# Essentials of Astronomy
## (Part -1)
## Units & Magnitude Scale

S N Hasan

# Starry sky

# Our Position in the Universe

**(order of magnitude)**

Humans

~2m = $10^0$ m

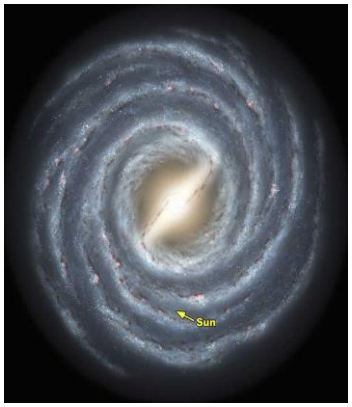
Earth 6400 km ~$10^6$ m

Planets $10^6$ – $10^7$ m

Solar System

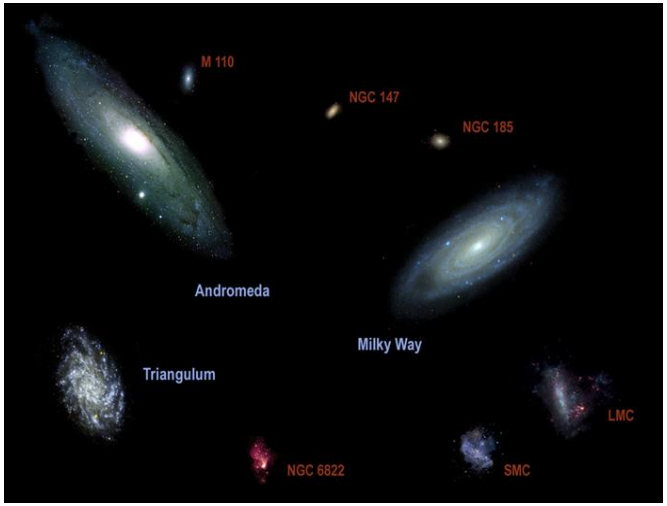

Planetary Systems $10^{13}$m

Milky Way Galaxy



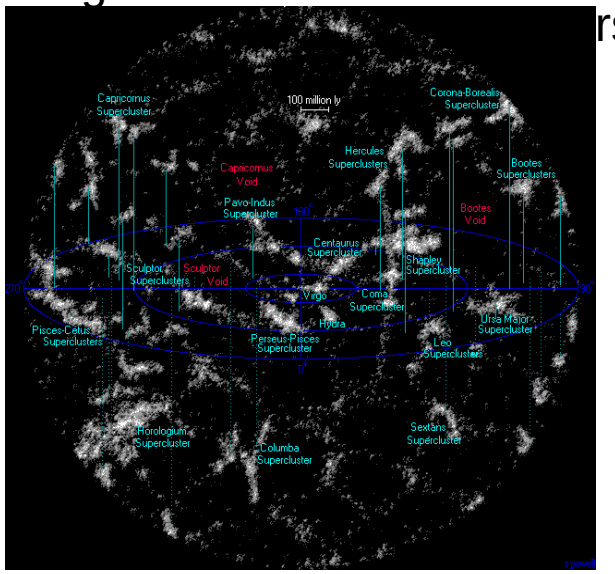

Galaxy $10^{19}$ m

Local Group



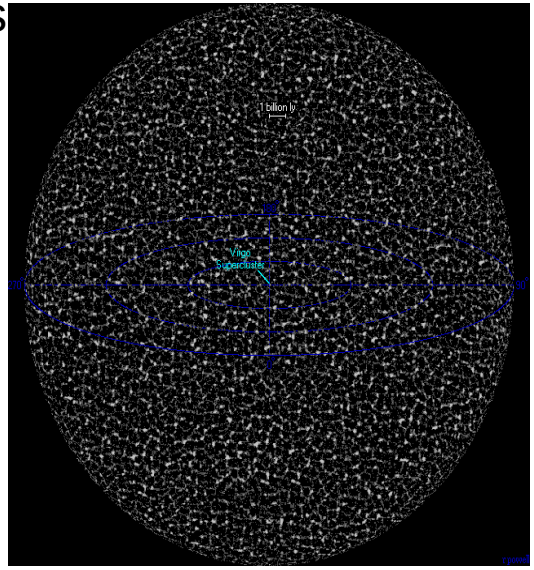

Galaxy Clusters $10^{22}$ m

Virgo Cluster




Super Clusters $10^{24}$ m

Visible Universe 14 billion lt rs




Visible Universe $10^{26}$ m

# Units – Mass, Length & Time

- Unit of Mass:
  $M_{sun}$ =1.99 X $10^{30}$ kg

- Unit of length
  AU = 150, 000,000 km = 150 million km= 1.5 X $10^{8}$ km
  light year = distance travelled by light in one year = 9.5 X $10^{12}$ km
  parsec (pc) = 3.26 light years = 3.09 X $10^{13}$ km

- Unit of Time
  seconds
  year = 3.16 X $10^{7}$ sec. (Earth Year)

# Stars – brightness (Luminosity)

# Magnitude – Brightness - Luminosity

Hipparcus (2 B.C.)

