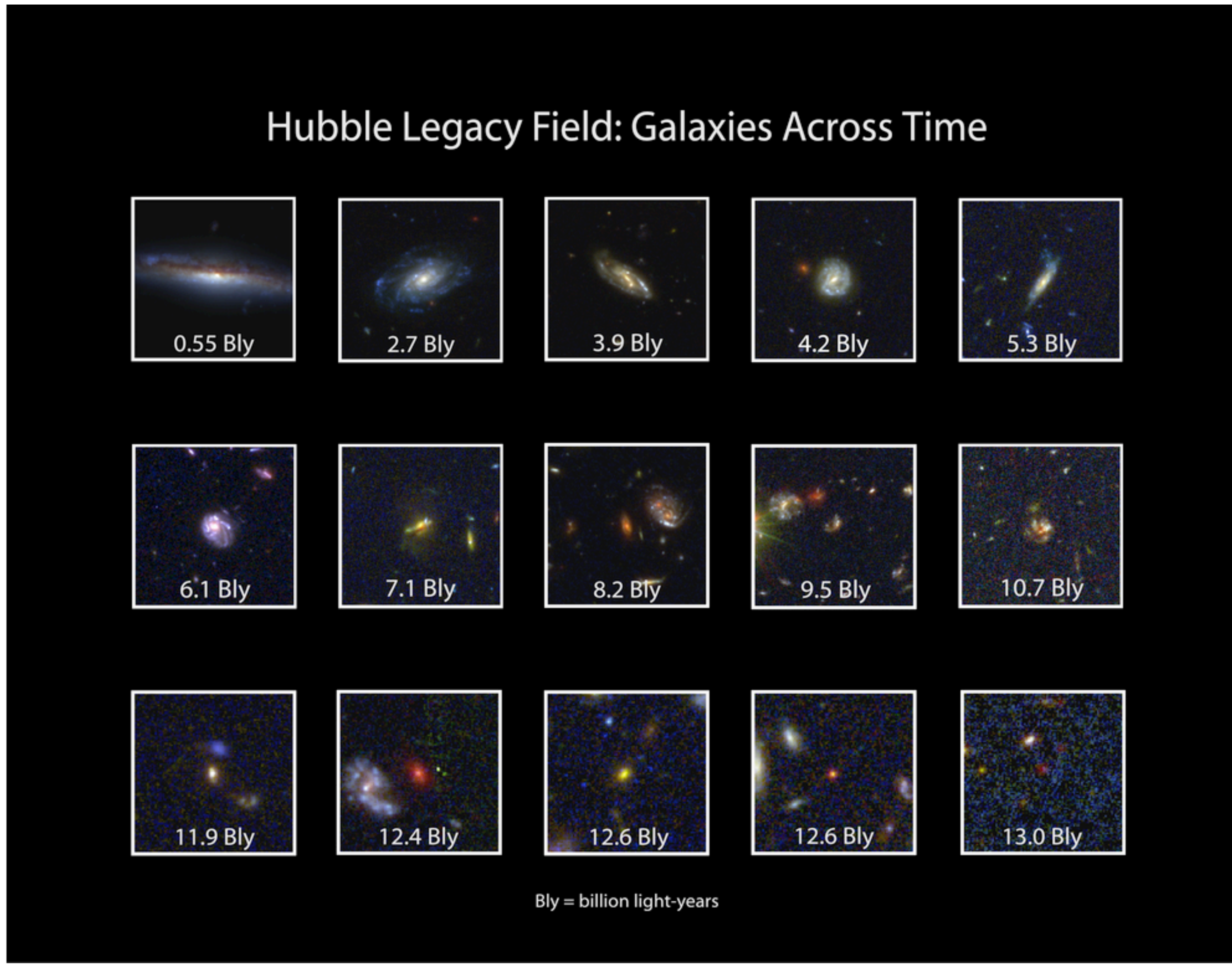
10 pc

Nearby versus Far-away Galaxies

Study of nearby and far-away galaxies

The possibilities and techniques to study nearby and far-away galaxies are different, as the level of resolution is different

Galaxy at z~0



Picture credit: *NASA, ESA, Illingworth et al. (Hubble Legacy Field Team)*