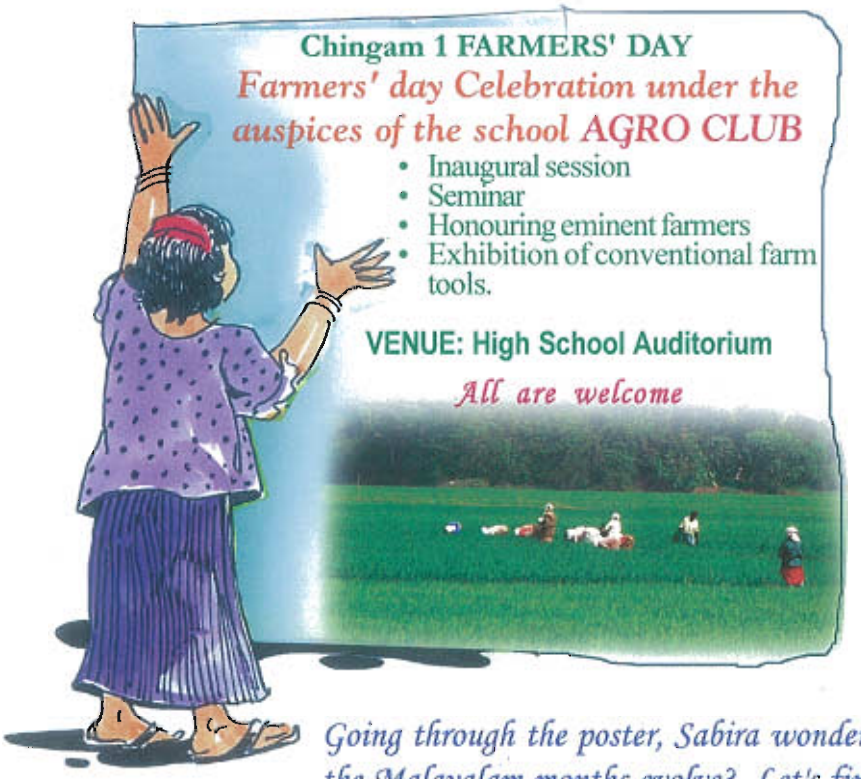
11 OUR UNIVERSE



Going through the poster, Sabira wondered : How did the Malayalam months evolve? Let's find out.

Haven't you gazed at the sky at night? What all things do you see?

- Stars
-

Are they seen at the same position everyday? Have you observed?

Haven't you noticed the change in the phase and position of the moon each day?

Are the stars / clusters of stars seen in the vicinity of the moon in its path, the same, each day?

Discuss this with your friends in the light of your observations and Fig. 11.1.

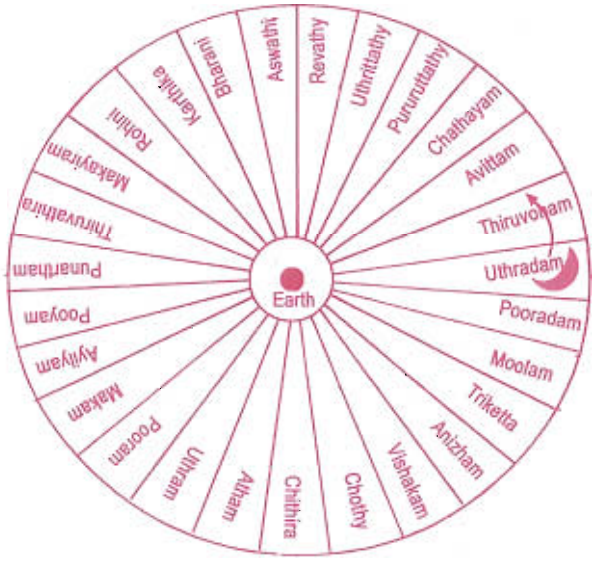


Fig. 11.1

The moon takes approximately 27 days to revolve round the earth once. That is, it moves 13 $\frac{1}{3}$ degrees in its orbit per day. The moon's orbit can be divided into 27 segments, each of 13 $\frac{1}{3}$ degrees. These 27 segments are named on the basis of the names of stars or groups of stars seen in each segment.