Classified stars on the basis of brightness

Magnitude I, II, ……, VI

Brightest I magnitude

Faintest VI magnitude

First magnitude stars were brightest

Sixth magnitude stars were faintest

Depends on:

- Distance
- Its intrinsic brightness

# Eye response
# not linear but logarithmic

- **Magnitude**

  **I II III IV V VI**

- **Magnitude difference of 5**

  **equivalent to a star being 100 times brighter**

**Two successive classes differ in apparent brightness by a factor of (Pogson 1856)**

$$(100)^{1/5} = 2.512$$

## Luminosity or Brightness of a star depends on:

- **Distance from the observer**
  **(closer stars look brighter and distant look fainter)**

- **Temperature of the Star**

- **Size of the star (Radius)**

$$L = 4\pi R^2 \sigma T^4$$

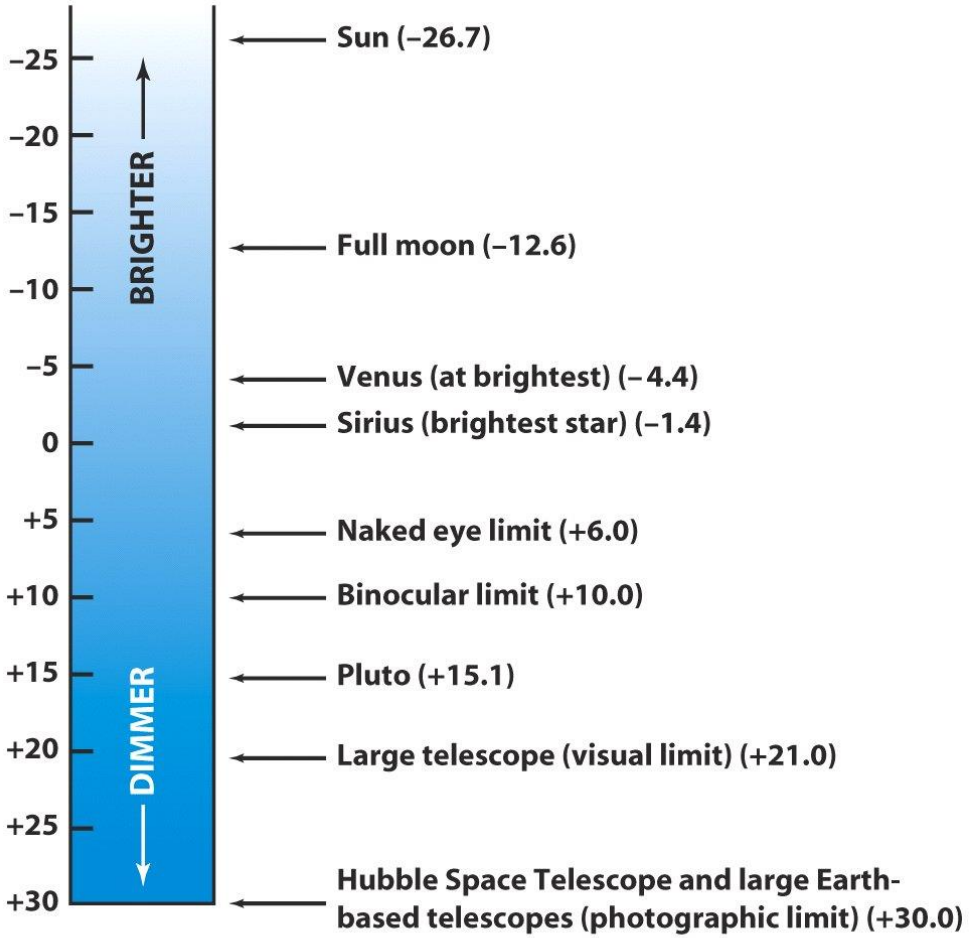
$L$ = star's luminosity, in watts
$R$ = star's radius, in meters
$\sigma$ = Stefan-Boltzmann constant = $5.67 \times 10^{-8}$ W m$^{-2}$ K$^{-4}$
$T$ = star's surface temperature, in kelvins

