Chapter
31
Universe

Universe is the limitless expanse of space around us consisting of solar system. star, galaxies *etc*.

Solar System

Solar system is a family of nine planets, satellites, asteroids, comets, meteors, meteorites and dust particles orbiting around the Sun.

(1) **Planets :** Nine planets revolving around the sun in elliptical orbits. In order of increasing distance from Sun, these are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto.

(i) The gravitational pull of the Sun on the planets control their motion.

(ii) There are other heavenly bodies (about 32) which revolve around the planets called satellites (or moons) of the planets.

(iii) A planet does not emit light of its own.

(iv) A planet do not twinkle at night.

(v) The planets are very small in size as compared to stars or Sun.

(vi) The relative positions of planets keep on changing day by day.

(vii) Most of the planets move around the sun from west to east.

(viii) The planets are made of rocks and metals.

(ix) The temperature of planet depends upon its distance from sun.

(2) **Asteroids :** The small pieces of planet revolving around the sun between orbits of Mars and Jupiter are called Asteroids.

(i) Astronomers have identified about 2000 asteroids ranging from the largest 770 *km* diameter to bodies 1.5 *km* in diameter.

Table 31.1 : Some information about planets

Planet	Radius $R \times 10^3$ *km*	Mean distance from sun $\times 10^6$ *km*	Mass as compared to earth	Time of revolution around the sun	Time taken to complete one rotation around its own axis	Number of satellites
Mercury	2.4	57.9	0.055	88 days	59 days	—
Venus	6.1	108.2	0.815	225 days	243 days	—
Earth	6.3	149.6	1	1 Year	23 hrs. 56 min.	1
Mars	3.4	227.9	0.108	1.9 Year	24 hrs. 27 min	2
Jupiter	71.4	778.3	317.9	11.8 Year	9 hrs. 50 min	14
Saturn	60.0	1427	95.2	29.5 Year	10 hrs. 14 min	10 + Ring
Uranus	23.4	2870	14.6	85 Year	10 hrs. 49 min	5 + Ring
Neptune	22.3	4594	17.2	165 Year	15 hrs.	2
Pluto	3.2	5900	0.002	248 Year	6.39 days	—

(ii) The largest asteroids are called Ceres.

(iii) The largest asteroid complete one revolution around the sun in 4.6 years.

(3) **Comets :** These are composed of rock like materials surrounded by large masses of easily vaporisable substances like, ice, water, ammonia and methane.

(i) They revolve around the Sun in highly elliptical orbits.

(ii) Their time period of revolution around the Sun is very large.

(iii) Comets appear to be having a bright head and a long tail while passing close to the Sun and when away from sun generally they show no tail.

(iv) The tail of comet is formed when the comet is passing close to the Sun and the heat of Sun exerts a pressure on the material which gets evaporated due to heat of Sun.

(v) Hally comet was seen in early 1986 and is expected to be seen again in 2062.

(4) **Meteors and meteorites :** Meteors are the smaller pieces of stones and metals which may be produced due to the breaking up of comets while approaching the Sun. When they reach earth's atmosphere due to friction they start buring. They are also called shooting stars.

Sometimes, the large pieces of stones (acting as meteors) do not burn completely and reach the surface of the earth as stony, iron balls resulting in crators on the earth surface. These are called meteorites.

Measurement of Size of Planet

We can measure the size of a planet by measuring the angle subtended by its diameter AB at a point on the earth. This angle is called angular diameter of planet. If d denotes diameter of planet and D its distance from the earth

$$\alpha \simeq \frac{d}{D}$$

or $\quad d \simeq D\alpha$

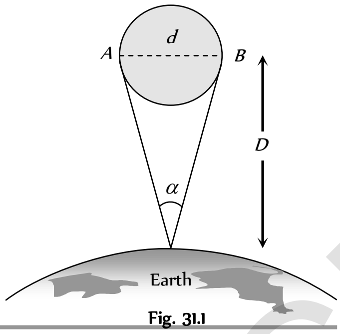


Fig. 31.1

Measurement of Distance of Planet From the Earth

(1) **Parallax method :** The planet O is observed from two points P_1 and P_2 on the surface of the earth. The distance between these two points, $P_1P_2 = b$, is called basis. The angle subtended by planet at these two points is called parallax angle or parallactic angle

