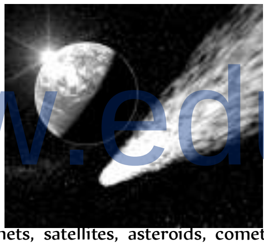
Chapter
31
Universe

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 $d \simeq D\alpha$

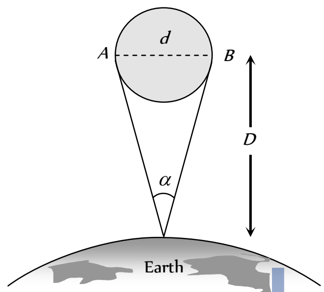


Fig. 31.1

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

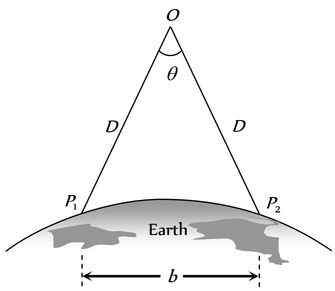


Fig. 31.2

(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,

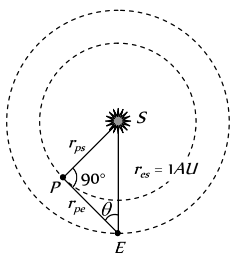


Fig. 31.3

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

where $1\,AU = 1.496 \times 10^{11}\ m$

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

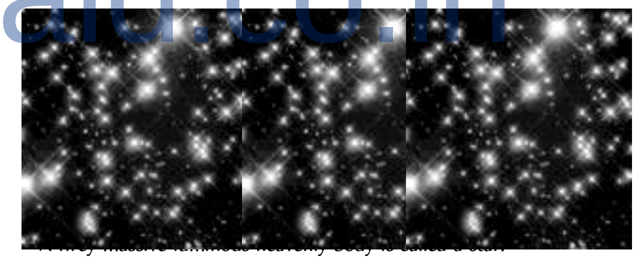
(3) **Kepler's law :** According to Kepler's law the square of time period of planet around sun is proportional to cube of semi-major axis of the orbit of planet around sun *i.e.* $\dfrac{a^3}{T^2} = \text{constant}$, if a_1 and a_2 are semi-major axes of planets 1 and 2 and T_1 and T_2 their respective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



(1) **Some features**

(i) Stars twinkle at night.

(ii) Stars are countless in number ; about 10^{22} 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* $5M_s$ 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*).

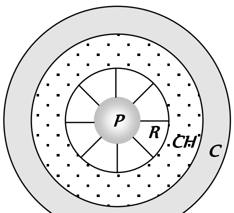


Fig. 35.4

(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

$= 5.68 \times 10^{-8}$ S.I. unit

T = Surface temperature of Sun

R = Radius of Sun

r = Radius of Earth's orbit

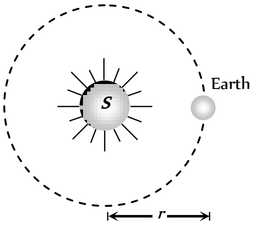


Fig. 31.5

(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 $G = 6.67 \times 10^{-11}$ 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

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

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 $G = 4\pi^2$

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

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	1.55×10^4 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

$$\lambda_m \propto \frac{1}{T} \quad \text{or} \quad \lambda_m T = b \quad \text{or} \quad T = \frac{b}{\lambda_m}$$; 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*).

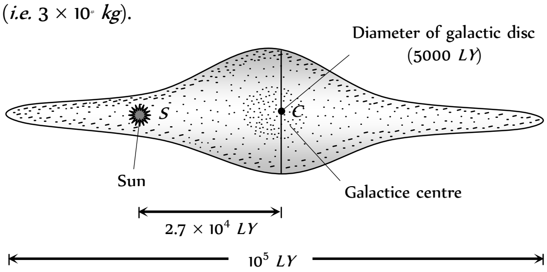


Fig. 31.6

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.

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

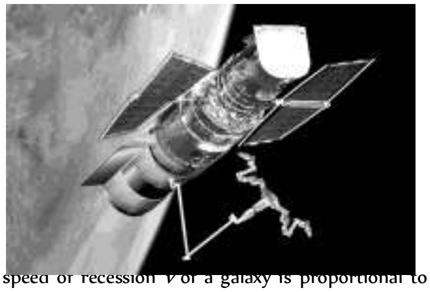
For $v << c$, Red shift (or Doppler's shift) $\Delta\lambda = \lambda_S \frac{v}{c}$

(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.

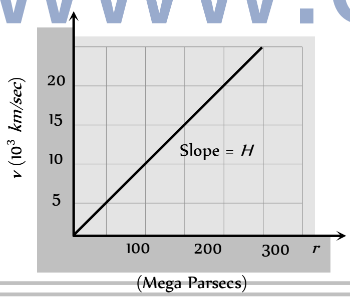


Fig. 31.7

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.

