HUBBLE'S LAW:

HUBBLE'S CONSTANT $\approx 70 \frac{km/s}{Mpc}$

$$v = Hd$$

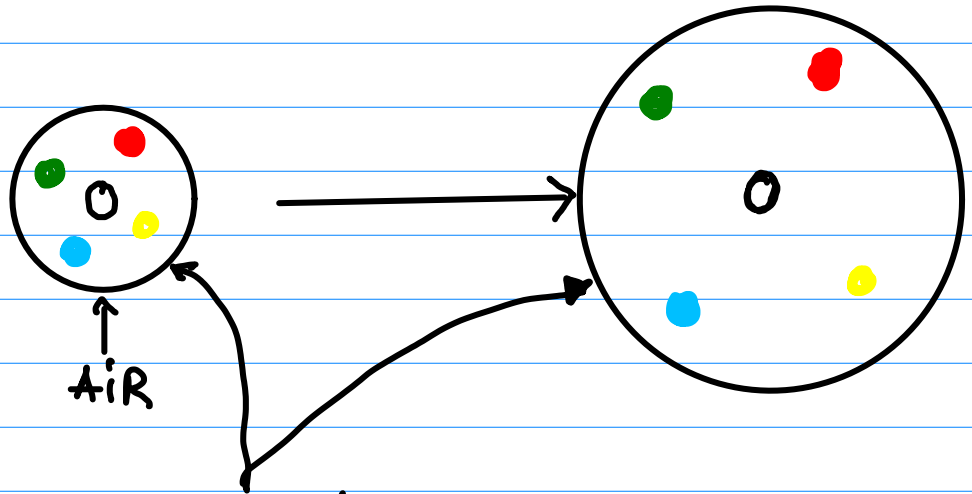
v: RECESSION VELOCITY

d: DISTANCE OF A GALAXY

MEASURE v FROM THE REDSHIFT OF THE SPECTRUM ($\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$). USE HUBBLE'S LAW TO FIND d.

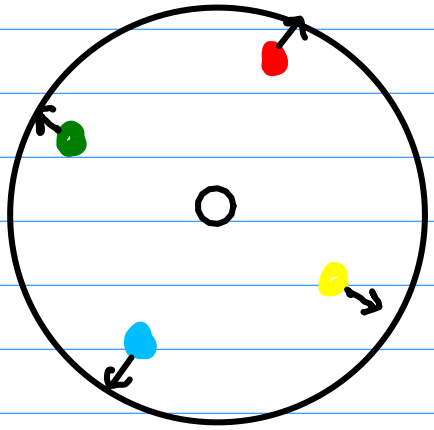
HUBBLE'S LAW IS CONSISTENT WITH AN EXPANDING UNIVERSE, I.E. ITS SPACETIME.

ANALOGY: EXPANDING BALLOON

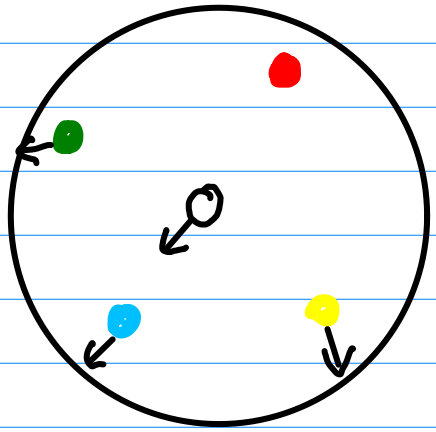


THE UNIVERSE IS TWO-DIMENSIONAL SURFACE OF THE BALLOON (NO INSIDE OR OUTSIDE)

AN OBSERVER LOCATED ON O WOULD SEE:

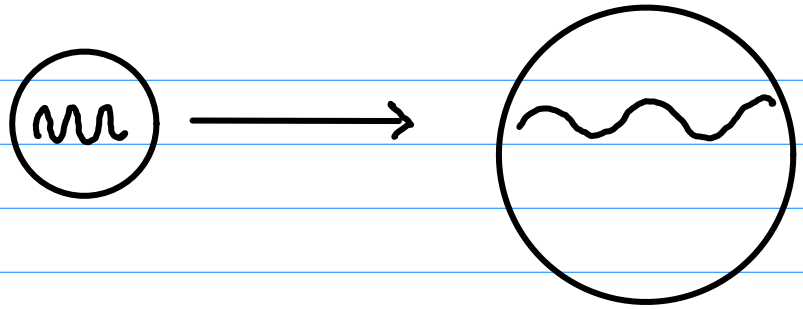


AN OBSERVER LOCATED ON ● WOULD SEE



IN THIS EXPANSION OF SPACE THERE IS NO SINGLE CENTER OF EXPANSION OR, EQUIVALENTLY, EVERY POINT IN SPACE COULD BE TAKEN AS A CENTER OF EXPANSION.

