ASTRO 160
part 3

(OSMOLOGY!
(particularly: Dark Energy)

[note: tests will be returned Tuesday]
THERE WILL BE A P.S.
due next week!

1920: Frontiers of Cosmology

"spiral nebulae"
→ clouds of glowing gas
part of our "galaxy"

CORRECT → → "island universes"

FABLE: "The Great Debate"
MORAL: You can have many good arguments, and still be wrong

solved by Edwin Hubble
There are many galaxies!

"STANDARD CANDLE" METHOD

1) know how bright something is
2) measure how bright the object looks
3) compute the distance

example of a class of objects whose brightness is known
"standard candle"

MEASURING BRIGHTNESS

magnitude scale

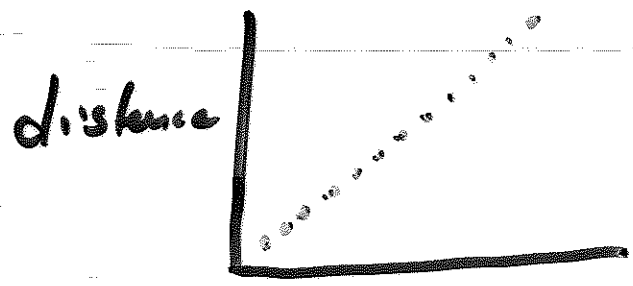
$m_1 - m_2 = -\frac{5}{2} \log\left(b_1/b_2\right)$

m_1, m_2: magnitudes; b_1, b_2: brightness

HELP SHEET

Motions of galaxies

ALL moving away from us



Hubble Diagram

→ Hubble's constant

$V = H D$

$H = 70$ kms/Mpc

└ 10^6 parsec

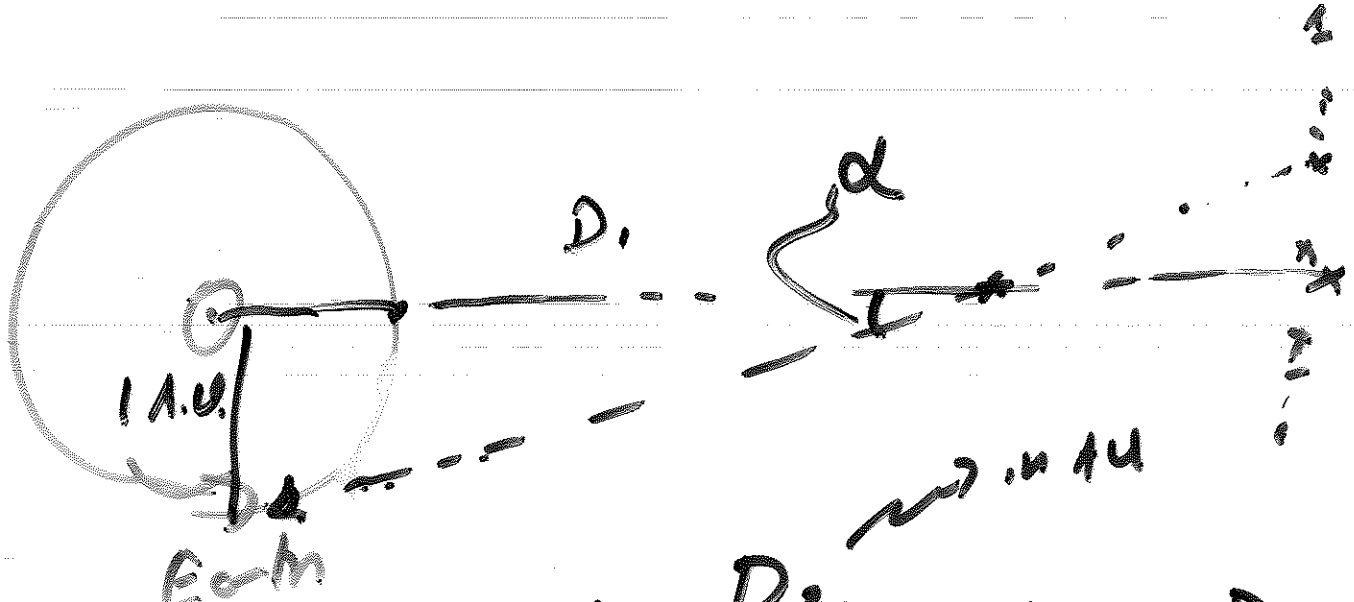
1 pc = 3×10^{16} m
$= 3 \times 10^{13}$ km

