

ASTROPHYSICS

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Assumptions

- Brightest dots in the galaxy images are bright stars
- Bright stars have the same luminosity
- Inverse Square Law:

 $L = F \times 4 \pi d^2$

- Spectra of galaxies
 - Doppler shift:

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

HUBBLE'S LAW



HUBBLE'S CONSTANT



EXERCISE

If all galaxies were twice as far what would be the Hubble's constant?

v = H d 32 km/s/Mpc

80 Mpc

10.000 km/s

EXERCISE

The Andromeda Galaxy is approaching the Milky Way at 266 km/s. The distance is approx. 10⁶ pc. How long will it be until they collide?



 $t = 1.1 \ 10^{17} \text{ sec}$ $t = 3.5 \ 10^9 \text{ years}$

COSMOLOGICAL PRINCIPLE

- Homogenous
- Isotropicdirection



EXPANSION

Hubble:

- Galaxies are moving away.
- The universe is expanding!
- Homogenous
- Isotropic





HUBBLE TIME



HUBBLE TIME – AGE OF THE UNIVERSE

- Simple logic!
 - If things are expanding; at some point in the time everything was at one single point.
- Let's go back to when nothing has started to expand.
- Assume: the Hubble constant remained unchanged.

$$v = H d$$
 $t = \frac{1}{H}$

$$t \approx 14 \cdot 10^9 years$$

OLBER'S PARADOX



COSMIC MICROWAVE BACKGROUND



Wilkinson Microwave Anisotropy Probe

BIG BANG EXPANSION



NOTE: The numbers in cosmology are so great and the numbers in subworke physics are so small dat it is often necessary to express them in exponential form. Ten multiplied by itself, or 100, is written as 10². One theorem is written as 10³. Similarly, one-benth is 10⁻¹, and one-hundredth is 10⁻².

Source: The Birth of the Universe: The Kinglisher Young People's Book of Space TIME Graphic by Ed Gabel

BIG BANG EXPANSION



INFLATION



http://link.springer.com/openurl?genre=book&isbn=978-3-642-54083-7

TIMELINE











DARK MATTER & DARK ENERGY



DARK MATTER & DARK ENERGY

What The Universe Is Made Of





21%



DARK MATTER



"That isn't dark matter, sir-you just forgot to take off the lens cap."

CURVATURE



BIG CRUNCH



BIG FREEZE – BIG RIP – HEAT DEATH



ILLUSTRIS



HOMEWORK

- 5 things you learned in this course that
 - surprised you

or

- made you happy to learn
- 5 things you wish you have learned more about

5 things you would change about this course

REFERENCES

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