Ordinary Thinking

Objective Questions

Universe

1. A study of binary stars is most helpful in [CBSE PMT 1993]

   (a) Finding their distances
   (b) Finding their temperature
   (c) Finding their masses
   (d) Verifying Newton's force law of gravitation

2. A group of bright and faint stars is called [AFMC 1994]

   (a) Galaxy (b) Comet
   (c) Black hole (d) Constellation

3. According to modern astronomers into how many constellations, the whole sky is divided [BHU 1994]

   (a) 10 (b) 88
   (c) 880 (d) 5000

4. Which of the following theories is the most satisfactory about the origin of the universe [CBSE PMT 1994]

   (a) Big Bang theory (b) Pulsating theory
   (c) Steady state theory (d) None of these

5. Which of the planet is brightest [BHU 1999]

   (a) Mercury (b) Venus
   (c) Mars (d) Jupiter

6. A star which appears blue will be [CPMT 1998]

   (a) As hot as the sun (b) Cooler than the sun
   (c) Very cold indeed (d) Much hotter than the sun

7. Hubble showed that the universe as a whole is expanding and the distant stars are receding from us. The spectral line from a star, when compared with the corresponding line from an source will then show [Haryana CEE 1996]

(a) A shift in frequency towards the red end

(b) A shift in frequency towards the violet end

(c) No shift in frequency at all

(d) A shift in frequency towards the violet end as well as a decrease in intensity

8. The solar constant on the surface of the earth is *S*. What will be its value on the surface of another planet which is about 5.3 *A.U.* away from sun [AMU 1996, 97]

(a) $\frac{S}{5.3}$ (b) $\frac{S}{(5.3)^2}$

(c) 5.3 S (d) $(5.3)^2 S$

9. CO_2 gas is found in which of the following pairs of the planet [AFMC 1994]

(a) Earth and Mercury (b) Mercury and Saturn

(c) Venus and Saturn (d) Venus and Mars

10. The wavelength of maximum energy, released during an atomic explosion, was 2.93×10^{-10} *m*. Given that the Wien's constant is 2.93×10^{-3} *m K*, the maximum temperature attained must be of the order of [Haryana CEE 1996]

(a) 10^{-7} K (b) 10^{7} K

(c) 10^{-13} K (d) 5.86×10^{7} K

11. Black hole is a [BHU 1995; MH CET 2003]

(a) Hole in the ozone layer of atmosphere

(b) Hole in earth's centre

(c) Highly dense matter available in the atmosphere

(d) Hole in troposphere

12. A planet of mass M has a satellite of mass m, revolving around the planet in a circular orbit of radius r and time period T. The mass (M) of the planet is [AMU 2000]

(a) $\frac{4\pi^2 r^3}{GT^2}$ (b) $\frac{4\pi^2 r^2}{GT^3}$

(c) $\frac{GT^2}{4\pi r^3}$ (d) $\frac{r^3 G}{4\pi T^2}$

13. The age of universe is believed to be [NTSE 1995]

(a) 1 billion years (b) 10 billion years

(c) 10-20 billion years (d) 1000 billion years

14. A planet which is born sister of earth is [AFMC 2000]

(a) Mercury (b) Venus

(c) Mars (d) Jupiter

15. Source of Sun's energy is [CBSE PMT 1992; KCET 1994; AFMC 1998; BHU 2000; DCE 2001]

(a) Burning of hydrogen

(b) Fission reactions involving hydrogen

(c) Fusion reactions involving hydrogen

(d) Some other source

16. Asteroids are [DPMT 2000]

(a) Small planets

(b) Shooting stars

(c) Found in a belt between Earth ad Venus

(d) None of these

17. Sun radiates continuously and maintains its brightness because [MP PMT 1990; JIPMER 1997]

(a) Helium is converted into iron in its core

(b) Of fusion of hydrogen nuclei into helium

(c) Fusion of helium in hydrogen

(d) Burning of carbon, in its core

18. Venus appears brighter than other stars because [MP PMT 1990]

(a) It is heavier than other planets

(b) Its density is more than other planets

(c) It is nearer to earth in comparison to other planets

(d) Nuclear fusion takes place at its surface

19. There is no atmosphere on moon because [MP PMT 1990]

(a) There is no vegetation

(b) The escape velocity at its surface is very low

(c) Diffusion constant of gases is high

(d) There is vacuum in space

20. Which of the following planets have rings around it [MP PMT 1991]

(a) Uranus (b) Mars

(c) Jupiter (d) Saturn

21. Milky way is [MP PMT 1991; Kerala PMT 2001]

(a) A planet of our system

(b) A sun

(c) One of the solar system

(d) One of the enormous galaxies of universe

22. Hubble's law states that the velocity with which the 'milky way' is moving away from the earth is proportional to [MP PMT 1991; Kerala PMT 2004]