From figure $\theta \simeq \dfrac{b}{D}$

or $\quad D \simeq \dfrac{b}{\theta}$

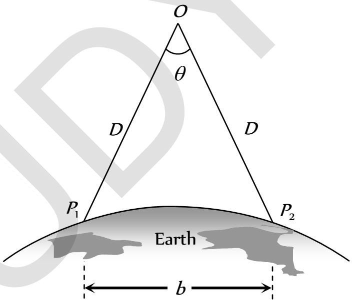


Fig. 31.2

(2) **Copernicus method :** The inferior planets (Mercury and Venus) have nearly circular orbits. Angle between directions of observation from earth to sun and earth to planet is called planet's elongation.

$r_{es} =$ The distance of earth from Sun, $r_{ps} =$ The distance of planet from Sun and $r_{pe} =$ The distance of planet from Earth

The r_{ps} and r_{es} are fixed distances as orbits have been assumed to be circular. During orbital motion of the planet the distance r_{pe} changes. Planet's elongation is maximum when earth and sun subtend an angle 90° at the planet. From figure,

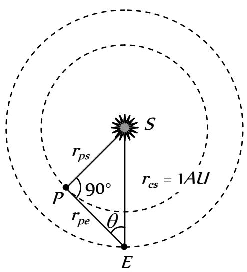


Fig. 31.3

$$\sin\theta = \frac{PS}{ES} = \frac{r_{ps}}{1\,AU}$$

where 1 AU = 1.496 × 10^{11} m

Thus $\sin\theta = r_{ps}$, similarly $\cos\theta = \dfrac{PE}{ES} = \dfrac{r_{pe}}{1\,AU} \Rightarrow r_{pe} = \cos\theta$

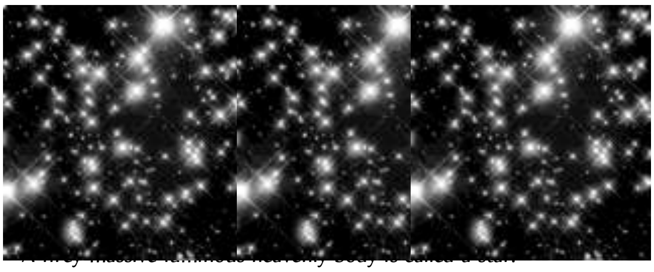
(3) **Kepler's law :** According to Kepler's law the square of time period of planet around sun is proportional to cube of semi-major axis of the orbit of planet around sun *i.e.* $\dfrac{a^3}{T^2} = \text{constant}$, if a_1 and a_2 are semi-major axes of planets 1 and 2 and T_1 and T_2 their respective periods of revolution, then

$$\frac{a_1^3}{T_1^2} = \frac{a_2^3}{T_2^2} \quad \text{or} \quad a_2 = \left(\frac{T_2}{T_1}\right)^{2/3} a_1$$

For circular orbits a_1 and a_2 represent the radii of orbits.

(4) **Spectroscopic method :** In this method, photograph of two different planets P_1 and P_2 are taken on similar photographic plates from one place of the earth. Let I_1 and I_2 be the intensities of the images of these two planets. If R_1 and R_2 be the distances of these planets from the earth then $\dfrac{I_1}{I_2} = \dfrac{R_2^2}{R_1^2}$ ($\because$ intensity at a point is inversely proportional to the square of the distance)

Stars



A very massive luminous heavenly body is called a star.

(1) **Some features**

(i) Stars twinkle at night.

(ii) Stars are countless in number ; about 10^{11} in a universe.

(iii) Stars are very big in size but they appear small because they are very far off.

(iv) The relative positions of stars do not change day by day.

(v) Stars appear to be moving from west to east.

(vi) The temperature of stars is very high.

(vii) The Sun is the nearest star to the earth. Its light reaches the earth in 8.3 minutes.

(viii) After Sun the next nearest star to earth is Alpha centuri. Its distance is 4.3 light year from earth.