✶ Which is the star seen in the vicinity of the moon in the figure?

- -

✶ Which star, do you think, will be near the moon the next night?

- -

✶ By how many degrees does the position of the moon change each day?

- -

The time taken by the moon to describe 1/27 of its orbit is called an asterism or a birthstar (*naal*).

✶ If so, how many asterisms are there altogether?

- -

In ancient days, the position of celestial objects were used to mark important events. Weren't there kings known by their birthstars in the history of Kerala? For example, Chithira Thirunal, Uthradam Thirunal etc.

Which star do you think was seen near the moon when Maharaja Sree Chithira Thirunal was born? Think about it.

Haven't you seen asterisms marked in calendars? If December 29 is marked in the calendar as Chithira,

✶ what does this mean?

- -

You may have understood that asterisms are formed on the basis of the stars that come in the moon's orbit.

Now let's see how Malayalam months were evolved.

We know, it is due to the earth's rotation that we feel the sun rises in the east and sets in the west.

Notice the bright star seen at dawn in the eastern horizon before sunrise one morning. It vanishes when the sun rises. Note the time when it vanishes. Observe the star after five days at the same time. Is the star at the same position as before? In this manner, observe continuously for a month at intervals of five days. Enter your observations in your science diary.

You might have found out that stars move away from the sun towards the west at the rate of 1 degree approximately each day. It can also be said that, relative to the stars, the sun moves towards the east at the rate of one degree per day. Thus it appears that the sun moves 30 degree towards the east in a month. Does the sun or the stars move like this actually? Discuss on the basis of Fig.11.2.

Take note of the position of the earth, the sun and the stars in Fig. 11.2.

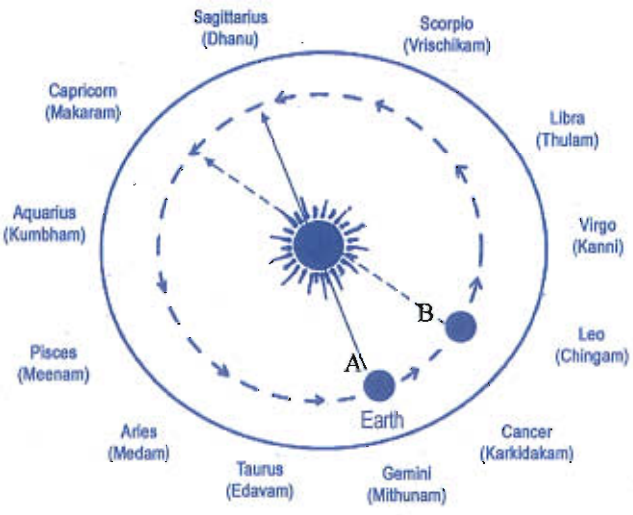


Fig. 11.2

★ Which is the constellation seen in the background of the sun by an observer on earth, when the earth is at A?

- -

★ And when the earth is at B?

- -

★ Which is the constellation seen in the background of the sun when the earth is again at A after revolving once around the sun?

- -

★ How many days are required for the earth to revolve once around the sun?

- -

Aren't you convinced that our feeling of the sun moving among the stars is due to the revolution of the earth?

This orbit, along which the sun appears to move among the stars, is known as ecliptic.

The ecliptic is divided into 12 equal parts. These are the 12 solar constellations. Each constellation is known by the shape of the stellar distribution in it.

★ Observe the figure. To an observer on earth, in which constellation is the sun seen?

