Optical Telescopes

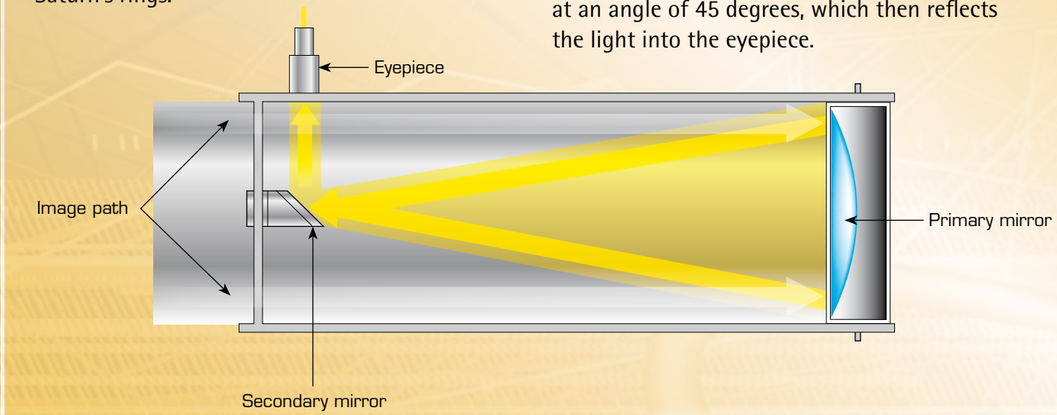
Optical telescopes collect and focus light from the visible part of the ***electromagnetic spectrum*** *to make objects in space appear larger and brighter. There are three main types of optical telescopes: refractors, which use lenses, reflectors, which use mirrors, and* ***catadioptrics****, which use both lenses and mirrors.*

The first optical telescopes

The first optical telescopes, built in the early 1600s, were refractors which had a magnification of just three times, or 3x. Italian astronomer Galileo Galilei improved on the original design by developing a telescope that magnified 33x. Using this telescope, he discovered Jupiter's four largest moons and Saturn's rings.

How does an optical telescope work?