(a) Square of the distance of the milky way from the earth

(b) Distance of milky way from the earth

(c) Mass of the milky way

(d) Product of the mass of the milky way and its distance from the earth

23. The hottest planet of solar system is [CBSE PMT 1992]

(a) Mars (b) Mercury

(c) Venus (d) Pluto

24. Towards the centre of sun [MP PMT 1992]

(a) Density decreases

(b) Pressure decreases

(c) Temperature decreases

(d) Density and pressure increases

25. Period of revolution increases in the order of [MP PMT 1992]

(a) Saturn, Uranus, Venus (b) Mars, Saturn, Pluto

(c) Mercury, Neptune, Mars (d) Mars, Jupiter, Venus

26. The length of Milky way is [MP PMT 1992]

(a) 100,000 light years (b) 10,000 light years

(c) 1000 light years (d) 100 light years

27. Which of the nine planets is nearest to sun [CBSE PMT 1992]

(a) Venus (b) Mercury

(c) Mars (d) Jupiter

28. An extremely hot star would appear to be [AMU 1996, 97]

(a) Red (b) Blue

(c) Yellow (d) Orange

29. The sun emits a light with maximum wavelength 510 mm while another star X emits a light with maximum wavelength of 350 nm. What is the ratio of surface temperature of sun and the star X

(a) 2.1 (b) 0.68

(c) 0.46 (d) 1.45

30. A double star is a system of two stars rotating about their centre of mass only under their mutual gravitational attraction. Let the star have mass m and $2m$ and their separation be l. Their time period of rotation about their centre of mass will be proportional to [JIPMER 2000]

(a) $l^{2/3}$ (b) l

(c) $m^{1/2}$ (d) $m^{-1/2}$

31. Hubble's law is related with [AIIMS 2002; Pb. PET 2002]

(a) Comet (b) Speed of galaxy

(c) Black hole (d) Planetary motion

32. 'Albedo' is [Pb. PET 2001; BHU 2001; Kerala PET 2002; AFMC 2002]

(a) Reflecting power of a heavenly body

(b) Transmitive power of a heavenly body

(c) Absorptive power of a heavenly body

(d) Refracting power of a heavenly body

33. According to the pulsating theory the expansion and contraction of the universe repeats after every [TNPCEE 2002]

(a) 11 years (b) 8 billion years
(c) 8 million years (d) 80 billion years

34. Meteors are [TNPCEE 2002]
(a) Small stars
(b) Burnt pieces of comets that fall on earth
(c) Comets without tails
(d) None of these

35. Which of the following helps us in the determination of the temperature of sun [CBSE PMT 2001]
(a) Kirchhoff's law (b) Maxwell Boltzmann law
(c) Planck's law (d) Stefan's law

36. How does the red shift confirms that the universe is expanding
(a) Due to Wien's law (b) Due to Stefan's law
(c) Due to Kirchhoff's law (d) Due to Doppler's effect

37. Two stars P and Q are observed at night. Star P appears reddish while, star Q is white. From this we conclude [Roorkee 1992]
(a) Temperature of Q is higher than that of P
(b) Temperature of Q is lower than that of P
(c) Star Q is at the same distance at that of star P
(d) Star P is farther than star Q

38. Albedo is maximum for [Pb. PET 2000]
(a) Pluto (b) Venus
(c) Earth (d) Mercury

39. When original mass of star is greater than 5 M (M = mass of the sun). The death of this star will give rise to [Pb. PET 2000]
(a) White dwarf (b) Black hole
(c) Quasars (d) Nebula

40. The tail of the comet is due to [Pb. PET 2002]
(a) Vaporisation of water on the comet
(b) Sublimation of vapour in the comet
(c) Cooling of water in the comet
(d) Vaporisation of heat in the comet

41. In our solar system, there is one sun and [BHU 2004]
(a) Seven planets
(b) Nine planets
(c) Eleven planets
(d) Indefinite number of planets

42. Which one of the following planet has the longest day [AFMC 2003]
(a) Venus (b) Mars
(c) Mercury (d) Earth

43. Which one of the following is known as Saptarishi [AFMC 2003]
(a) Orion (b) Ursa major
(c) Ursa minor (d) Scorpion

44. Smaller pieces of heavy stones and metals which on entering earth's atmosphere burns out are [AFMC 2003]
(a) Comets (b) Meteorites
(c) Asteroids (d) All of these

45. In determining the temperature of a distant star, one makes use of [DCE 2003]
(a) Kirchhoff's law (b) Stefan's law
(c) Wien's displacement law (d) None of these

46. The motion of planets in the solar system is an example of conservation of [DCE 2001, 03]
(a) Mass (b) Momentum
(c) Angular momentum (d) Kinetic energy

47. Mass of earth has been determined through [Kerala (Engg.) 2002]
(a) Use of Kepler's T/R constancy law
(b) Sampling the density of earth's crust and using R
(c) Cavendish's determination of G and using R and 'g' at the surface
(d) Use of periods of satellites at different heights above earth's surface

48. The galaxies are moving away from each other. It is explained by [Pb. PMT 1997; AIIMS 2001]
(a) White dwarf star (b) Red shift
(c) Neutron star (d) None of these

49. Speed of recession of galaxy is proportional to it's distance [DCE 1999]
(a) Directly (b) Inversely
(c) Exponentially (d) None of these

