MahaScience9

CLASS 9 SCIENCE · MAHARASHTRA STATE BOARD

CHAPTER 18

Observing Space: Telescopes

Chapter Notes

1. Observing space and different forms of light

We learn about stars, planets and galaxies by studying the **light** that comes from them. Light is an **electromagnetic wave**. Besides **visible light**, objects in space give out many other forms of electromagnetic radiation that our eyes cannot see. All these forms together make up the **electromagnetic spectrum**.

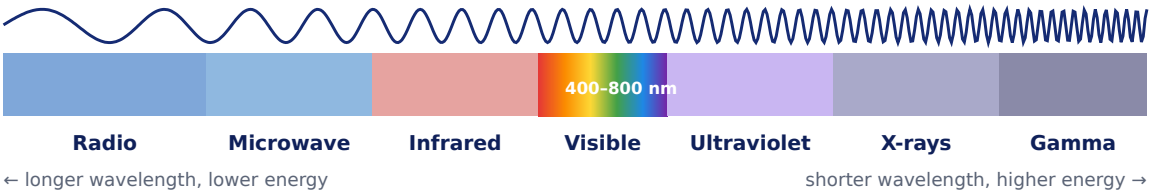


Fig. 18.1 The electromagnetic spectrum (wavelength decreases from left to right)

- The wavelength of **visible light** is about **400 nm to 800 nm** (1 nm = 10^{-9} m). Violet has the shortest wavelength and red the longest.
- All forms of electromagnetic radiation travel at the speed of light, **3 × 10^8 m/s**, but have different wavelengths and energies.
- Different objects in space give out different forms of radiation. To study the universe fully, scientists use **different telescopes for different forms of light**.

Why are some telescopes in space?

Earth's **atmosphere absorbs** most radiation coming from space. Only **visible light**, some **radio waves** and a little infrared reach the ground. Gamma rays, X-rays and most ultraviolet and infrared rays are blocked. That is good for life on Earth, but it means telescopes for these rays must be placed **outside the atmosphere**, in space.

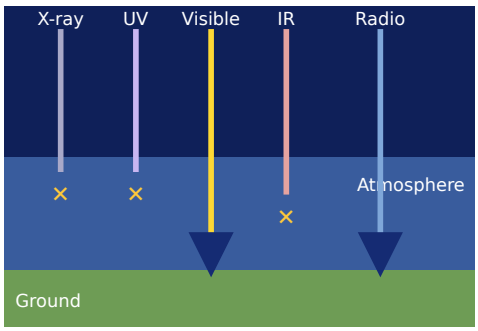


Fig. 18.2 Which radiations reach the ground

2. Fundamentals of a telescope

A **telescope** is an instrument that collects light from distant objects and forms a bright, clear, magnified image. **Galileo Galilei** was the **first scientist to use a telescope to observe space** (1609). With it he saw craters on the Moon, four moons of Jupiter, the phases of Venus and sunspots.

The **bigger the aperture** (size of the main lens or mirror), the more light the telescope collects. Fainter and more distant objects can then be seen, in more detail.

3. Types of telescopes

Type	Radiation studied	Examples
Optical telescope	Visible light	Galileo's telescope, Newtonian and Cassegrain telescopes, Devasthal telescope, Hubble
Radio telescope	Radio waves	GMRT (near Pune)
Space telescopes	X-rays, ultraviolet, infrared, gamma rays (and visible)	Hubble, Chandra, AstroSat

3.1 Optical telescopes

Optical telescopes are of two kinds: **refracting telescopes**, which use **lenses**, and **reflecting telescopes**, which use **mirrors**.

Refracting telescope (Galileo's telescope):

- Galileo's telescope has two lenses fitted in a tube: a large **convex lens** as the **objective** facing the object, and a small **concave lens** as the **eyepiece**.
- The objective collects light from the distant object and makes it converge; the eyepiece makes it diverge again so the eye sees a **magnified, erect image**.
- Later telescopes (Keplerian) use convex lenses for both, giving an inverted image.