(ix) Other bright stars in the sky are known as Spica (Chitra), Arcturus (Swati), Polaris (Dhruva), Sirius (Vydha), Canopus (Agasti) *etc.*

(x) The temperature of a star is estimated from the colour of its light received on earth. The blue coloured star is at higher temperature than red coloured star.

(2) **Constellation :** Many of the stars appear to be bunched together in groups. These groups are called constellations.

(i) The Great-bear (Saptarishi), Taurus (Vrishabha) Aries (Mesha) *etc.* are the other constellations near the north and south celestial poles.

(ii) According to modern astronomy there are 88 constellations in the sky.

(3) **Brightness of star :** Brightness of stars is represented through system of magnitudes. Magnitude of star is the measure of its brightness when observed from earth.

(i) Hipporacus, a Greek astronomer divided the stars (visible with naked eye) into six magnitude classes. Brightness goes on decreasing as the magnitude increases. A first magnitude star is about 100 times as bright as a sixth magnitude star. Decrease in magnitude number by one increases brightness by ratio $100^{1/5} = 2.5119.$ In general

$$\frac{\text{The brightness of star in } n^{\text{th}} \text{ magnitude class}}{\text{The brightness of star in } (n+m)^{\text{th}} \text{ magnitude class}} = (2.512)^m$$

(ii) If two stars have magnitudes m_1 and m_2 ($m_2 > m_1$) and brightness I_1 and I_2($I_2 < I_1$), then $\frac{l_1}{l_2} = 100^{(m_2 - m_1)/5}$

Taking logarithm to base 10 of both sides, we get

$$(m_2 - m_1) = -2.5 \log \frac{l_2}{l_1}$$

(iii) For a star of zero magnitude $m_1 = 0$, $I_1 = I_0$, $m_2 = m$ and $I_2 = I$.

$$\Rightarrow m = 2.5 \log \frac{l_0}{l}$$

(iv) The star vega is of zero magnitude and of brightness $l_0 = 2.52 \times 10^{-8} W/m^2$.

(v) A star having negative magnitude is brighter; *e.g.*, a star having magnitude – 5 will be 100 times more bright than a star of zero magnitude.

(4) **Absolute luminosity :** The total energy radiated into space per second from the surface of a star is called absolute luminosity of the star. The absolute luminosity of the Sun is $\approx 3.9 \times 10^{26}\ J/sec$.

(5) **Birth of a star :** Star dust and gases present in interstellar space come closer together with a gravitational force in the form of a cloud.

(i) When the cloud is quite big, due to compression cloud heats up and starts radiating

(ii) At this temperature, fusion of hydrogen atom into helium atom takes place and a star is said to have come into existence.

(iii) This process result in the release of energy, which keeps the star shining for millions of years.

(6) **Death of a star :** When large number of hydrogen atoms of a star are converted into *He*, the core of star begins to contract and other layers begin to expand. At this stage star appears red, the stage is called Red Giant.

(i) Now a violet explosion occurs in star. This is called nova or super nova explosion.

(ii) Due to explosion, the outer layers are thrown back into interstellar leaving behind the core of the star. This is known as **death of the star**.

The core of the star may further end up into one of the following three dead bodies (stellar dead materials) :

(a) White dwarf (b) Neutron star (c) Black hole

(a) **White dwarf :** When the original mass of the star is less than $2M_s$ (M_s being solar mass), the core of the star tends to die as White dwarf. It was theoretically discovered by S. Chandrasekhar in1930 and is known as **Chandrasekhar limit**. As the core keeps on emitting heat and light for millions of year, it colour changes from white to yellow, then to red finally it becomes black. Now this becomes invisible for ever.

(c) **Neutron star :** When the original mass of the star is lies between $2M_s$ *and* $5\ M_s$ the core of the star tends to finish up as neutron star. In such a case, when super nova explosion occurs, the core of the star is compressed and electrons and protons combine to form neutrons. Due to this reason, this is called as neutron star. It is found to have a radius of about 10 *km*.

(7) **Black hole :** When the original mass of the star is more than $5M_s$, then on supernova explosion, the core continues suffering compression indefinitely due to recoil. This gives rise to a black hole. The mass of the black hole is greater than the mass of the Sun but its size is very small. Due to this fact, the gravitational pull of black hole is very strong. This is the reason that the photon of radiation emitted by it cannot escape from its surface. On the other hand, a photon approaching a black hole is swallowed by it. Hence it is called a black hole.