50. Great bear is a [DCE 1998]
(a) Star (b) Galaxy
(c) Constellation (d) Planet

51. Surface temperature of the sun is of the order of [DCE 1996]
(a) 5000 K (b) 7000 K
(c) 6000 K (d) 12000 K

52. The colour of a star is an indication of its [BCECE 2005]
(a) Weight (b) Distance
(c) Surface temperature (d) Size

53. Which of the following is coldest planet [BCECE 2005]
(a) Mercury (b) Pluto
(c) Earth (d) Venus

54. According to Hubble's law, the redshift (Z) of a receding galaxy and its distance r from earth are related as [AIIMS 2005]
(a) $Z \propto r$ (b) $Z \propto 1/r$
(c) $Z \propto 1/r^2$ (d) $Z \propto r^{3/2}$

55. The condition for a uniform spherical mass m of radius r to be a black hole is [G = gravitational constant and g = acceleration due to gravity] [AIIMS 2005]
(a) $(2Gm/r)^{1/2} \le c$ (b) $(2Gm/r)^{1/2} = c$
(c) $(2Gm/r)^{1/2} \ge c$ (d) $(gm/r)^{1/2} \ge c$

56. Fraunhofer lines of the solar system is an example of [AIIMS 2001]
(a) Emission spectrum
(b) Emission band spectrum
(c) Continuous emission spectrum
(d) Line absorption spectrum

57. The difference in the lengths of a mean solar day and a sidereal day is about [AIIMS 2003]
(a) 1 min (b) 4 min

(c) 15 min (d) 56 min

Critical Thinking

Objective Questions

1. A bright star is indicated to have a brightness magnitude of – 5 compared to a star of brightness zero magnitude. It means that this star compared to the reference star of zero brightness is

(a) 100 times less bright (b) 5 times more bright

(c) 5 times less bright (d) 100 times more bright

2. The sun revolves around the galaxy with a speed of 250 *km/sec* and it's radius is 3×10^4 light year. The mass of the milky way is

(a) 3×10^{40} *kg* (b) 3×10^{41} *kg*

(c) 5×10^{40} *kg* (d) 6×10^{41} *kg*

3. There are certain types of stars called visible stars which undergo periodic change in their light output. If such a star quadruple it's light output, how much does it's magnitude change

(a) – 1.25 (b) – 1.5

(c) – 1.75 (d) – 2

4. A particular emission line, detected in the light from a galaxy, has a wavelength $\lambda' = 1.1\lambda$, where λ is the proper wavelength of the line. The galaxy distance from us

(a) $1.6\times10^9\,ly$ (b) $0.97\times10^9\,ly$

(c) $2.4\times10^9\,ly$ (d) $1.62\times10^{11}\,ly$

5. Assuming that the dimmest visible star to the naked eye has a magnitude of about 6. Brightness of planet Venus (magnitude = – 4) *w.r.t.* this star is

(a) 10,000 times brighter (b) 2000 times brighter

(c) 15000 times brighter (d) 4000 times brighter

6. A galaxy is observed to be moving with a velocity of 8600 *km-sec*. If it is at a distance of 430 million light year from us, Hubble constant and corresponding age of the universe are respectively

(a) $2\times10^{-5}\dfrac{kms^{-1}}{ly}, 1.49\times10^{10}\,year$

(b) $2\times10^{-6}\dfrac{kms^{-1}}{ly}, 1.58\times10^{3}\,year$

(c) $10^{6}\dfrac{kms^{-1}}{ly}, 1.49\times10^{10}\,year$

(d) None of these

7. Consider a binary star system consisting of two stars of masses M_1 and M_2 separated by a distance of 30 AU with a period of revolution equal to 30 years. If one of the two stars is 5 times farther from the centre of mass than the other. The masses of the two stars in terms of solar masses are

(a) 5, 15 (b) 25, 5

(c) 25, 10 (d) 7, 25

8. A planet of mass m moves in an ellipse around the sun of mass M_S so that its maximum and minimum distances are r_1 and r_2 respectively. The angular momentum of the planet relative to the centre of the sun is

(a) $\sqrt{\dfrac{2GM_S r_1}{(r_1+r_2)}}$ (b) $\sqrt{\dfrac{2GM_S m^2 r_1 r_2}{(r_1+r_2)}}$

(c) $\sqrt{\dfrac{GM_S r_1 r_2}{(r_1+r_2)}}$ (d) $\sqrt{\dfrac{2GM_S}{r_1 r_2 (r_1+r_2)}}$

9. The percentage of Sun's total energy which reaches the earth's surface is [Kerala PMT 2003]

(a) 10^{-7} % (b) 10^{-6} %

(c) 10^{-3} % (d) 10^{-2} %

10. Suppose a planet goes around Sun with a linear speed twice as fast that of earth. What will be it's orbit size as compared to that of earth ? (Radius of earth = *R*) [BHU 1993]

(a) *R* / 4 (b) *R* / 2

(c) *R* (d) 2*R*

Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : The stars twinkle while the planets do not.
Reason : The stars are much bigger in size than the planets.[AIIMS 2003]

2. Assertion : A pulsor is a source of radio waves which change in terms of intensity at regular interval of time
Reason : A pulsor is a rotating neutron star [AIIMS 1998, 2002]

3. Assertion : The comet do not obey Kepler's laws of planetary motion
Reason : The comet do not have elliptical orbit [AIIMS 1995]

4. Assertion : A star which appears blue will be much hotter than the sun
Reason : It is based on Wien's law

5. Assertion : There is no atmosphere on moon
Reason : Escape velocity at the surface of moon is low.

6. Assertion : Red shift confirms that the universe is expanding
Reason : Wavelength of red light is maximum in the visible region

7. Assertion : Sun is at the galactic centre C of the milky way
Reason : All planets of solar system revolve around the sun.