THIS EXPANSION OF SPACE CAUSES SO-CALLED COSMOLOGICAL REDSHIFT:



THE STRETCHING OF SPACE CAUSES THE STRETCHING OF THE WAVE, I.E. AN INCREASE IN ITS WAVELENGTH – THE REDSHIFT. THIS IS CALLED THE COSMOLOGICAL REDSHIFT. THE SPECTRA OF GALAXIES ARE REDSHIFTED BY THE COSMOLOGICAL REDSHIFT.

THE DISTANCES OF THE MOST DISTANT GALAXIES IN THE UNIVERSE ARE DETERMINED USING TYPE Ia SUPERNOVAE (NO HYDROGEN SPECTRAL LINES). THEY ARE VERY BRIGHT AND COULD BE OBSERVED FROM GREAT DISTANCES. MOREOVER, THEIR LUMINOSITY IS ALWAYS THE SAME BECAUSE THEY GO OFF WHEN THE MASS OF A WHITE DWARF IN A BINARY SYSTEM GETS CLOSE TO THE CHANDRASEKHAR LIMIT OF $1.4\,M_\odot$ (THERE IS ALWAYS THE SAME AMOUNT OF "EXPLOSIVE").

FOUND FROM NEARBY TYPE Ia SUPERNOVAE

$$B = \frac{L}{4\pi d^2}$$

MEASURE

DEDUCE

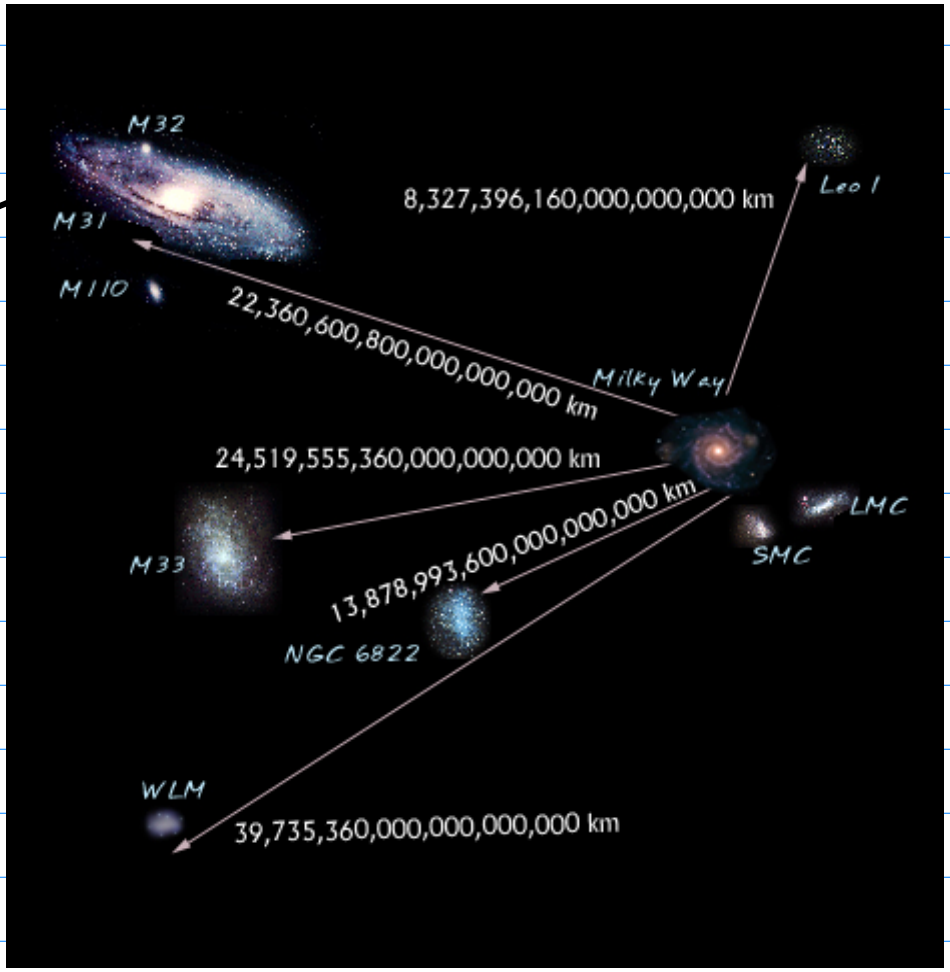
DISTRIBUTION OF GALAXIES: THE GALAXIES OCCUR IN CLUSTERS.

1) RICH GALAXY CLUSTERS: THEY CONTAIN MORE THAN 1000 GALAXIES

RICH GALAXY CLUSTER ABELL 2218

2) POOR GALAXY CLUSTERS: THEY CONTAIN LESS THAN 1000 GALAXIES.

ANDROMEDA (OR M31)



LOCAL GROUP

COLLISION / INTERACTION BETWEEN THE GALAXIES IS MUCH MORE LIKELY THAN THE STAR-STAR COLLISION:

TYPICAL GALAXY DISTANCES ARE ABOUT 20 TIMES THEIR DIAMETERS;

TYPICAL STAR-STAR DISTANCE IS ABOUT 10 MILLION TIMES THE DIAMETER OF A STAR.