- -

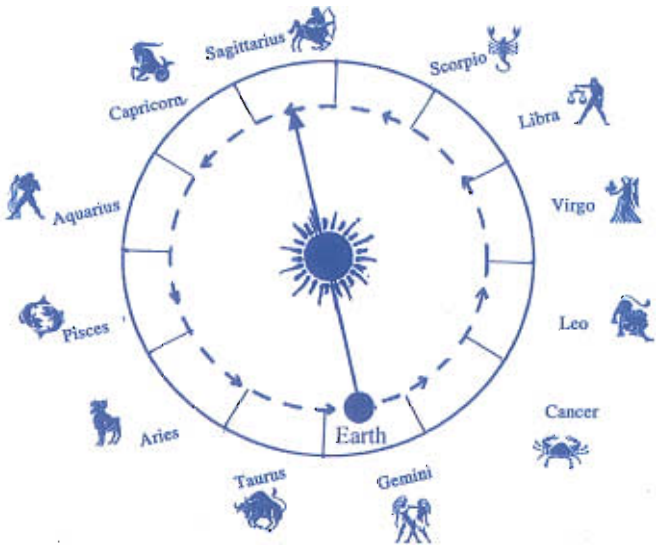
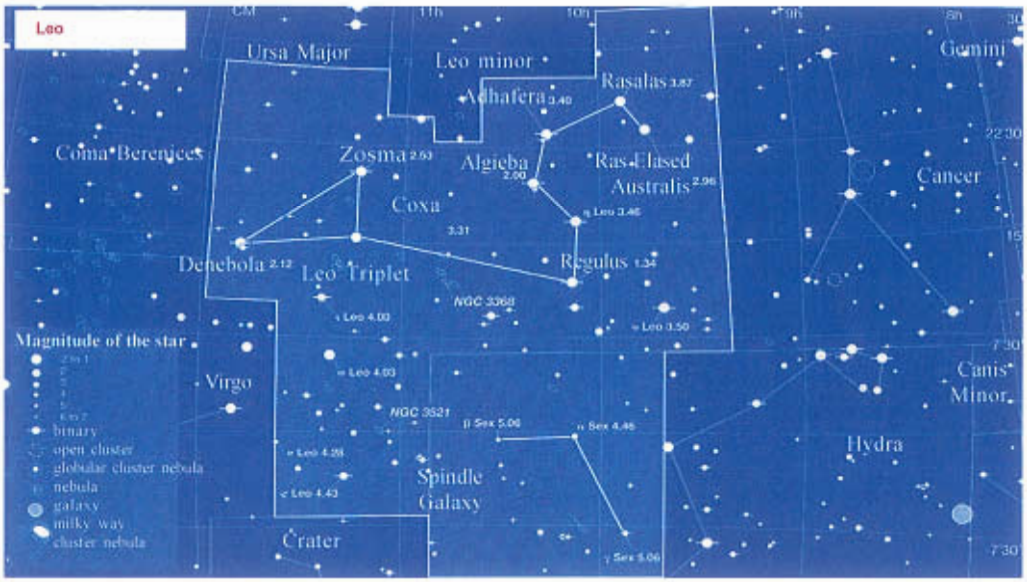


Fig. 11.3

As it rises and sets along with the sun, this constellation which forms the background of the sun is not visible in the sky at this time.

A month will be known after the constellation in which the sun is seen. The sun takes nearly 30 days to cross a constellation.



★ In which constellation will the sun be seen next month?

A Malayalam month will be known by the name of the constellation in which the sun appears to be at that time.

You have now understood how Malayalam months evolved, haven't you?

Isn't it now clear that in olden days the motion of celestial spheres was used for the prediction of seasons?

What are the other purposes for which sky watching might have helped?

- To find the direction
-

The positions of the sun and stars were considered to ascertain whether it was the right time to prepare land for cultivation.

When the Samuthiri king was informed that foreigners carried away pepper vines to their countries, this was his response: "They can take only our pepper saplings. They cannot take our Thiruvathira Njattuvela".

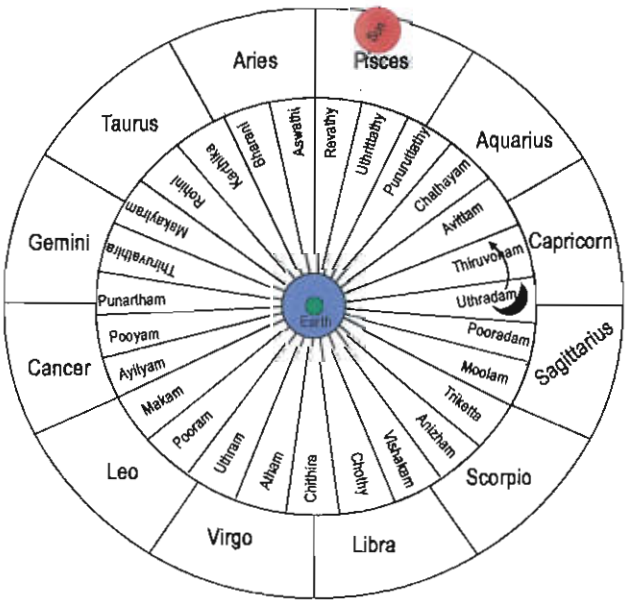


Fig. 11.4

What is '*Njattuvela*'?