The black hole is said to have been formed if the star of mass *M* has contracted within a radius *r* which is given by $r \le \frac{2GM}{c^2}$

Sun

The Sun called the centre of the solar system, is a star nearest to the earth.

(1) **Properties of the Sun**

(i) It's average distance from earth is 1.49×10^8 *km* = 1 *AU*

(ii) It's mass is 1.99×10^{30} *kg*

(iii) It's mean diameter is 1.392×10^6 *km*

(iv) The density of the Sun varies from 10^{-4} kg/m^3 at the surface to 10^4 kg/m^3 at the centre. It's mean density is 1410 $kg\ m^{-3}$.

(v) The pressure at the centre of the Sun is about 2×10^6 N/m^2.

(vi) Light takes 8 minute to reach earth from the Sun.

(vii) 70% of Sun's mass is H_2, 28% *He* and 2% Lithium or Uranium.

(viii) The Sun is also called Yellow Dwarf.

(2) **Structure of Sun :** The Sun structure consist of four parts : Photosphere (*P*), Reversing layer (*R*), Chromosphere (*CH*) and Corona (*C*).

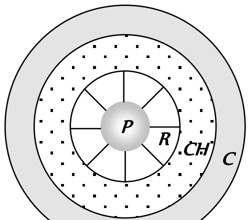


Fig. 364

(3) **Solar activity :** The surface feature of the Sun are called Solar activity. This can be classified as follows

(i) **Sun spots :** These are dark spots on the surface of sun associated with strong magnetic fields. The sun spots move across Sun slowly, so there numbers vary over a cycle of 11 year called Sun spot cycle. After every eleven year activity of sun spots tends to be maximum. Movements of sun spots have revealed the time period of rotation of sun on its own axis as about 25 days.

(ii) **Faculae :** These are bright patches near Sun spots.

(iii) **Granules :** Small granules form a covering over photosphere.

(iv) **Flares :** Sudden increase in magnetic activity is called flare. During these flares Sun emits streams of protons, α-particles and electrons.

(v) **Spicules :** Bright spikes emerging from chromosphere are termed spicules. Spicules are source of large number of charged particles into the corona.

(vi) **Prominences :** Surface of photosphere is covered by rising clouds called prominences.

(vii) **Filaments :** These are thin markings on the photosphere.

(4) **Solar constant (S) :** Energy falling in one second on the unit area of the earth's surface held normal to Sun's rays is called solar constant. It is given by $S = \dfrac{\sigma T^4 R^2}{r^2} = 1.388 \times 10^3 W/m^2$

where σ = Stefan's constant

= 5.68 × 10^{-8} S.I. unit

T = Surface temperature of Sun

R = Radius of Sun

r = Radius of Earth's orbit

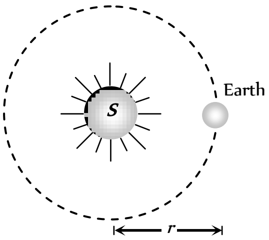


Fig. 31.5

(5) **Solar Luminosity (L) :** It is defined as the amount of energy emitted by the Sun per second in all directions.

$$L_s = (4\pi r^2)S = 3.9 \times 10^{26} W$$

(6) **Temperature of Sun (T) :** The surface temperature of the Sun is given by $T = \left(\dfrac{r}{R}\right)^{1/2}\left(\dfrac{S}{\sigma}\right)^{1/4}$

(7) **Mass of the Sun (M) :** Let M be the mass of sun and m be the mass of a planet moving around it, then as gravitational force of attraction between them supplies the necessary centripetal force

$$F = \frac{GMm}{r^2} = \frac{mv^2}{r} \Rightarrow \text{Mass of Sun } M = \frac{v^2 r}{G}$$

$$= \frac{r^2\omega^2 r}{G} = \frac{r^3\omega^2}{G} = \frac{r^3\left(\frac{2\pi}{T}\right)^2}{G} = \frac{4\pi^2 r^3}{GT^2}$$

where G = 6.67 × 10^{-11} Nm^2 kg^{-2} and r is distance between the sun and planet. T period of revolution of planet around the sun.

