18. Observing Space : Telescopes

- Forms of light
- Telescopes and types of telescopes
- Telescopes in space
- Indian Space Research Orgnaisation (ISRO)

Can you recall?

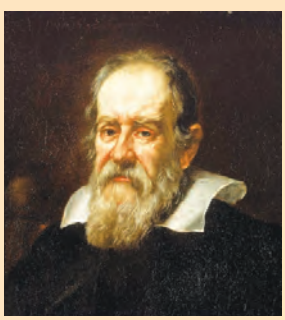
1. What is the difference between the sky and space?
2. What is meant by space observation? Why is it important?

From early days, man has been curious about the sun as well as the moon and stars seen in the night sky. Using his boundless imagination, he tried to understand the sky as observed by the naked eyes. He noticed that the position of the stars changed with time and had something to do with the occurrence of seasons. As the knowledge of the cycle of seasons was necessary for agriculture, sky watching began to prove useful to him. The position of the constellations was also useful to sea goers for navigation. Man began to make determined efforts to find answers to questions which arose out of his sky watching. But he did not have any equipment to get a closer view of the stars and planets in the sky.

Today, 400 years after Galileo's use of the telescope, tremendous progress has been made in telescope technology and in space science and technology on the whole. This great leap in technology has helped to construct for us an astounding picture of our universe. Space science and technology are not only important for research purposes, but also to help provide us with many of the comforts and facilities we enjoy in our everday life. A telescope is used to observe space, but will one telescope be sufficient for us to observe space completely? Why do we need different telescopes for the purpose? Are telescopes installed even in space? In this chapter, we are going to study the science behind many such questions.

An introduction to scientists

In 1608, spectacle maker and researcher, Hans Lippershey discovered that seeing through two lenses kept one behind the other, seems to brings objects closer to us. He thus made the first telescope. Galileo made a telescope in 1609 and used it for space observations. He realized that there are many more stars than what could be seen with naked eyes. Using his telescope, he also discovered the moons of Jupiter, the black spots on the sun, etc.



Galileo Galilei

Different forms of light

Light is an electromagnetic wave. Every wave has a characteristic wavelength. Our eyes can see only that light which has wavelengths between 400 nm to 800 nm. Such light is called visible radiation. However, there are electromagnetic waves of wavelengths other than the visible ones most of which we cannot 'see' as our eyes are not sensitive to them.

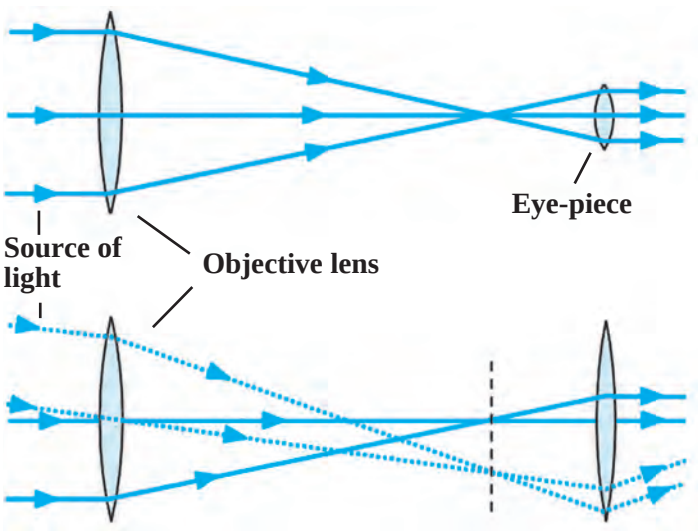
Study the following table.

1 nm (nanometer) = 10^{-9} m and 1 pm (picometer) = 10^{-12} m

Type of radiation	Wavelength
Radio waves	Longer than about 20 cm
Micro waves	0.3 mm – 20 cm
Infrared waves	800 nm – 0.3 mm
Visible light rays	400 nm – 800 nm
Ultraviolet rays	300 pm – 400 nm
X-rays	3 pm – 300 pm
Gamma rays	Shorter than 3pm

Of all the above types, our eyes are only capable of seeing the visible radiation. Thus, we use the visible radiation telescopes i.e. optical telescopes, made from regular lenses or mirrors to see the visible radiation coming from the space. However many heavenly bodies emit radiations other than the visible light. Thus we need different types of telescopes like the X-ray, gamma-ray and radio telescopes to receive such radiation and to study their sources.