Won't the sun pass through the 27 asterisms also while it passes through the 12 constellations?

★ The sun takes nearly 365 days to pass past these 27 asterisms once. Then how many days will the sun stay with one asterism?

The period of time for which the sun appears together with an asterism is a *njattuvela* (*njayar* means the sun and *vela* means interval of time).

A *njattuvela* is approximately 13-14 days.

★ In which month does the *Thiruvathira Njattuvela* occur?

★ And the *Aswathi Njattuvela*?

It is the heavy rain in Kerala during the *Thiruvathira Njattuvela* that helps pollination in pepper plants and fetches good yield. Have you now understood the implication of the Samuthiri's response? Try to identify different constellations and the stars in them, based on the knowledge acquired so far and by observing the sky. Only about 6000 stars can be seen with the naked eye. The sun, which is the centre of the solar system is one star among them.

The Sun

We can view stars with our naked eye. But why is it said that the sun should not be viewed with the naked eye?

★ Have you focussed the sun's rays on a white paper using a convex lens? What was your experience?

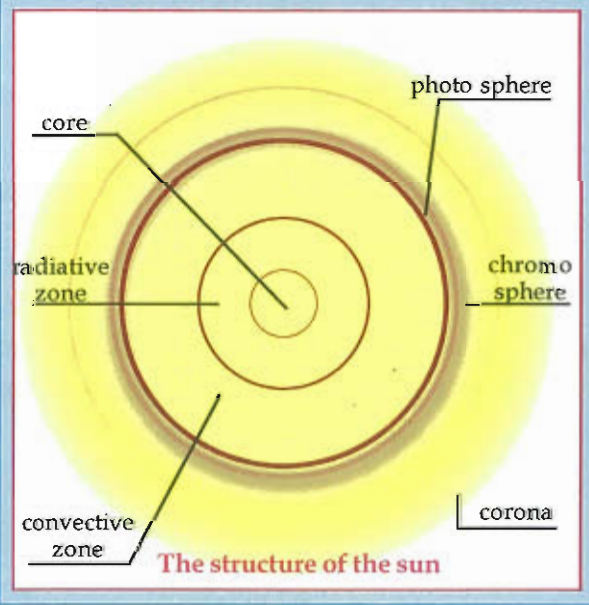
★ Don't our eyes too have a convex lens? What will be the effect if the direct rays from the sun are focussed on the retina by it?

The sun is a white hot gaseous sphere. What we see is the photosphere which is its outer layer. The temperature there is approximately 6000 kelvin. But at its core the temperature is 1.5 crores kelvin and the pressure extremely high. The source of the sun's energy is the fusion of hydrogen taking place in the core. This energy flows out of the core in the form of gamma rays through the radiative zone (see the figure) by repeated absorption and reradiation. The convective zone, outside the radiative zone, receives this energy and transfers it to the photosphere through the process of convection. What we see is the light radiated by the white hot photosphere.

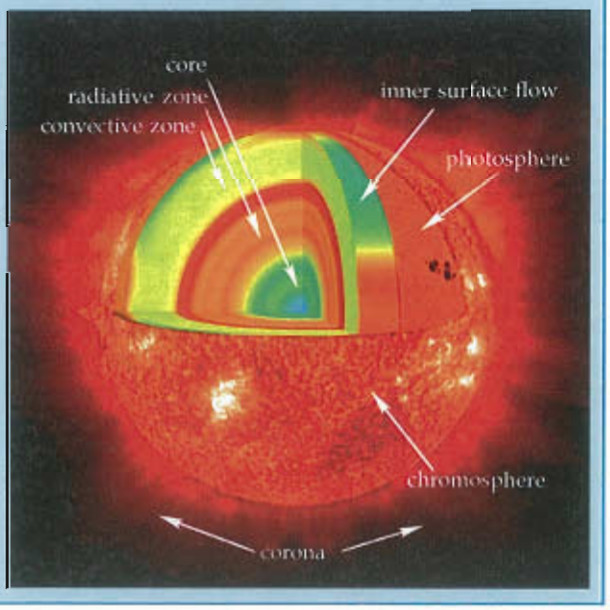
The chromosphere which is the thin layer outside the photosphere and the corona which is an extensive region outside it, can be considered as the atmosphere of the sun.