8. Assertion : Moon is seen as it partly reflects the sun light falling on it
Reason : Moon is a satellite of earth. It does not emit light of its own

9. Assertion : The value of Hubble's constant is 16 km/s

Reason : Hubble's constant means that a galaxy at 1 million light years away is receding at the rate of 16 km/s.

Answers

Universe

1	d	2	d	3	b	4	a	5	b
6	d	7	a	8	b	9	d	10	b
11	c	12	a	13	c	14	b	15	c
16	a	17	b	18	c	19	b	20	d
21	d	22	b	23	b	24	d	25	b
26	a	27	b	28	b	29	b	30	d
31	b	32	a	33	d	34	b	35	d
36	d	37	a	38	b	39	b	40	a
41	b	42	a	43	b	44	b	45	c
46	c	47	c	48	b	49	a	50	c
51	c	52	c	53	b	54	a	55	c
56	d	57	b						

Critical Thinking Questions

1	d	2	b	3	b	4	a	5	a
6	a	7	b	8	b	9	a	10	a

Assertion and Reason

1	b	2	b	3	b	4	a	5	a
6	b	7	e	8	a	9	e		

Answers and Solutions

Universe

1. (d) A study of binary star is most helpful in verifying Newton's law of gravitation.
2. (d) A group of bright and faint stars is called a constellation
3. (b) The sky is divided into 88 constellations.
4. (a) Big Bang theory is the most satisfactory theory about the origin of universe.
5. (b) Venus is the brightest planet.
6. (d) A star which appears blue will be much hotter than the sun.
7. (a) When distant stars are receding from us, spectral line from the star, when compared to with the corresponding line from source will show red shift *i.e.* a shift in frequency towards the red end.
8. (b) Solar constant is the energy crossing per unit area per sec at earth's distance, area being normal to the sun's rays. Also energy falling is inversely proportional to the square of distance from the source.

$$\therefore\ S' = \frac{S}{(5.3)^2}$$

9. (d) Venus and Mars have both CO_2 present.
10. (b) $\lambda_m T = b \Rightarrow 2.93\times10^{-10}\times T = 2.93\times10^{-3} \Rightarrow T = 10^7\ K$
11. (c) Black hole is highly dense malter in the atmosphere which has very large value of gravitational pull, so that nothing escapes from it.
12. (a) $F = \frac{GMm}{r^2} = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$

$$M = \frac{mr^3 4\pi^2}{GmT^2} = \frac{4\pi^2 r^3}{GT^2}$$

13. (c) The age of universe is believed to be 10-20 billion years.
14. (b) Planet Venus is called Earth's sister.
15. (c) Source of Sun's energy is fusion reactions involving hydrogen.
16. (a) Asteroids are a group of rock pieces moving around the Sun in between Mars and Jupiter. They are believed to be the remains of a large planet which exploded due to gravitative attraction of Sun and that planet, may be called small planets.
17. (b) The energy of the sun is due to fusion of hydrogen nuclei into helium.
18. (c) Venus appears brighter as it is nearest to the earth and the light of sun reflected form sun reaches earth with greater intensity.
19. (b)
20. (d) Saturn only has ring around it.
21. (d) Milky way is one of the enormous galaxies of the universe.
22. (b) According to Hubble's law, $v \propto r$.
23. (b) The hottest planet of solar system is one which is nearest to sun and has no atmosphere.
24. (d) As we move towards the centre of the sun, the density and pressure increases.
25. (b) As $T^2 \propto r^3$ and distance of planet from sun in increasing order is for Mars, Saturn and Pluto.
26. (a) Length of milky way is 10^5 light years.
27. (b) Mercury is the nearest planet to sun.
28. (b) According to Wien's law, $\lambda_m \propto \frac{1}{T}$. It means higher the temperature of a star, the lower is the wavelength of maximum intensity radiation emitted from star which tells the colour of star.
29. (b) As $\lambda \propto \frac{1}{T}$; so $\frac{T_1}{T_2} = \frac{\lambda_2}{\lambda_1} = \frac{350}{510} = 0.68$
30. (d) $\frac{Gm\times 2m}{l^2} = m\times\frac{2l}{3}\frac{4\pi^2}{T^2}$ or $T = \left(\frac{4\pi^2 l^3}{3Gm}\right)^{1/2}$ *i.e.* $T \propto m^{-1/2}$
31. (b) Speed of galaxy is proportional to it's distance from us *i.e.* $U \propto r$. This is Hubble's law
32. (a) Reflecting power of a heavenly body is called albedo.
33. (d)
34. (b) Meteors are burnt piece of comet. When they reach earth's atmosphere, they start burning due to friction.
35. (d) According to Stefan's law $E = \sigma T^4$

36. (d) If the light received from galaxies indicates a shift towards the red end of spectrum of light, it means that the galaxies should be receding away (Doppler's effect). Therefore we conclude that the universe is expanding.