Telescopes



18.1 **A refracting telescope**

Optical telescopes

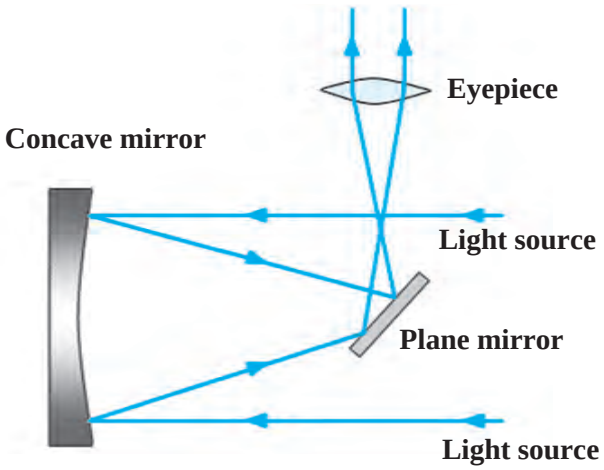
Most optical telescopes are made with two or more lenses as shown in figure 18.1. To collect the maximum amount of light coming from a heavenly object, the objective lens should be made as large as possible. Using the light collected by the objective a smaller lens, called the eyepiece, produces a large image of the source. Light rays change their direction as they enter a lens from the atmosphere and again when they enter the atmosphere after passing through the lens. This is called refraction. Hence such telescopes are called **refracting telescopes**. We shall study image formation by lenses in the next standard.

Even though such a telescope is useful for space observations, it presents certain difficulties.

1. As we saw above, if we wish to obtain a bright image of a source by collecting the maximum possible light from it, the objective lens must be made as large as possible. However, it is very difficult to make very large lenses. Also, large lenses are very heavy and tend to get distorted.
2. As the objective and eyepiece are placed at the opposite ends of the telescope, the length of the telescope also increases with increase in the size of the lenses and the telescope becomes difficult to manage.
3. The images formed by lenses have erorrs of colours. This is called chromatic aberration.

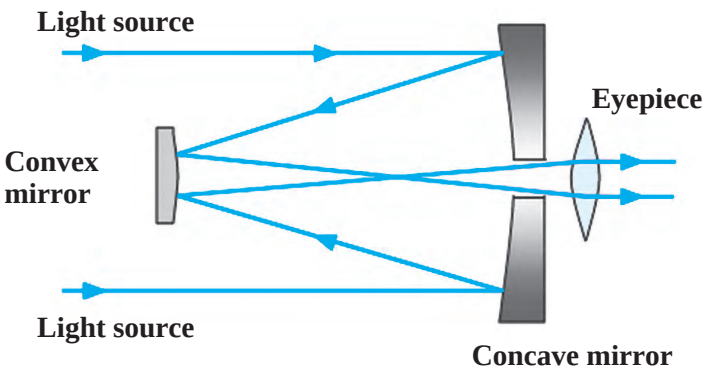
To overcome these difficulties, telescopes are made using concave mirrors. As light rays get reflected by mirrors in these telescopes, they are called **reflecting telescopes**. In order to get a bright image of a source, large mirrors are necessary (so that they can collect a large amount of light from the source), but it is easier to make large mirrors as compared to making large lenses. Also, big mirrors can be made by combining several smaller pieces. The weight of a large mirror too is less than that of a lense of the same size. The images formed by mirrors do not have errors of colour. Only by using these large telescopes, can we see far away stars and galaxies, which we could never have seen using our naked eyes.

The reflecting telescopes are mainly of two types: Newtonian and Cassegrain. As shown in figure 18.2 light rays coming from space are reflected by the concave mirror. Before these reflected rays converge at the focus, they are deflected again by a small plane mirror. As a result, they get focused at a point lying on the perpendicular to the axis of the telescope's cylinder. They pass through the eyepiece and we get a magnified image of the source.