Though the temperature of the photosphere comes to 6000 kelvin, there are certain regions of lower temperature (about 3500 kelvin) in it that appear as black spots. These are known as sun spots.

From the surface of the sun, there is a massive flow of helium nuclei (alpha particles) and hydrogen nuclei (protons). This is the solar wind. Sometimes huge flames rise from the surface of the sun and fall back in the form of an arch. They are the solar prominences.



The structure of the sun



★ What are the different modes of transmission by which the energy produced at the centre of the sun reaches the sun's surface?

- -

★ The chromosphere and the corona are not visible generally. Why?

- -

★ During a total solar eclipse, the chromosphere and the corona are made visible. Discuss, find the reason and record.

- -

★ Why is the sun seen bigger than other stars?

- -

★ Are all stars seen in the same colour as that of the sun?

- -

When observed keenly, stars are seen as blue, orange and red.

Try to find out the names of a few stars with the help of a star chart or consulting people who know about stars. A few days' intermittent observation, is needed for this. Record your observations and findings.

Try to classify the stars you have observed according to their colours.

Red	Blue	Orange
Thrikketta	Regal	Aldebaran
Thiruvathira	- - - - - -	Chothi
- - - - - -	- - - - - -	- - - - - -

When a piece of metal is heated in fire, it becomes red at first. When heated further it becomes yellow, and then turns white at very high temperature. Haven't you seen blue flames, yellow flames and red ember? Is there a relation between their colours and temperatures? Note down the colours in the descending order of temperature.

- Blue
- - - - - - - -

You have understood that the colour of a star is related to its temperature. Let's see how energy is generated in stars.

Evolution of stars

Energy generation in stars

Energy is generated in the sun and the stars by the process of fusion taking place at their core. At very high temperature, four hydrogen nuclei combine to form a helium nucleus. The mass of the helium nucleus thus formed is slightly less than the mass of the four hydrogen nuclei (7 in 1000 parts). This mass is converted into energy. The application of Einstein's equation $E = mc^2$ (E = energy, m = mass, c = velocity of light) is what takes place here. In the sun, 40 lakh tons of hydrogen is converted into helium every second!

How does matter attain the high temperature required for this? The gaseous clouds in the interstellar space is the birth place of stars. These are known as nebula. They contain the gases hydrogen and helium, and a small quantity of certain other elements. The contraction of the gaseous cloud in the nebula due to gravitation, initiates the birth of a star. Gases and dust move continuously and come closer, and contract to the centre of the nebula due to increased gravitation. This cramming due to gravitation provides the temperature required to initiate fusion. A star becomes visible to us only when the energy due to fusion is produced.

★ At which stage is a star said to be born?

★ If it is gravitation that leads to the birth of a star, which nebula will reach the status of a star faster : a nebula of greater mass or smaller mass?

★ The sun and the planets that revolve around it were born by the contraction of the same nebula. Can the earth produce energy in the same way as the sun?

Let's see what changes occur in stars when energy production goes on in them.

Observe Fig. 11.5

★ Trace out the path of evolution of the sun since its birth.

