

ASTRO 160

part 3

(COSMOLOGY!
(particularly: Dark Energy)

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

1920: Frontiers & controversies

"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

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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

↑ magnitudes

↑ brighter

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

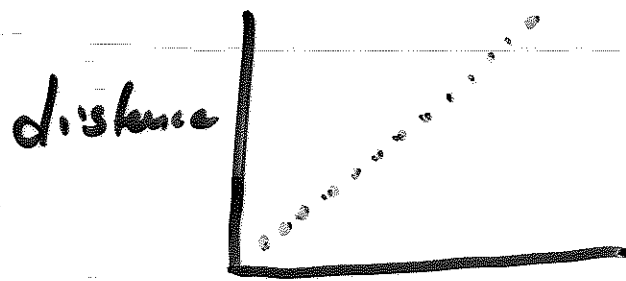
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HELP SHEET

Motions of galaxies

ALL moving away from us



Hubble Diagram

→ Hubble's constant

redshift z
 v/c

$$V = H D$$

$$H = 70 \text{ km/s/Mpc}$$

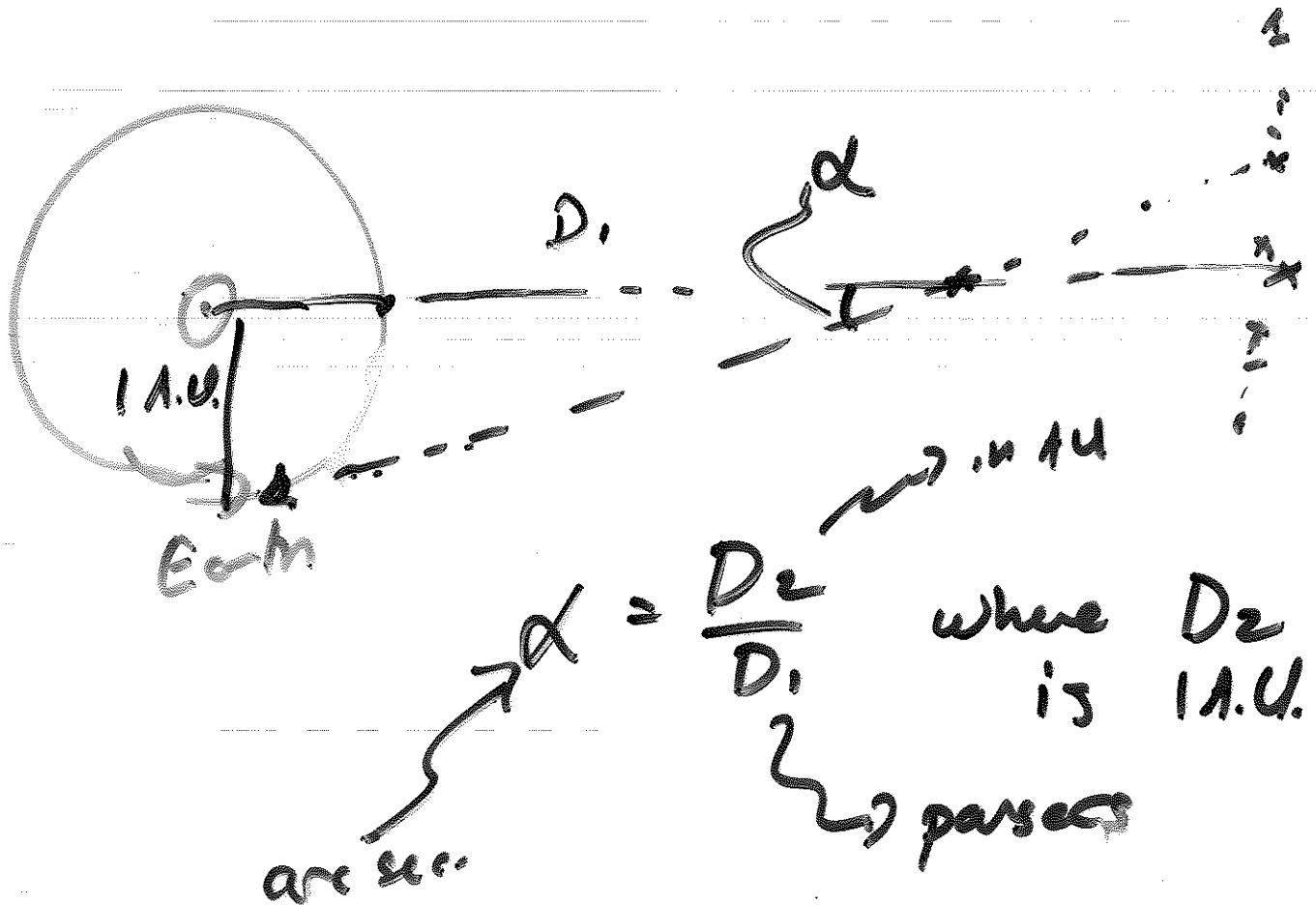
$$\begin{aligned} &\sim 10^6 \text{ parsecs} \\ 1 \text{ pc} &= 3 \times 10^4 \text{ km} \\ &= 3 \times 10^{13} \text{ km} \end{aligned}$$

\Rightarrow Universe is expanding
 \rightarrow Big Bang exist

measuring radial velocity:
Doppler shift

DISTANCE measurements are
hard

MEASURING DISTANCE



$$\frac{1}{\alpha} \text{ in arcseconds} = \text{distance in parsecs}$$

PARALLAX method

"parsec" is "one parsec second"

WORKS TO MAXIMUM OF
a few hundred parsecs

Star Vega is defined
to have magnitude 0.

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

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

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

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

$$= 2\frac{1}{2}$$

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

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

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

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

$$M_s - M_v = -\frac{5}{2} \log (b_s/b_v)$$

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

$$= -\frac{5}{2} \log (10^{0.48})$$

$$= -\frac{5}{2} \cdot \frac{1}{2} = -\frac{5}{4}$$

M_s \downarrow 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

$$m - M = 5 \log (D/10 \text{ pc})$$

\uparrow app mag \uparrow abs mag

\downarrow

if $D = 10 \text{ pc}$
 $\log(1) = \log(10^0)$
 $= 0$

What is abs. mag of
Sirius

$$\begin{aligned} -\frac{5}{4} - M &= 5 \log \left(\frac{1}{3} \right) \\ &= 5 \log (10^{-1/2}) \\ &= -\frac{5}{2} \end{aligned}$$

$$M = \frac{5}{2} - \frac{5}{4} = \frac{5}{4} \quad \text{absolute mag of series}$$

$$\log \left(\frac{1}{3} \right) = \log (10^{-1/2})$$

$$\frac{1}{10^n} = 10^{-n} \quad \Rightarrow \quad \log (10^{-1/2})$$

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

$$\left. \begin{aligned} -\frac{5}{4} - M &= -\frac{5}{2} \quad \text{or} \\ \frac{5}{4} + M &= \frac{5}{2} \end{aligned} \right\}$$

if you observe a star
like Sirius and measure
apparent mag

8.75

how far away is it?

$$m - M = 5 \log (D/10\text{pc})$$

$$8.75 - 1.25 = 5 \log (D/10\text{pc})$$

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

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

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

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

$$30 = D/10pc$$

$$D = 300pc$$

DISTANCE LADDER

nearby stars:
distance from
parallax method

examples of similar stars

~~XXX!!~~ \Rightarrow assured abs. mag
compute distance

\hookrightarrow use abs. mags of
brighter things
 \hookrightarrow measure further
away