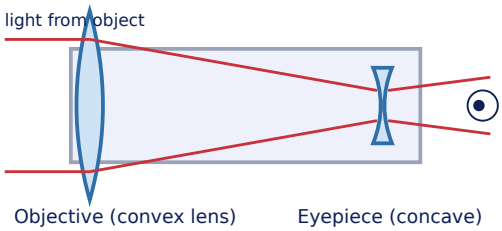


Fig. 18.3 Galileo's refracting telescope

Limitations: very large lenses are heavy and difficult to make; they sag under their own weight, and the image has coloured fringes (different colours focus at different points).

Reflecting telescope: uses a large **concave mirror** (the primary mirror) to collect and focus light. Mirrors can be made much larger than lenses, can be supported from behind, and give no coloured fringes, so all big modern optical telescopes are reflecting telescopes. **Isaac Newton** built the first reflecting telescope in 1668.

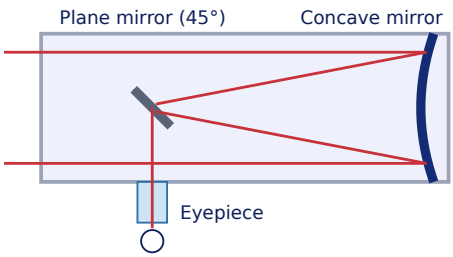


Fig. 18.4 Newtonian telescope: concave + plane mirror

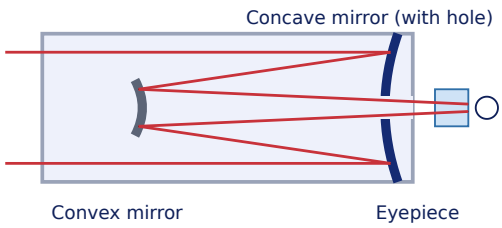


Fig. 18.5 Cassegrain telescope: concave + convex mirror

- **Newtonian telescope:** light reflected by the concave primary mirror is turned sideways by a small **plane mirror** kept at 45°, and is viewed through an **eyepiece (lens)** on the side of the tube.
- **Cassegrain telescope:** light reflected by the concave primary mirror falls on a small **convex mirror**, which reflects it back through a **hole in the centre** of the primary mirror to the eyepiece behind it. This makes the telescope shorter.

TEXTBOOK QUESTION: CONCAVE MIRROR, CONVEX MIRROR, PLANE MIRROR AND LENS

These parts make a **reflecting telescope**. Concave mirror + plane mirror + lens (eyepiece) = **Newtonian telescope**. Concave mirror + convex mirror + lens = **Cassegrain telescope**.

Problems with ground-based optical telescopes, and solutions

PROBLEMS

- The atmosphere absorbs and scatters some light, and its moving layers make stars twinkle, so images get blurred.
- Light from cities (**light pollution**) makes faint objects hard to see.
- Clouds, rain, dust and moisture stop observation.
- Observation is possible only on clear nights.

SOLUTIONS

- Build observatories on **high mountains in uninhabited areas**, where the air is thin, dry, clean and steady, and there are no city lights.
- Use computer-controlled mirrors that correct for air movement.
- Place telescopes **in space**, above the atmosphere (e.g. Hubble).

India's biggest optical telescope is the **3.6 m Devasthal Optical Telescope** at **Devasthal, near Nainital** (Uttarakhand), run by ARIES. Other major Indian observatories are at **Hanle** (Ladakh) and **Kavalur** (Tamil Nadu).

3.2 Radio telescopes

Many objects in space, such as stars, galaxies and pulsars, give out **radio waves**, which pass through the atmosphere.

- **Construction:** a radio telescope has a large **bowl-shaped (parabolic) dish** made of metal sheets or wire mesh, which reflects radio waves. An **antenna (receiver)** is placed at the **focus** of the dish.
- **Working:** the dish collects radio waves and focuses them on the antenna. The weak signals are **amplified** and studied by computers to create images.
- Radio telescopes work **day and night**, and even in cloudy weather.