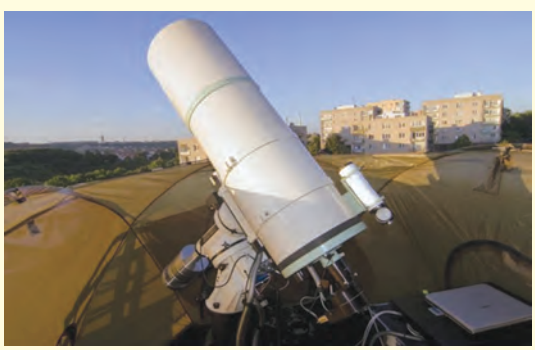
18.2 **The Newtonian telescope**

The construction of a Cassegrain type of telescope is shown in figure 18.3. The Cassegrain telescope also uses a concave mirror. However, here light rays, after reflection from the concave mirror, are reflected back towards it by a small convex mirror. They pass through a hole at the centre of the concave mirror and then through the eyepiece situated at the back of the mirror. The eyepiece gives us a magnified image of the source.



18.3 **The Cassegrain telescope**

In India, we have several telescopes with concave mirrors of 2 m diameter that have been in use for many years. The biggest optical telescope in India, having a mirror of 3.6 m diameter is situated in the Aryabhatt Research Institute of Experimental Sciences, Nainital. This is the largest optical telescope in Asia.

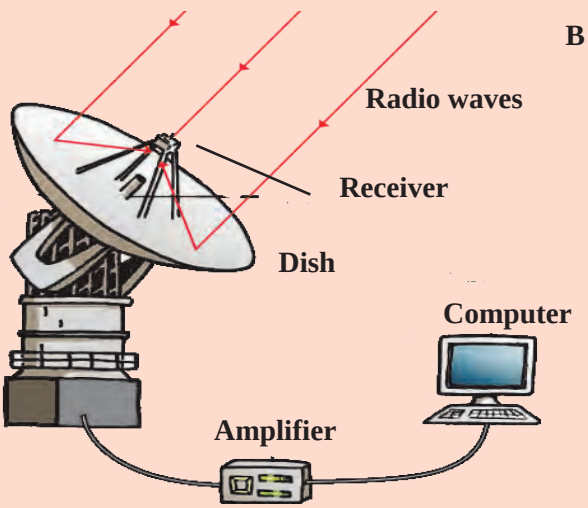


Radio telescope

Many heavenly objects emit radio waves in addition to visible radiation. We cannot see this radiation with our eyes. Hence, a special type of telescope is used to receive these rays. It is called a radio telescope. It is made from one or more dishes of a particular parabolic shape. As in optical telescope the incident radio waves are reflected by these dishes and converge at the focus. A radio receiver is placed at the focal point. The information gathered by this receiver is passed on to a computer which analyses it and constructs an image of the source.

A large radio telescope called the Giant Meterwave Radio Telescope (GMRT) has been erected at Narayangaon near Pune. It uses radio waves having wavelengths of about a metre, coming from planets and stars to study those heavenly bodies. This telescope is actually a collection of 30 dishes, each having a diameter of 45 m. It is called a giant telescope as the arrangement of the 30 dishes over an area which measures up to 25 km across, is made in such a way that it works as a single dish having a diameter of 25 km. This means that the GMRT gives the same data that we would have got from a telescope having a single dish of 25 km diameter! GMRT has been made by Indian scientists and engineers at minimum cost. It is a world standard research facility. Scientists study the solar system, solar winds, pulsars, supernova, interstellar hydrogen clouds, etc. with the help of the GMRT. Scientists from all over the world come to India to make use of this facility.