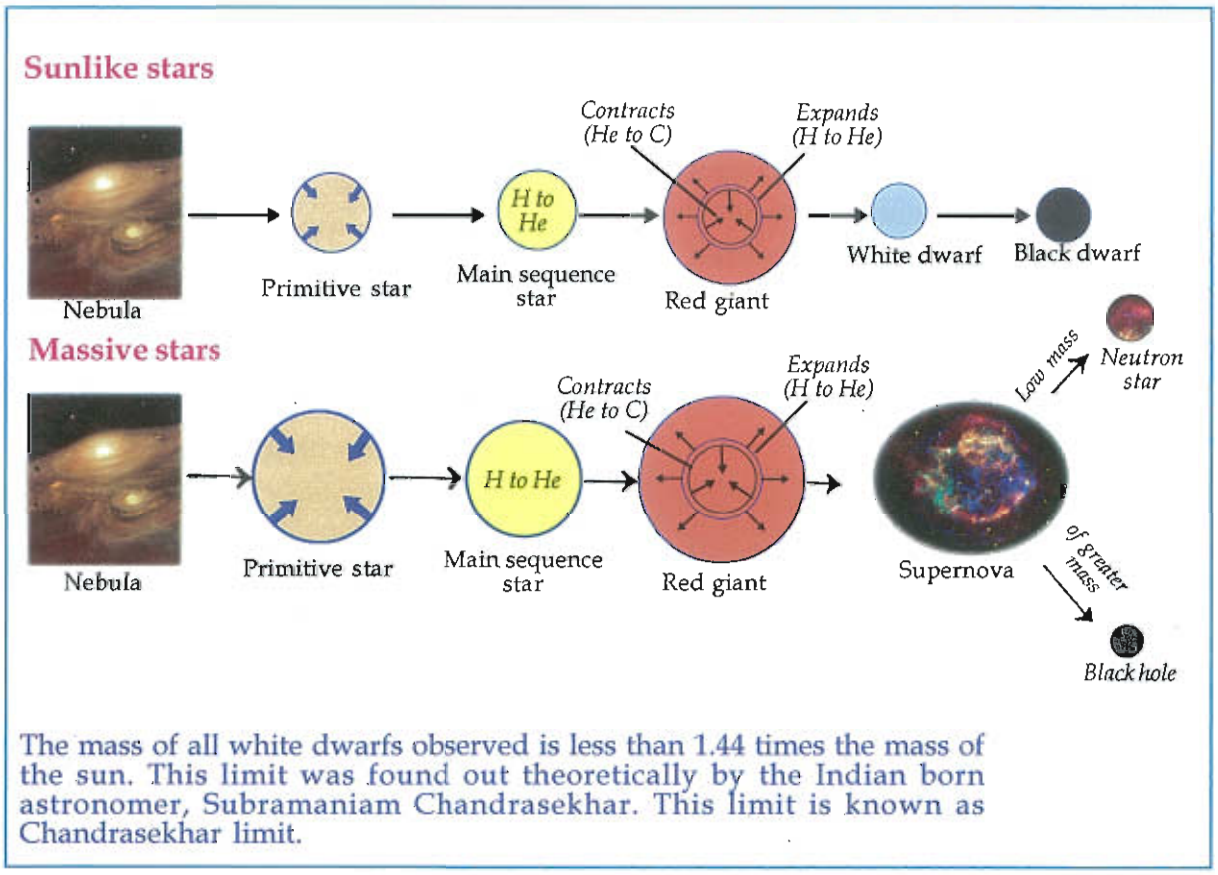
Nebula → _ _ _ _ _ _ _ _

★ Based on the colour, mention the stage of stellar evolution at which the star 'Thrikketta' is now?

★ What is the probability of a star becoming a black hole?

★ What type of stars become neutron stars?

Haven't you understood the process of birth and death of stars? Are the stars mutually related? Let's see.



The mass of all white dwarfs observed is less than 1.44 times the mass of the sun. This limit was found out theoretically by the Indian born astronomer, Subramaniam Chandrasekhar. This limit is known as Chandrasekhar limit.

Fig. 11.5

Galaxy

Renuka was observing a clear night sky in September. While she gazed at the stars of different colours, she happened to see many stars spread out in a layer of white cloud in the southern sky. She wondered whether there was anything special about this part of the sky. Can you help Renuka to understand this?

The stars we see with the naked eye belong to our galaxy, the Milky Way. A galaxy is a cluster of billions of stars and interstellar matter, bound by gravitational force. There are billions of galaxies in the universe. Galaxies spin about their own axes. The Milky Way is supposed to take nearly 200 million years to complete a rotation.