37. (a) The star which appears red is at less temperature, than the star which appears white. Therefore, temperature of Q is higher than that of P.

38. (b) The albedo (reflection power) is maximum for Venus, because it reflects 85% of incident light. It's value of albedo is 0.85.

39. (b) It is well known that if the mass of the star is more than that of mass of Sun, it explodes after it's red giant stage and dies out giving rise to supernova and a black hole.

40. (a) If a comet approaches the sun, the substances like water *etc.* on the comet, get vaporised due to the heat of Sun, and radiation pressure forces of these vapours move away from the Sun. Hence, it forms the tail of the comet.

41. (b)

42. (a) Venus has the longest day.

43. (b) Ursa major is known as saptarishi.

44. (b)

45. (c) The temperature of stars can be determined by Wiens displacement law which is $\lambda_m.T = \text{constant}$.

46. (c) The motion of planets in the solar system is based on the conservation of angular momentum.

47. (c)

48. (b)

49. (a) Hubble's law state that. Speed of recession (v) ∝ distance (r).

50. (c) Great bear is a constellation, which is a group of some stars.

51. (c) Surface temperature of Sun is about 6000 K.

52. (c) By using $\lambda_m T = \text{constant}$

53. (b) Because pluto is farthest from Sun.

54. (a) Hubble's law is a statement of a direct correlation between the distance (r) to a galaxy and its recessional velocity as determined by the red shift (Z). It is stated as $Z = Hr$.

55. (c) The criterion for a star to be black hole is

$$\frac{GM}{c^2R} \geq \frac{1}{2} \text{ or, } \sqrt{\frac{2GM}{R}} \geq c.$$

56. (d) Fraunhofer lines are produced by the absorption of rays of the Sun in the atmosphere. When white light from photosphere passes through chromosphere, the vapours and gases present in it absorbs certain wavelengths and produces dark lines (Fraunhofer lines).

57. (b) The difference in the length of mean solar day and a sidereal day is about 4 min.

Critical Thinking Questions

1. (d) Given that magnitude for brightest star = – 5
and magnitude of given star = 0
Now $m_2 - m_1 = 0 - (-5) = 5$
The brightness ratio is given by

$$\frac{l_1}{l_2} = 100^{(m_2 - m_1)/s} = 100^{5/5} = 100$$

So bright star is 100 time bright that the dim star.

2. (b) The mass of galaxy is given by $M = \frac{v^2 r}{G}$

where $v = 250\ km/sec = 250 \times 10^3 \frac{m}{\text{sec}}$

$r = 3 \times 10^4\ ly = 3 \times 10^4 \times 9.46 \times 10^{12}\ km \approx 3 \times 10^{20}\ m$

$$\therefore\ m = \frac{(250 \times 10^3)^2 \times (3 \times 10^{20})}{6.6 \times 10^{-11}} \approx 3 \times 10^{41}\ kg.$$

3. (b) $\frac{l_2}{l_1} = 4 \Rightarrow m_2 - m_1 = -2.5 \log\left(\frac{l_2}{l_1}\right) = -2.5 \log 4$

$= -2.5 \times 0.6021 = -1.5$.

4. (a) From Hubble's law $v = Hr$ where H = Hubble's constant = 19.3 *mm/sec-ly* and r = Distance of Galaxy from us.

According to Doppler's effect speed of Galaxy $v = \frac{c\Delta\lambda}{\lambda}$

$$\Rightarrow r = \frac{c\Delta\lambda}{H\lambda} = \frac{c \times 0.1\lambda}{H\lambda} = \frac{0.1 \times 3 \times 10^8}{19.3 \times 3 \times 10^{-3}} = 1.6 \times 10^9\ ly$$

5. (a) Here, for Venus $m_1 = -4$, for star $m_2 = 6$ using

$$\frac{l_1}{l_2} = 100^{(m_2 - m_1)/5} = 100^{[6-(-4)]/5} = 100^2 = 10{,}000.$$

6. (a) $H = \frac{v}{r} = \frac{8600}{430 \times 10^6} = 2 \times 10^{-5} \frac{kms^{-1}}{ly}$

Age of the universe, $t_0 = \frac{1}{H} = \frac{r}{v}$

Taking $r = 430 \times 10^6\ ly = 430 \times 10^6 \times 9.46 \times 10^{12}\ km$

$$\Rightarrow t_0 = \frac{430 \times 10^6 \times 9.46 \times 10^{12}}{8600} \text{ sec}$$

$$= \frac{430 \times 10^6 \times 9.46 \times 10^{12}}{8600 \times 3600 \times 24 \times 365} = 1.49 \times 10^{10}\ year$$

7. (b) $M_1 + M_2 = \frac{4\pi^2}{G} \cdot \frac{r^3}{T^2}$

If T is measured in years, r in *A.U.* and masses in Solar masses then $G = 4\pi^2$.