If we consider the planet and its satellite, mass of the planet can similarly be found

Stellar Radii, Mass and Spectra

(1) **Stellar radii :** The total energy radiated by the star per second is given by $E = \sigma T^4 \times$ Surface area of the star

$$\Rightarrow \quad E = \sigma T^4 \times 4\pi R^2 \Rightarrow \text{Radius of star } (R) = \left(\frac{E}{4\pi\sigma}\right)^{1/2} T^2$$

Usually, the radius of star is expressed in terms of solar radius $(R_s = 6.95 \times 10^8 m)$. Thus star radius $= \left(\dfrac{E}{4\pi\sigma}\right)^{1/2} \dfrac{T^2}{6.95 \times 10^8}$ solar radius.

$\Rightarrow$ The radii of most of the stars lie in the range 0.02 to 220 solar radii.

(2) **Stellar masses :** Let M_1 and M_2 be the masses of two stars revolving about their common centre of mass in circular orbits of radii r_1 and r_2 respectively such that $r_1 + r_2 = r$. Now

$$M_1 + M_2 = \frac{4\pi^2}{G} \times \frac{r^3}{T^2} \qquad \text{......(i)}$$

where T is common period of revolution.

If a planet of mass M_1 moves round the Sun of mass M_s , then the mass M_1 can be neglected in comparison with M_s because $M_S >> M_1$. Then equation (i) can be written as

$$M_S = \frac{4\pi^2}{G} \times \frac{r^3}{T^2} \qquad \text{.....(ii)}$$

As M_s is constant, it implies that $\dfrac{r^3}{T^2}$ = constant

which is Kepler's third law.

In binary system, r = 1 AU, T = 1 year and $M_1 + M_2 = 1$ solar mass. Hence equation (i) gives $G = 4\pi^2$

$$\therefore \quad M_1 + M_2 = \frac{r^3}{T^2} \qquad \text{..... (iii)}$$

Equation (iii) can be used to find the masses of two stars in binary system.

(3) **Spectra of stars :** The different stars are of different colours and the spectrum of a star is related to its colour, There are seven classes of stellar spectra denoted by letters O, B, A, F, G, K and M. Our sun belongs to G class star.

Table 31.2 : Spectrum of stars

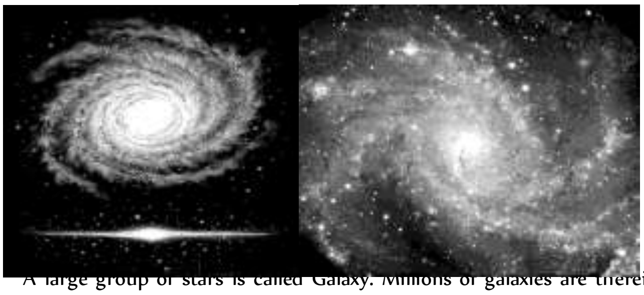
Spectra type	Colour	Surface temp (K)	Description of absorption spectra
O	Dark blue	3 × 10^4 to 4 × 10^4	Ionized helium lines
B	Blue	1.s5 × 10^4 to 2.3 × 10^4	Lines of neutral helium
A	White	9.5 × 10^3 to 1.1 × 10^4	Lines of H_2
F	Green	6.5 × 10^3 to 7.5 × 10^3	Lines of H_2 and ionised metals
G	Yellow	5800	Lines of ionised Ca, Fe, C
K	Orange	4500	Bands due to hydrocarbons
M	Red	3500	Bands of Titanium oxide

These relationship between the colour of a star and its temperature is expressed by Wien's displacement law. According to this law

$$\lambda_m \propto \frac{1}{T} \quad \text{or} \quad \lambda_m T = b \quad \text{or} \quad T = \frac{b}{\lambda_m}\text{; where } b = 2.89 \times 10^{-3}\ mK.$$

So those stars which appear blue (minimum wavelength) such as class *O* and *B*, are very hot and which appear red (maximum wavelength) such as class *M* are less hot.

Galaxies



A large group of stars is called Galaxy. Millions of galaxies are therein the sky. Each galaxy contains about 10^{11} stars.