Observe Fig. 11.6 of the galaxy, the Milky Way

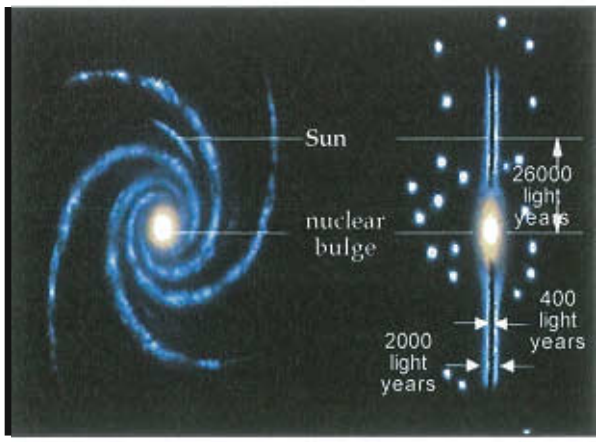


Fig. 11.6

* What is its shape?

- -

* In this, where is the position of the sun?

- -

* In which parts are the density of stars greater?

- -

* What is the distance of the sun from the centre of the Milky Way.

- -

Now, think of the position of our earth in the Milky Way.

It takes 8½ minutes for the light from the sun to reach the earth. The distance travelled by light in this time is approximately 150 million kilometers. This is one astronomical unit (AU). How vast is the space between the sun and the earth!

'Light Year' is the unit commonly used for stating large distances such as the distance of stars. One light year = 9.46×10^{12} kilometers (the distance travelled by light in one year).

The distance from the sun to the nearest star is 4¼ light years. The distance from one edge of our galaxy to the other edge is about one lakh light years. The distance of the adjacent galaxy Andromeda from our galaxy is estimated to be 24 lakh light years. Isn't the size of our universe containing crores of such galaxies, so vast that it surpasses all our imagination? How insignificant is our position in this vast universe! Inspite of this, we have been unravelling the secrets of nature through

persistent observations and our reflections based on the results of these observations.

Modern astronomy begins with Copernicus. The findings of Galileo, based on celestial observations using his telescope, formed the basis of the heliocentric theory of Copernicus.

The findings of Galileo:

- There are other planets like the earth.
- They also have satellites.
- Satellites of Jupiter.
- Rings of Saturn.
- Waxing and waning of Venus.

Discuss how the findings of Galileo paved way for the weakening of the geocentric theory of the universe.

Big Bang Theory

The observations through telescope led to the finding that the galaxies are receding from each other at unbelievable speed. These observations are in agreement with the theory of the expanding universe. It is believed that the universe was formed nearly 1400 crore years ago as a result of a huge explosion (the big bang) resulting in a state of unimaginable density and temperature.

Man designed a large number of devices for making his observations accurate and sharp, in his attempt to unveil the secrets of nature.

Write those you know.

•

•

Today, telescopes capable of picking up and studying radio waves, infrared rays, ultraviolet rays, x-rays, gamma rays etc. are in use. 'Chandra' is an x-ray telescope operating in space, revolving round the earth. The Hubble space telescope is another space telescope which works similarly.

✶ Which are the radiations likely to reach the earth from outer space? Try to write them down.

✶ What is the advantage of setting up a telescope outside the earth's atmosphere? Discuss.

We started getting a clearer picture of the universe with the advent of artificial satellites. The launching of Sputnik I by the Soviet Union in 1957 marked the beginning of the space age. Through different projects like Luna, Apollo, Mariner, Pioneer, Voyager, Venera, Messenger, Cosmos, Zonad, Cassini, Huygens, Chandrayan etc., a lot of information about planets, satellites, stars and other objects in space is made available.

The International Space Station and the space shuttle that provides access to it have been helping scientists in conducting a number of experiments in space.

Organise a seminar, collecting information about the history of space research.

How far has India advanced in the study of the universe?

Space research in India

"There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose. We do not have the fantasy of competing with the economically advanced nations in the exploration of the moon or the planets or manned space-flight. But we are convinced

that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society."

These are the words of Dr. Vikram Sarabai (1919 - 1997), the father of Indian Space Research. How far have we advanced towards his vision? Let's see.