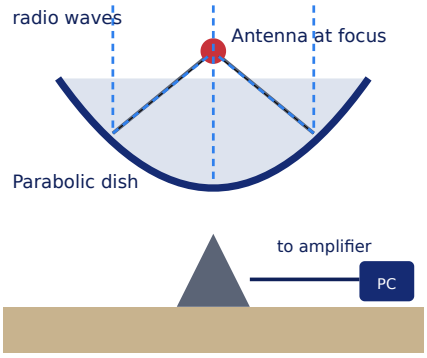


Fig. 18.6 A radio telescope

GMRT: GIANT METREWAVE RADIO TELESCOPE

Located at **Narayangaon (Khodad), about 80 km from Pune**, Maharashtra. It has **30 dishes, each 45 m in diameter**, spread over about 25 km, working together as one giant telescope. It studies **radio waves** with wavelengths of about a metre. It was built by the National Centre for Radio Astrophysics (NCRA–TIFR) under Prof. Govind Swarup, and is one of the largest radio telescopes of its kind in the world.

3.3 Telescopes in space

Telescope	Details
Hubble Space Telescope	Launched by NASA in **1990**; an **optical** telescope with a 2.4 m mirror, orbiting about 550 km above Earth. Above the atmosphere it takes very sharp pictures of distant galaxies and nebulae.
Chandra X-ray Observatory	Launched by NASA in **1999**; studies **X-rays** from black holes, exploding stars and hot gas. It is named after the Indian-born scientist **Subrahmanyan Chandrasekhar**, Nobel Prize winner (1983).

Why can't an X-ray telescope work on Earth? X-rays from space are **absorbed by Earth's atmosphere** and never reach the ground, so an X-ray telescope must be placed in space.

4. ISRO and AstroSat

The **Indian Space Research Organisation (ISRO)** was set up in **1969**, with its headquarters in **Bengaluru**. **Dr Vikram Sarabhai** is called the father of the Indian space programme. ISRO designs, builds and **launches artificial satellites** using its rockets **PSLV** and **GSLV** from Sriharikota.

- **Aryabhata** (1975): India's first satellite
- **Chandrayaan-1** (2008): found water on the Moon
- **Mangalyaan** (2013): reached Mars on the first attempt
- **Chandrayaan-3** (2023): landed near the Moon's south pole
- **Aditya-L1** (2023): studies the Sun

Indian satellites are used for communication, TV, weather forecasting, disaster warnings, navigation (NavIC) and mapping resources.

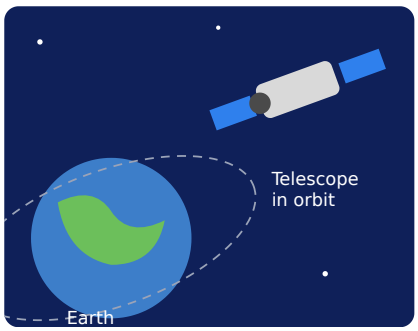


Fig. 18.7 A space observatory orbiting Earth

ASTROSAT

AstroSat is India's **first dedicated space observatory**, launched by ISRO on **28 September 2015** on a PSLV rocket. It orbits about 650 km above Earth and can observe the same object at the **same time in ultraviolet, visible and X-ray** light using its five instruments. This makes India one of very few countries with its own multi-wavelength space telescope.

5. Important questions for the exam

1. Fill in the blanks: (a) The wavelength of visible light is about **400 nm to 800 nm**. (b) GMRT is used to study **radio waves**. (c) The Chandra X-ray telescope is named after **Subrahmanyan Chandrasekhar**. (d) **Galileo** first used a telescope to observe space. (e) India's biggest optical telescope is at **Devasthal (Nainital)**.
2. Match: X-rays – Chandra; optical telescope – Hubble; Indian radio telescope – GMRT; launching artificial satellites – ISRO.

3. What difficulties arise in using ground-based optical telescopes? How are they overcome?
4. Which telescope can be made from a concave mirror, convex mirror, plane mirror and lens? Draw labelled diagrams.
5. Explain the construction and working of a reflecting telescope. Name another telescope that uses curved mirrors.
6. Describe the construction of Galileo's telescope and of a radio telescope.
7. Why are optical telescopes built on mountains in uninhabited areas? Why can't an X-ray telescope be on Earth?