The Sun and the planets of the solar system belong to the galaxy, called Milky way (Akash Ganga).

(1) **Types of galaxies :** There are two types of galaxies

(i) Normal galaxies, and (ii) Radio-galaxies.

(i) **Normal galaxies :** Besides milky way, there are billions of other galaxies in the universe. All these galaxies are called normal galaxies. There are three types of normal galaxies. (a) Elliptical galaxies (18%), (ii) Spiral galaxies (80%), and (iii) Irregular galaxies (2%).

(a) **Elliptical galaxies :** The galaxies which look like the flat elliptical discs are called elliptical galaxies. These generally consist of red giants, white dwarfs *etc. i.e.*, those stars which are nearing their ends.

(b) **Spiral galaxies :** The galaxies have lens-shaped central portion surrounded by a flat disc. It has two spiral arms which spiral around the central portion.

Example : Milky way and Andromeda.

(c) **Irregular galaxies :** These have no specific form of their own. Irregular galaxies are youngest normal galaxies and are middle aged and elliptical galaxies are quite old galaxies.

(2) **Radio galaxies :** The galaxies which emit electromagnetic radiations in the radio frequency are called radio galaxies. These have been classified as (i) Ordinary radio galaxies (ii) Quasars.

(i) **Ordinary radio galaxies :** A normal optical galaxy (*O*) which has two strong radio sources (R_1 and R_2) occurring symmetrically on either side of it, is called an ordinary radio galaxy. It appears like two ears on the two sides of the face of a person. The radio power output lies in the range 10^{30} to 10^{38} *watt*.

(ii) **Quasars :** Quasars are quasi-stellar radio sources. They are star like in structure and they emit powerful radio waves. They have a radio output of 10^{37} to 10^{38} *watt*. Quasars are farthest objects known. They are millions of light years away from Earth. These seem to be lying at the limit of the universe. They are moving away from Earth with a velocity of about 0.9 times the velocity of light. Their size is much smaller. It is of the order of light days. They form very dense galaxies. The density is also very large and their gravitational field is also very high. The cause of tremendous energy of the quasars is unknown. About 150 quasars have been detected so far.

(3) **Milky way (Akash Ganga) :** It is the name of the galaxy to which our earth belongs. The milky way is the glowing belt of the sky formed by the combined light of a very large number of stars. It is called milky way or Akash Ganga because the light from the various stars together gives the impression of a stream of milk flowing across the sky.

Milky way is a spiral galaxy. Its mass is 150 solar masses

(*i.e.* 3×10^{41} *kg*).

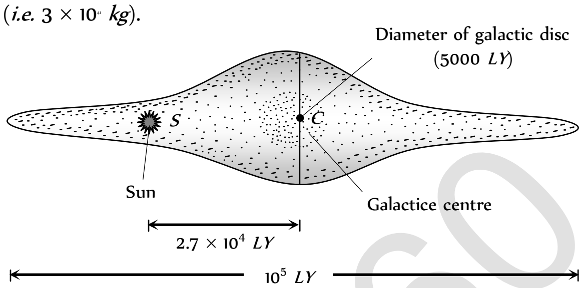


Fig. 31.6

Milky way contains 150 billions sun like stars.

Milky way contains clouds of dust and gases.

Pulsars

As the age of a star increases, its hydrogen content goes on decreasing. Ultimately, the star explodes as a supernova, in the universe. After explosion of a supernova, a variable star is born. It is not an ordinary star. It is the remaining part of a supernova. The variable star is called a pulsar. A pulsar emits electromagnetic waves in pulses and not continuously. The pulses are of very short duration (0.033 *s* to 0.088 *s*). The pulses may lie either in visible region or in radio region. About 50 pulsars have been detected, two in visible region and others in radio region. It is expected that there are about 100 pulsars in the universe.

Evolution of the Universe

Important theories about the origin and evolution of universe are as follows.

(1) **Big Bang theory :** The whole of the matter of the universe was concentrated in a very dense and hot fire ball about 20 billion years ago. An explosion occurred. The matter was broken into pieces in the form of stars and galaxies. The faster moving galaxies have gone farther than the slower ones. A galaxy situated at 20 billion light years is the boundary of the universe.