The establishment of TERLS (Thumba Equatorial Rocket Launching Station) was the first step in this direction. In 1969 ISRO (Indian Space Research Organisation) was established under the department of Atomic Energy Research. Successive activities paved way for establishing a rocket launching centre at Sriharikotta. With the launching of Aryabhatta, the first Indian satellite, in 1975, India too gained a foothold in the field of space research. Indian scientists have been able to develop many artificial satellites and launching vehicles like GSLV (Geosynchronous Satellite Launching Vehicle) to launch geostationary satellites, PSLV (Polar Satellite Launch Vehicles) to launch polar satellites etc.

Organise a seminar collecting data regarding the achievements of India in the field of space research.

Besides space research, what are the other uses of artificial satellites? Discuss and expand the list.

- Communication
- Weather forecasting
-
-

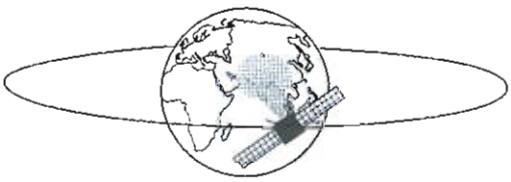
Equatorial satellites revolve around the earth along an orbit above the equator. If their period of revolution is the same as the period of the rotation of the earth, they are called geostationary satellites. The satellites revolving along an orbit passing above the north and south poles of the earth at an altitude of 200-1000 km are called polar satellites.

What is the difference in the orbits of revolution of the satellites shown in the two figures?

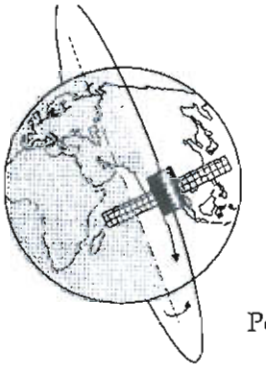
Discuss the uses of geostationary satellites and polar satellites.

Aren't you convinced that space research contributes considerably to the field of communication, weather forecasting, agriculture, resource studies, education, industries, etc.?

Examine the relevance of the words of Vikram Sarabai in the context of what you have understood about the history of Indian space research.



Equatorial satellite

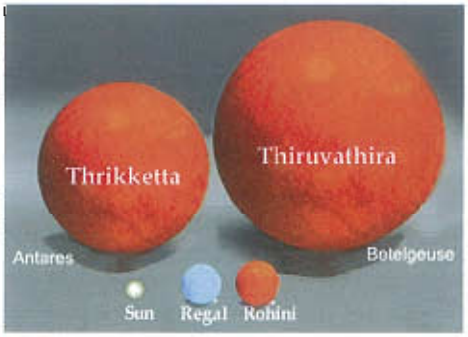


Polar satellite

Fig. 11.7

Follow up Activities

1. You know that the ecliptic is divided into 12 solar constellations.
   a. What do you mean by a constellation?
   b. How many days does the sun take to cross a constellation? And the moon?
   c. In the month of Chingam, on Thiruvathira nal, which are the constellations that come in the vicinity of the sun and the moon?
2. The fusion process going on at the centre of the sun is the source of energy of the sun.
   a. How is energy generated in a fusion process?
   b. What are the different transmission modes by which energy reaches the surface of the sun from its centre?
   c. The energy from the surface of the sun reaches the earth in just 8½ minutes. But the energy produced at the centre of the sun takes several years to reach its surface. Explain the reason.
3. We see many stars in the sky at night. They differ in brightness and colour.
   a. What is the reason for the difference in brightness?
   b. What is the reason for the difference in colour?
   c. Which is the galaxy to which these stars belong?
   d. Other than the Milky way, which is the galaxy that is visible to the naked eye?
4. Which is the practical unit used in astronomy to measure the distance between planets? And to measure the distance between the stars?
5. Can the sun become a neutron star as it goes through its evolutionary stages?
6. The figure given shows the colour and the relative sizes of the sun and the stars Regal, Rohini, Thrikketta and Thiruvathira.



   a. When viewed from the earth, are they seen in the same relative size? Explain.
   b. State in which stage of evolution each one is.
7. Observe the sky for a week. Note down the stars that come in the vicinity of the moon. Find out the constellation in which the sun comes during the same period.