$\therefore\ M_1 + M_2 = \frac{r^3}{T^2} = \frac{(30)^3}{(30)^2} = 30$ .....(i)

Now $r_1 + r_2 = 30 \Rightarrow r_1 + 5r_1 = 60$

$\Rightarrow r_1 = 5$ and $r_2 = 25$

Again $M_1 r_1 = M_2 r_2 \Rightarrow \frac{M_1}{M_2} = 5$ .....(ii)

After solving (i) and (ii) we get $M_1 = 25$ and $M_2 = 5$

8. (b) From conservation of energy

$\frac{1}{2}mv_1^2 - \frac{GM_S m}{r_1} = \frac{1}{2}mv_2^2 - \frac{GM_S m}{r_2}$. Angular momentum is conserved, that is $mv_1 r_1 = mv_2 r_2$

or $v_2 = v_1 \frac{r_1}{r_2} \Rightarrow \frac{1}{2}mv_1^2 - \frac{GM_S m}{r_1} = \frac{1}{2}m\left(\frac{v_1 r_1}{r_2}\right)^2 - \frac{GM_S m}{r_2}$

or $v_1 = \sqrt{\frac{2GM_S r_2}{r_1(r_1 + r_2)}} \Rightarrow L = mv_1 r_1 = \sqrt{\frac{2GM_S m^2 r_1 r_2}{r_1 + r_2}}$

9. (a) If S is the total energy emitted by Sun per second and r is the distance of earth from Sun; then energy reaching earth of radius R per second $= \frac{S}{4\pi r^2} \times 2\pi R^2 = \frac{SR^2}{2r^2}$.

∴ Percentage of energy reaching earth

$$= \frac{SR^2}{2r^2 S} \times 100 = \frac{(6.4 \times 10^6)^2 \times 100}{2 \times (1.5 \times 10^{11})^2} \simeq 10^{-7}\%$$

10. (a) From Kepler's law $T \propto R^{3/2}$ and also $T = \frac{2\pi R}{v}$

$$\Rightarrow v \propto \frac{1}{R^{1/2}} \Rightarrow \frac{v_1}{v_2} = \left(\frac{R_2}{R_1}\right)^{1/2} \Rightarrow \frac{v_1}{2v_1} = \left(\frac{R_2}{R_1}\right)^{1/2}$$

$$\Rightarrow R_2 = \frac{R_1}{4} = \frac{R}{4}$$

Assertion and Reason

1. (b) Stars twinkles due to variation in density of atmospheric layer. Also stars are much bigger in size than planets but it has nothing to deal with twinkling phenomenon.

2. (b) Pulsar is a source of radio waves which emits pulses of radio waves at short and regular time of intervals.

Pulsar is formed, due to super nova explosion, when super nova explosion occurs, the core of the star is compressed and electrons and protons combine to form a neutron. Due to this region pulsar is called neutron star.

3. (b) Comets do not revolve around the sun in fixed elliptical orbit like other planets and don't obey Kepler's law for planetary motion.

4. (a) According to Wien's law, $\lambda_m T = b =$ constant. As λ_m for the star is blue, which is less than λ_m for sun, which is yellow, therefore temp. T of star will be much higher than the temperature of the sun.

5. (a) At the surface of moon $v_{rms} > v_{escape}$ hence molecules escape out before reaching their *rms* velocity that's why there is no atmosphere present.

6. (b) Red shift means that wavelength of light received from stars is increasing *i.e.,* apparent frequency is decreasing. Therefore, the stars/galaxies must be receding away. Hence the universe is expanding. Reason is also true, but it does not explain the assertion appropriately.

7. (e) The reason is true, but the assertion is false. Infect, distance of sun of our solar system from galactic centre is 3×10^4 light years.

8. (a) Both the assertion and reason are true and reason is a correct explanation of the assertion.

9. (e) The assertion is not true. Infect, the value of Hubble's constant is 16 km per sec per million light years.

Universe

SET Self Evaluation Test -31

1. "The universe is expanding" means
   (a) Size of the hole in Ozon layer is increasing
   (b) Universe is expanding into something
   (c) Infinite universe is becoming more infinite
   (d) None of these

2. The galaxy in which we live is
   (a) Spiral galaxy (b) Radio galaxy
   (c) Irregular galaxy (d) None of these

3. The distance of Venus from the sun is 0.72 AU. the orbital period of the Venus is
   (a) 200 days (b) 320 days
   (c) 225 days (d) 325 days

4. Suppose the sun was located at the position occupied by the nearest star, say, alphacenturi 4 light years away. By what factor the solar radiation received per sec per unit area decrease
   (a) 1.5×10^{-6} (b) 1.5×10^{-8}
   (c) 1.5×10^{-9} (d) 1.5×10^{-11}