The apparent magnitude scale star's apparent brightness

denoted by "m"

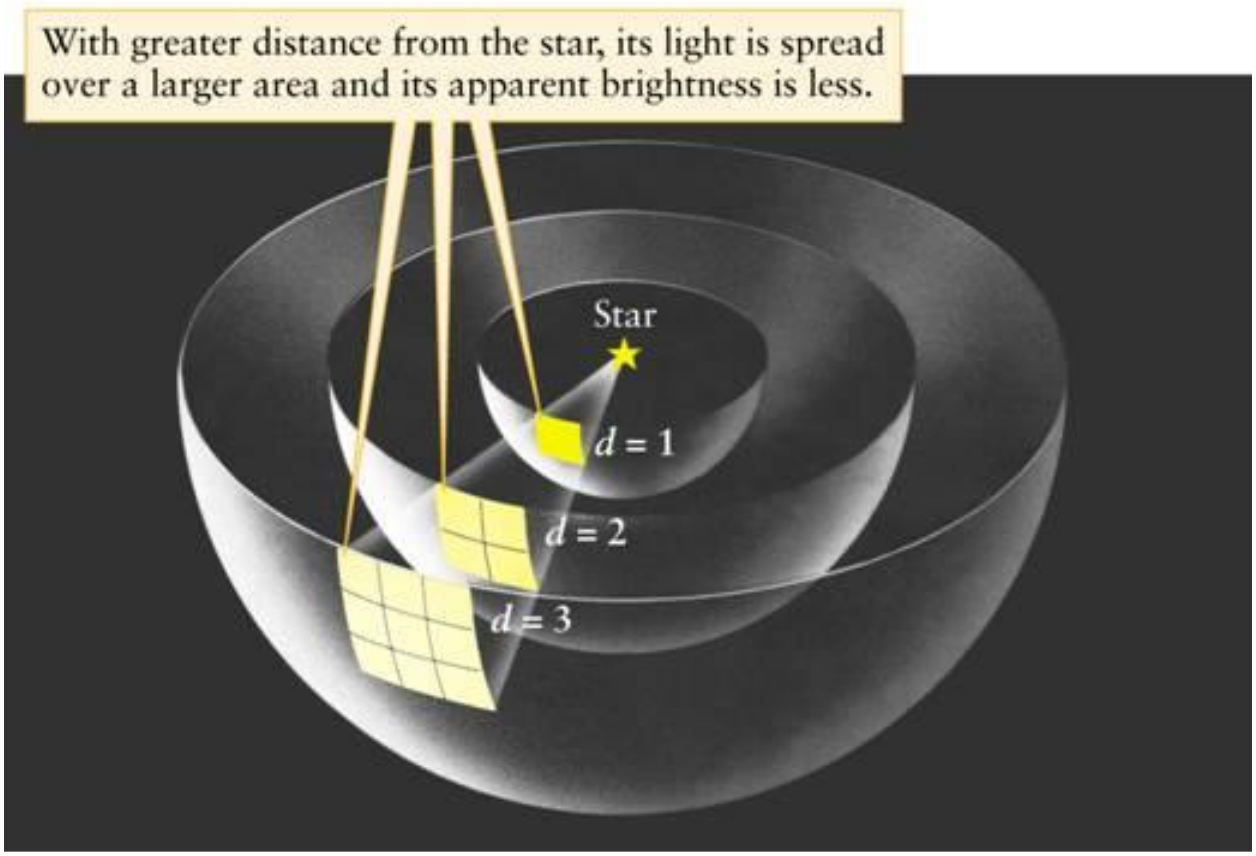
The absolute magnitude of a star is the apparent magnitude if it was viewed from a distance of 10 parsecs

denoted by "M"




Some apparent magnitudes

# Decrease in luminosity with increase in distance




Decrease in luminosity as square of the distance

# Magnitude scale

Stars in two magnitude class luminosity differs by $100^{1/5}$

Suppose we have 2 stars


$$\ell_2 / \ell_1 = (100)^{1/5\,(m1-m2)}$$

$$(m_1 - m_2) = 2.5 \log_{10} (\ell_2 / \ell_1)$$

If we have a star moved to 10 pc

$$m - M = 2.5 \log_{10} (d^2 / 10^2)$$

$$m - M = 5 \log_{10} (d / 10)$$

$$m - M = 5 \log_{10} (d) - 5$$

*The stars send us not only that visible and gross light which strikes our bodily eyes, but from them also comes to us a light far more subtle, which illuminates our minds.*

- Henri Poincare

*Thank You*

Astronomy is useful because it raises us above ourselves; it is useful because it is grand;.... It shows us how small is man's body, how great his mind, since his intelligence can embrace the whole of this dazzling immensity, where his body is only an obscure point, and enjoy its silent harmony.