(2) **Expanding universe theory :** All the galaxies would continue to move away from the Earth and we will have an empty universe because on account of continuous expansion of the universe, more and more galaxies will go beyond the boundary of the universe and will be lost.

The motions of galaxies relative to the earth can be measured by observing the shifts in the wavelengths of their spectra. For distant galaxies these shifts are always toward longer wavelength, so they appear to be receding from us and from each other. Astronomers first assumed that these were Doppler shifts and used a relation between the wavelength λ_0 of light measured now from a source receding at speed *v* and the wavelength λ_S measured in the rest frame of the source when it was emitted.

$$\lambda_0 = \lambda_S \sqrt{\frac{c+v}{c-v}}$$

For $v << c$, Red shift (or Doppler's shift) $\Delta\lambda = \lambda_S \dfrac{v}{c}$

(3) **Pulsating universe theory :** As the galaxies move away, the expansion of the galaxies would be stopped by the gravitational pull. The galaxies would come so close that again a new explosion would take place. The same sequence will be repeated. Thus, we have alternate expansion and contraction of the universe giving rise to a pulsating universe. This takes place after every 80 billion years.

(4) **Steady state theory :** As the farthest galaxies speed away from each other, new galaxies are born to take their places. The total number of galaxies in the universe remains constant.

It is certain that : (i) The age of the universe is about 20 to 30 billion years. (ii) The most distant galaxy is situated at a distance of two billion light years away from the Earth. (iii) This galaxy is receding away from the Earth with a velocity 0.3 times that of light. (iv) The universe will live for about 100 million years more. Thus, the universe is quite young at present.

Hubble's law

(1) The speed of recession v of a galaxy is proportional to it's distance r from us *i.e.* $v \propto r \Rightarrow v = Hr$ this relation is called Hubble's law.

(2) Here H = An experimental quantity, called Hubble's constant. It's value is 19.3 *mm/sec* for each light year.

(3) Determining H has been a key goal of the Hubble's space telescope.

(4) The quantity $\frac{1}{H}$ has the dimensions of time.

(5) This time is called Hubble's times, which is an estimate of the order of magnitude of time that has elapsed since the Big Bange, and thus of the age of universe.

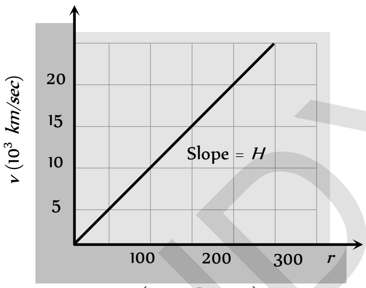


Fig. 31.7

Tips & Tricks

✍ The name black hole is given because it's gravity is so high that it prevents even light to radiate into space.

✍ Visible light is restricted from entering a telescope by dust particles in universe. Therefore range of a telescope is limited. Observation made in visible range are referred to as optical astronomy. Whereas observations made in radio range is called Radio-Astronomy.

✍ **Albedo :** The presence of atmosphere, clouds, *etc.* is acknowledged by a parameter known as albedo. It is the ratio of energy reflected by a planet to that incident on it. Clouds being good reflectors of light, they considerably increase the reflecting power of the planet and hence it's albedo is large. Venus has an albedo of 85% (highest).

✍ Mercury, Pluto and Venus do not have any satellites.

✍ On a clear night 5000 stars can be observed with naked eye.

✍ Closet star is alpha centuri (after the Sun) which is 4.3 light years away.

✍ Astronomy is branch of science which deals with the study of universe.

✍ Study of heavenly bodies is based upon visible light (λ ranging from 4000 Å to 8000 Å) and radio waves (λ ranging from 1 *mm* to 20 *m*).

✍ Hipparchus, a Greek astronomer, divided naked eye stars into six magnitude classes, on the basis of their brightness. The brightest stars were placed in the first magnitude class. Faintest visible stars were put in the sixth magnitude class.

✍ A comet does not have any tail when it is far from the Sun.

✍ **Mercury**

(i) Smallest planet (ii) Closest to the Sun

(iii) Fastest (iv) No atmosphere.

✍ Cygnus is a group of five stars. Which forms a cross like a swan.

✍ The clouds of dusty gas are called nebulae.