A



B

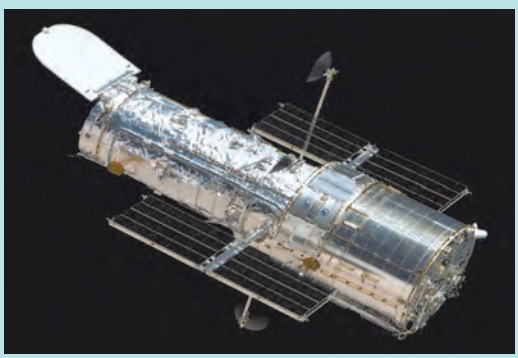
18.4 A. Radio telescope (photograph) B. The structure of a radio telescope

Telescopes in space

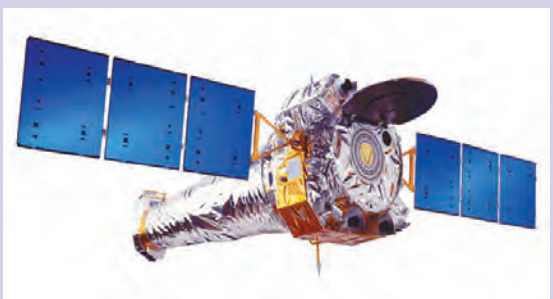
Visible light and the radio waves emitted by heavenly bodies in space can pass through the earth's atmosphere and reach the earth's surface. So, optical and radio telescopes can be erected on the surface of the earth. However, these earth-based telescopes present some problems in making good quality observations.

The visible light coming from a heavenly body has to pass through the earth's atmosphere to reach the earth's surface. During this journey, some of the light is absorbed by the atmosphere and the intensity of the light reaching the earth's surface decreases. A second problem is caused by the changes in atmospheric pressure and temperature. These changes cause turbulence in the atmosphere which in turn cause of the light rays to change their path slightly and thereby shake the position of the image. Also, because of Sunlight, we cannot use optical telescopes during the day. During the night too city lights and cloudy weather can cause difficulties in observing the heavenly bodies. To reduce these problems, optical telescopes are situated on top of mountains, at in uninhabitated places. However, if we want to get rid of all the above problems completely, we should place the telescope above the earth's atmosphere, in space itself. These problems do not exist in the space and thus the image obtained by space telescopes would be bright and very clear and will ramain at one place. Scientists have turned this idea into reality.

In 1990, the National Aeronautics and Space Administration launched into space an optical telescope called the **Hubble telescope**. It has a mirror of diameter 94 inches and is orbiting the earth at a height of 589 km from it. This telescope is still working and has helped to make important discoveries.



In 1999, the National Aeronautics and Space Administration launched an X-ray telescope named **Chandra**, in space, to study X-rays coming from heavenly objects. Special mirrors which can reflect X-rays were used in this telescope. Chandra has given us very useful information about stars and galaxies. The telescope is named after the famous Indian scientist Subramanian Chandrashekhar.



Indian Space Research Organization (ISRO) Bengaluru

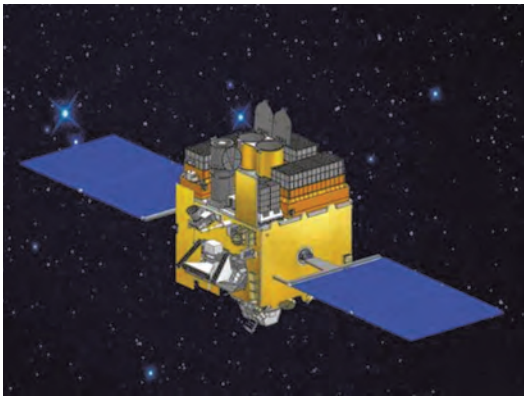
This institute was established in 1969 with the aim of developing technology for making and launching of artificial satellites. Till date, ISRO has successfully launched a large number of satellites. ISRO's programme is foremost among the successful programs undertaken by independent India. India's progress in space science has played a big role in national and social development.

The INSAT and GSAT series of satellites support our telecommunication network, television broadcasting and meteorological services. It is because of them that telephone, television and internet services are available everywhere in the country. The EDUSAT satellite in this series is used exclusively for education. The IRS satellite series is used for the monitoring and management of natural resources as well as disaster management.

Website : www.isro.gov.in

Astrosat

In 2015, Indian Space Research Organization (ISRO) launched an artificial satellite called Astrosat, in space. This satellite has ultraviolet and X-ray telescopes and detectors. Most of the parts used in this satelite are made in India. It is a unique system having different kinds of telescopes on a single satellite. Indian scientists are studying various aspects of the Universe using the data obtained with these telescopes.