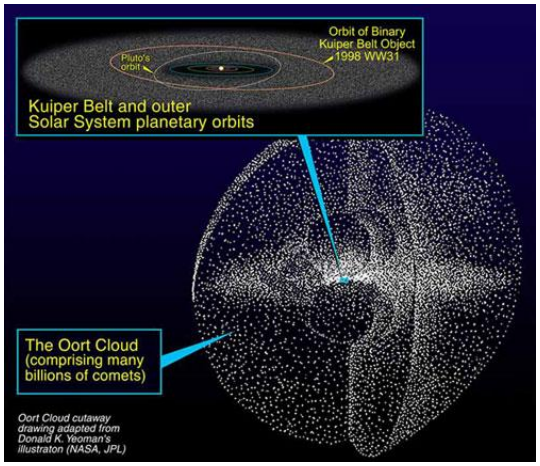
— Henri Poincare —

AZ QUOTES

# Our Universe

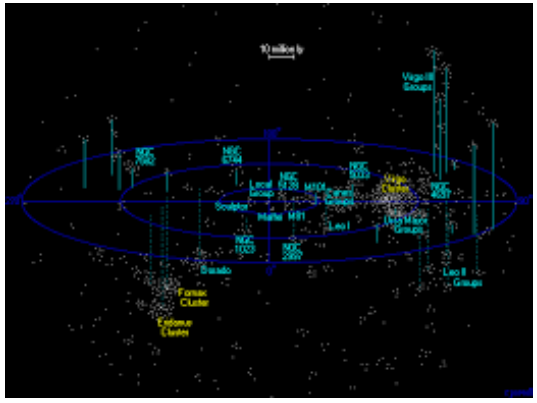
Solar System

Sun- Neptune 4.545 billion km
Sun – Sedna 143.73 billion km
~ 960.78 AU

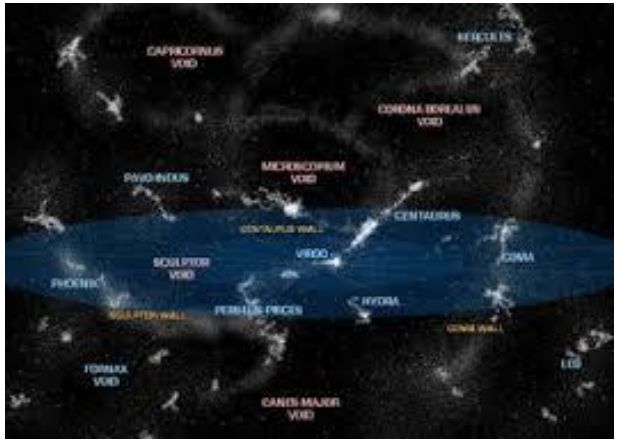



~ 50,000 AU (1 lt yr)
1-2 lt yrs

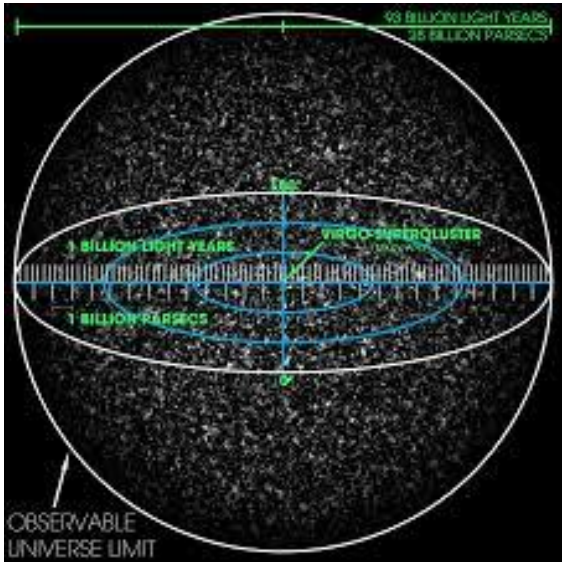

MW 100,000 lt yrs



Local Group
10 million light-years



Virgo Super Cluster
55 million light years




Visible Universe
~ 13.7 billion lt yrs