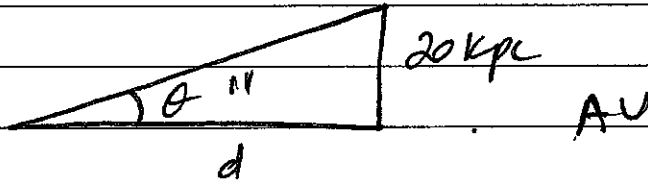


OBSERVATIONAL ASTROPHYSICS LAB PART III GALAXY CLUSTERS + COSMOLOGY

FINDING GALAXIES IN HYDRA I TO DETERMINE DISTANCE TO CLUSTER.

ASSUME ALL GALAXIES IN HYDRA I ARE 10KPC IN RADIUS (AS THE MILKYWAY IS)

SMALL ANGLE APPROXIMATION;



$$\tan \theta \sim \theta = r/d = 20kpc/d$$

$$\text{DISTANCE TO HYDRA I} = (20kpc/\theta)$$

ANGULAR SIZE OF GALAXIES;

GALAXY #	TYPE	SIZE(mm)	θ (arcmin) ($\times 1.12$)	DIST(kpc) ($20/\theta$)
1				
2				
3				
4				
5				

$$\left(1 \text{ arcmin} = \left(\frac{1}{60}\right)^\circ = \frac{1}{60} \times \frac{\pi}{180} \text{ RADIANS} \right)$$

$$= 2.9 \times 10^{-4} \text{ RADIANS}$$

OR... USE JUST SPIRAL GALAXIES TO IMPROVE THE ESTIMATE.

AVERAGE DIST TO HYDRA I =

\overline{AV} (USING JUST SPIRALS) DIST =

VIRGO CLUSTER;	SIZE (mm)	θ (arcsec)	DIST (Mpc)
SPIRALS #1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
ELLIPSOIDS #1			
2			
3			
4			
5			
6			
7			
8			
9			

HYDRAE	SIZE (mm)	θ (arcmin)	DIST (Mpc)
SPIRAL #1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
ELLIPTICAL #1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

ELLIPTICAL

$$\frac{d_h}{d_e} = \frac{\theta^E}{\theta^E_h}$$

SPIRAL

$$\frac{d_h}{d_e} = \frac{\theta^S}{\theta^S_h}$$

SHOULD BE SIMILAR RATIOS:

$$d_v = 15 \text{ Mpc} \quad \text{so } d_h = \underline{\hspace{2cm}}$$

HUBBLE'S CONSTANT

HUBBLE'S LAW: $V = H_0 d$

↑
VELOCITY SOMETHING
IS MOVING AWAY
FROM US AT

← HUBBLE'S CONSTANT

← DISTANCE FROM US

USE DOPPLER SHIFT TO MEASURE VELOCITY AT WHICH HYDRA I IS MOVING AWAY FROM US AT

AVERAGE V OF HYDRA I = 3392 km s^{-1}

$$\rightarrow H_0 = V/d = \frac{3392}{d} \text{ km s}^{-1} \text{ Mpc}^{-1}$$

[TEMPERATURE DEPENDENCE]

Temperature dependence

$$k_{obs} = k_0 e^{-\frac{E_a}{RT}}$$

(1) Arrhenius plot

Arrhenius plot
 $\ln k_{obs} = \ln k_0 - \frac{E_a}{RT}$

The plot of $\ln k_{obs}$ versus $1/T$ is a straight line with a negative slope. The slope of the line is $-E_a/R$.

$$\ln k_{obs} = \ln k_0 - \frac{E_a}{RT}$$

$$\ln k_{obs} = \ln k_0 - \frac{E_a}{RT}$$

AGE OF THE UNIVERSE

GALAXY 100 Mpc AWAY. $H_0 = 100 \text{ km s}^{-1} \text{ Mpc}^{-1}$

$$(100 \text{ Mpc} = 100 \times 10^6 \times 3.1 \times 10^{16} \text{ m} = 3.1 \times 10^{21} \text{ km})$$

$$V = H_0 d = 100 \times 100 = 10^4 \text{ km s}^{-1}$$

ASSUMING GALAXY ALWAYS MOVED WITH SAME SPEED

GALAXY WAS AT OUR POSITION;

$$\text{TIME} = \frac{\text{DISTANCE}}{\text{VELOCITY}}$$

$$= \frac{100 \text{ Mpc}}{10^4 \text{ km s}^{-1}} = \frac{3.1 \times 10^{21} \text{ km}}{10^4}$$

$$= 3.1 \times 10^{17} \text{ s}$$

$$= 10^{10} \text{ YEARS}$$

How experimentally determine μ

$$= b$$

$$= a/t$$

$$\text{and } \mu = \frac{a}{b}$$

$$= b \text{ and } \mu$$

$$\text{Time} = \frac{L}{V} = \frac{L}{\mu} = \frac{L}{a/b} = \frac{Lb}{a}$$

=

1) In the experiment, measurement of μ is done

$$\mu = \frac{a}{b}$$

$$\text{Time} = \frac{L}{V} = \frac{L}{\mu}$$

=

ADVANCED PROBLEMS

MARK GALAXIES ON TRANSPARENT SHEET

WIDTH OF CLUSTER =

ANGULAR WIDTH = $\times 1.12$ =

DISTANCE TO CLUSTER =

SIZE OF CLUSTER (Mpc) = dist \times angular size

=

REPRODUCTION

NUMBER OF OFFSPRING = NUMBER OF PARENTS

NUMBER OF OFFSPRING = NUMBER OF PARENTS

NUMBER OF OFFSPRING = NUMBER OF PARENTS

NUMBER OF OFFSPRING = NUMBER OF PARENTS

NUMBER OF OFFSPRING = NUMBER OF PARENTS

...