Find out

Collect more information about telescopes that work in space apart from the Hubble and Chandra telescopes.

Exercises

1. Fill in the blanks with the proper words.

a. The wavelength of visible light is between …….. and ……
b. GMRT is used for ……. waves.
c. A certain X-ray telescope is named after scientist ……..
d. The first scientist to use a telescope for space observation was ..... .
e. The biggest optical telescope in India is situated at …….

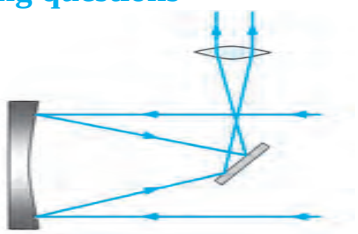
2. Form pairs

'A' Groups	'B' Groups
(i) X-rays	(a) GMRT
(ii) Optical Telescope	(b) ISRO
(iii) Indian radio telescope	(c) Hubble
(iv) Launching artificial satellites	(d) Chandra

3. What are the difficulties in using ground based optical telescopes? How are they overcome?

4. Which type of telescopes can be made using a concave mirror, convex mirror, plane mirror and a lens? Draw diagrams of these telescopes.

5. Study the figure and answer the following questions



a. What type of telescope is shown in the figure?
b. Label the main parts of the telescope.
c. Which type of mirror does the telescope use?
d. What other type of telescope uses a curved mirror?
e. Explain the working of the above telescope.

6. Answer the following questions.

a. Explain the construction of Galileo's telescope.
b. Explain the construction of a radio telescope.
c. Why are optical telescopes located in uninhabited places on mountains?
d. Why can an X-ray telescope not be based on the earth?

Project : Collect information about various observatories in India and present it in the class.

Science and Technology - Educational Planning

There are altogether eighteen chapters in which the subject of Science and Technology has been covered. Of these, the first ten chapters deal with the topics included in the portion of Paper I and Paper II to be studied the first term. There are two separate papers for the two subjects namely Science and Technology in each term. The sequence of the chapters in the textbook has been planned accordingly. Paper I includes physics and chemistry while Paper II deals with Biology and the rapidly developing and indispensable topics related to Environment, Space, Weather and climate, Disaster management and Information communication technology all of which have a great impact on all our lives.

Even though, in both terms, the subject has been separated into Paper I (physics and chemistry) and Paper II (biology and other Science-related subjects such as environment, space, weather and climate, disaster management and information communication technology), teachers must adopt an integrated approach and consistently teach with that attitude. Some important points which teachers may keep in mind for the purpose of making annual plans are given below.

Term-wise plan of chapters

First Term

	Part I		Part II
Chapter No.	Name of chapter	Chapter No.	Name of chapter
1	Laws of Motion	6	Classification of plants.
2	Work and Energy	7	Energy Flow in an Ecosystem
3	Current Electricity	8	Useful and Harmful Micro-organisms
4	Measurement of matter	9	Environmental Management
5	Acids Bases and Salts	10	Information Communication Technology (ICT) : The new direction of progress

Second Term

	Part I		Part II
Chapter No.	Name of chapter	Chapter No.	Name of chapter
11	Reflection of Light	15	Life Processes in Living Organisms
12	Study of Sound	16	Heredity and Variation
13	Carbon : An important element	17	Introduction to Biotechnology
14	Substances in Common Use	18	Observing Space.....Telescopes

1. Practical work, written exams and all information about it will be given separately.
2. While doing practical work, along with the given experiments, the various activities given in the textbook must also be done.
3. A record of practical work done should be organized under the heads Title, Apparatus/Materials/ Chemicals, Diagram, Procedure, Observations, Inference/Conclusion.
4. As the questions given at the end of each lesson are based on the content of the lesson as well as the various activities and projects, a deliberate effort will have to be made to guide the students to the expected answers.
5. Several of the given activities are newly included in our textbooks and each of them should be completed separately. The report of the activity should be written in the following order : Preface, Need/ Necessity, Methodology, Observations, Inferences and Conclusion.