⇒ Universe is expanding
→ Big Bang exist

Measure radial velocity : Doppler shift

DISTANCE measurements are hard

MEASURING DISTANCE



$$\alpha = \frac{D_2}{D_1}$$ where D_2 is 1 A.U.

D_2 → in AU

D_1 → parsecs

α → arc sec.

$\frac{1}{\alpha}$ in arcsecs = distance in parsecs

PARALLAX method

"parsec" is "one parallax second"

WORKS TO MAXIMUM OF a few hundred parsecs

Star Vega is defined to have magnitude 0.

$$\log(10^x) = x$$

$$\log(3 \times 10^2) =$$

$$\log(10^{1/2} \cdot 10^2)$$

$$= \log(10^{2.5})$$

$$= 2\,1/2$$

$$\log(10^x \cdot 10^y) = x + y$$

$$\log(10^x / 10^y) = x - y$$

$$\log([10^x]^m) = m \cdot x$$

Sirius is 3 times brighter than Vega. What is its magnitude?

$$m_S - m_V = -\frac{5}{2}\log\left(\frac{b_S}{b_V}\right)$$

$$= -\frac{5}{2}\log(3)$$

$$= -\frac{5}{2}\log(10^{0.4})$$

$$= -\frac{5}{2}\cdot\frac{4}{10} = -\frac{5}{4}$$

m_S zero $= -5/4$

intrinsic brightness: Absolute mag M

observed brightness: apparent mag m

ABSOLUTE mag:

The apparent mag IF the object were exactly 10 pc away.

Sirius is 3 pc away

$$m - M = 5 \log (D/10\,pc)$$

m: app. mag; M: abs. mag

if D = 10 pc

$\log(1) = \log(10)^0 = 0$

the sun's abs. mag of Sirius

$$-\frac{5}{4} - M = 5 \log(1/3)$$

$$= 5 \log(10^{-1/2})$$

$$= -\frac{5}{2}$$

$$M = \frac{5}{2} - \frac{5}{4} = \frac{5}{4}$$ absolute mag of Sirius

$$\log(1/3) = \log(1/10^{1/2})$$

$$1/10^{1/2} = 10^{-1/2} = \log(10^{-1/2})$$

$$5 \log(1/3) = 5 \cdot -\frac{1}{2} = -\frac{5}{2}$$

$$-\frac{5}{4} - M = -\frac{5}{2} \quad \text{or}$$

$$-\frac{5}{4} + M = \frac{5}{2}$$

if you observe a star like Sirius at mag

apparent mag

8.75

how far away is it?

$$m - M = 5 \log (D/10\,pc)$$

$$8.75 - 1.25 = 5 \log (D/10\,pc)$$

$$\frac{7.5}{5} = \log (D/10\,pc)$$

$$1.5 = \log (D/10\,pc)$$

$$10^{1.5} = 10^{\log (D/10\,pc)} = D/10\,pc$$

$10^{1.5} = 10^1 \times 10^{1/2} = 3 \times 10^1 = 30$

$30 = D/10pc$

$\boxed{D = 300pc}$

DISTANCE LADDER

nearby stars:
distance from
parallax method

examples of similar stars
measure app mag
YAY!! ⟹ assume abs. mag
compute distance

⟶ abs. mags of
brighter things

⟶ measure further
away

Open Yale courses