5. If a galaxy is at a distance 430 million light years from us, determine Hubble's constant. Its speed being $6.48\times10^{6} ms^{-1}$
   (a) 16 kms^{-1} per million light year
   (b) 15 kms^{-1} per million light year
   (c) 14 kms^{-1} per million light year
   (d) None of these

6. The magnitude of two stars A and B are 2.5 and –5 respectively. The brightness ratio of $\frac{B}{A}$ is
   (a) 7.5 (b) 10^{2}
   (c) 10^{3} (d) $10^{7.5}$

7. A body at 1500 K emits maximum energy at a wavelength 20,000 $\AA$. If the Sun emits maximum energy at wavelength 5500 $\AA$, then the temperature of Sun is
   (a) 5454 (b) 4454
   (c) 4550 (d) 5400

8. The hottest type of stars are called
   (a) A type (b) B type
   (c) O type (d) M type

9. Venus appears brighter than other stars because
   (a) It is heavier than other planets
   (b) Its density is more than other planets
   (c) It is nearer to earth in comparison to other planets
   (d) Nuclear fusion takes place at its surface

10. The death of a star results is in a neutron star if the original mass of star in terms of mass of Sun (M) is
    (a) Less than $2M$
    (b) Between $2M$ and $4M$
    (c) Greater than 5 M
    (d) Exactly equal to M

11. The tail of a comet points
    (a) Towards the Sun
    (b) Away from the Sun
    (c) In arbitrary
    (d) Away from the earth

12. The angle of maximum elongation for Venus is 47°. The distance of Venus from earth in A.U. is
    (a) 0.68 A.U. (b) 0.86 A.U.
    (c) 1 A.U. (d) 0.73 A.U.

13. The number of stars in our solar system is
    (a) 9 (b) 5
    (c) 1 (d) More than 9

14. If angular diameter of Sun is about 30′ and it's distance from earth is 1.5 × 10^{11} m, then solar diameter is
    (a) 1.1 × 10^{7} m
    (b) 1.5 × 10^{8} m
    (c) 1.4 × 10^{9} m
    (d) 1.9 × 10^{11} m

AS Answers and Solutions

(SET -31)

1. (c)

2. (a) The galaxy in which we live is spiral galaxy. Our galaxy Milky way is a spiral galaxy.

3. (c) $\frac{T_2^2}{T_1^2} = \left(\frac{r_2}{r_1}\right)^3$ or $T_2 = T_1\left(\frac{r_2}{r_1}\right)^{3/2} = 1\left(\frac{0.72}{1}\right)^{3/2}$

= 0.62 year or 225 days.

4. (d) $\frac{E_1}{E_2} = \frac{r_2^2}{r_1^2}$ or $\frac{E_2}{E_1} = \frac{r_1^2}{r^2} \Rightarrow \frac{(1.5\times10^{11})^2}{(4\times9.46\times10^{15})^2} = 1.5\times10^{-11}$

where r_1 = Distance of Sun from earth = 1.5×10^{11} m = 1 AU, r_2 = 4 ly = $4 \times 9.46 \times 10^{15}$ m

5. (b) $H = \frac{v}{r} = \frac{6.48\times10^6}{430} = 15.07\, kms^{-1}$ per million light year

6. (c) $m_B - m_A = -2.5\log_{10}\left(\frac{I_B}{I_A}\right)$

$\Rightarrow -5-(2.5) = -2.5\log_{10}\frac{I_B}{I_A} \Rightarrow \log_{10}\frac{I_B}{I_A} = 3$

$\Rightarrow \frac{I_B}{I_A} = 10^3$.

7. (a) According to Wien's displacement law $\lambda_m T$ = constant

or $\lambda_m T = \lambda_m' T'$

or $T' = \frac{\lambda_m}{\lambda_m'}\times T = \frac{20{,}000 Å \times 1500K}{5500 Å} = 5454K.$

8. (c) O type stars are hottest.

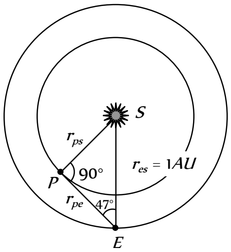
9. (c) Venus appears brighter than other stars because it is nearest to earth than other stars.

10. (b)

11. (b) Tail of comet points away from the sun.

12. (a) The angle formed at earth between earth planet and earth sun direction is called planet's elongation represented by ε, when planet appears farthest from the Sun, the angle subtended by the Sun and earth at the planet is $90°$.

From the geometry of figure



$\frac{r_{PE}}{r_{sE}} = \cos\varepsilon = \cos 47°$

$r_P = r_{sE}\cos 47°$

$= (\cos 47°)\times 1AU = 0.68AU$

Choice (a) is correct

[$\cos 45° = \frac{1}{\sqrt{2}} = 0.707$. As angle increases its cosine decreases $\cos 47°$ can not be 0.86, 0.73 or 1]

13. (c) The number of stars in our solar system in one (our Sun).

14. (c) We know that

$$D = r\theta = 1.5\times10^{11}\times\frac{1}{2}\times\frac{\pi}{180°} = 1.4\times10^9 m$$

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