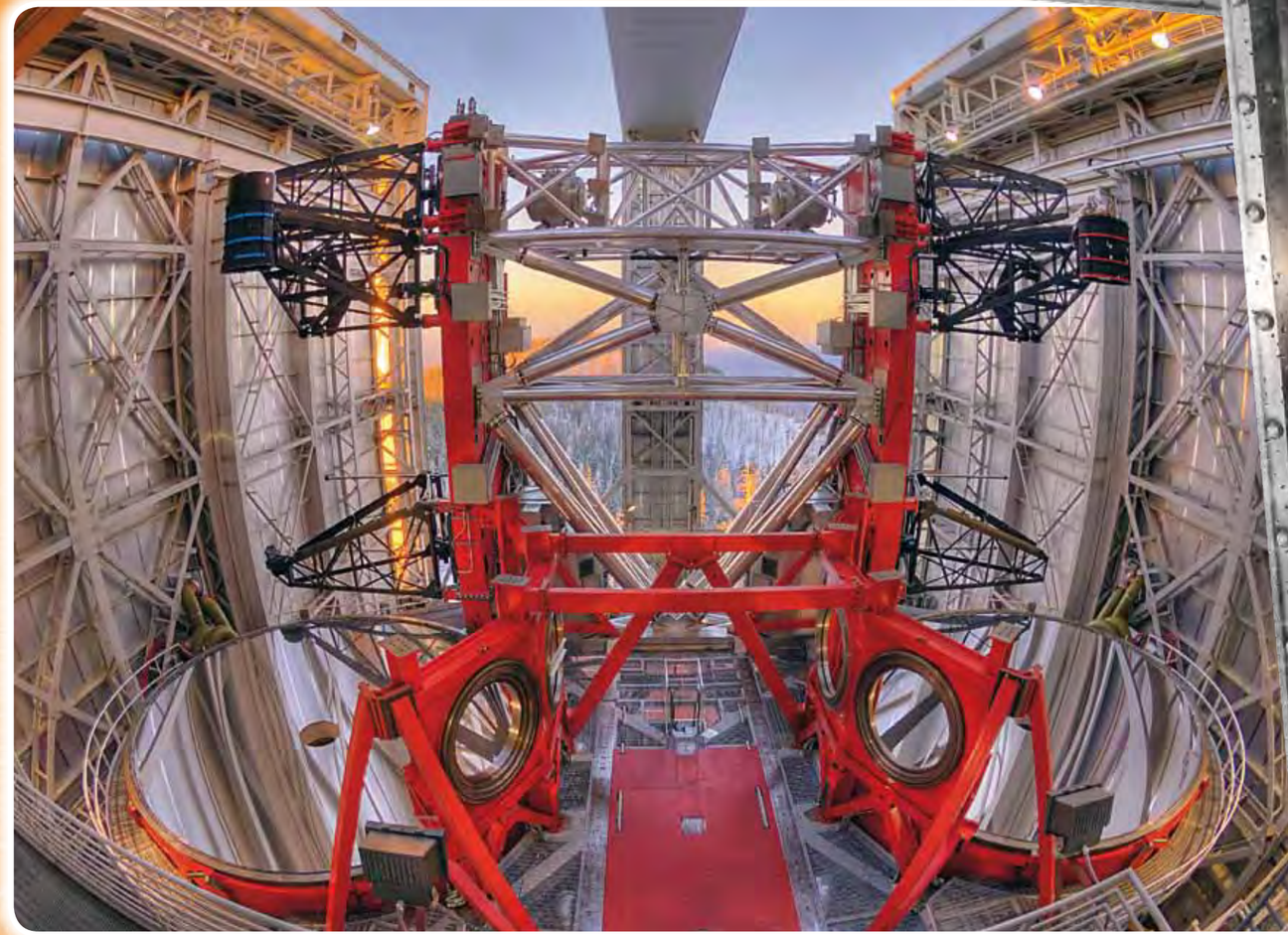
The diagram below shows a Newtonian reflector – a type of optical telescope developed by British physicist Isaac Newton in 1669. Light enters from the left and hits the curved primary mirror. The primary mirror focuses the light onto a small, flat, secondary mirror, positioned at an angle of 45 degrees, which then reflects the light into the eyepiece.



The Newtonian reflector uses only one curved mirror, which makes it easier and cheaper to produce than more complex designs.

Techno-fact!

Even though the Newtonian reflector was invented more than 300 years ago, variations of the design are still manufactured today and are used by many amateur astronomers.



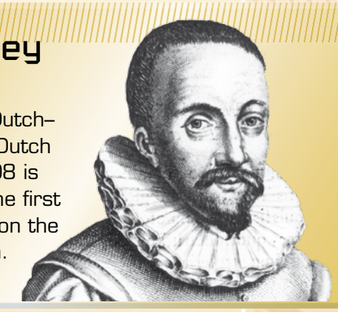
The Large Binocular Telescope in Arizona, the United States, is one of the world's largest optical telescopes. Each of its two mirrors has a diameter of 8.4 metres (27.6 feet).

Optical telescopes today

Today, nearly all large optical telescopes used by professional astronomers are reflectors. Reflectors can be built much larger than refractors because it is easier to build a large mirror accurately than a large lens. Furthermore, the bigger a telescope's mirror is, the more light it can collect, which allows astronomers to see fainter objects. Greater size also allows for greater resolution, which means images are clearer.

Hans Lippershey
(1570–1619)

Hans Lippershey was a Dutch–German lensmaker. His 'Dutch perspective glass' of 1608 is recognised by many as the first true telescope. A crater on the Moon is named after him.



X-ray and Gamma Ray Telescopes

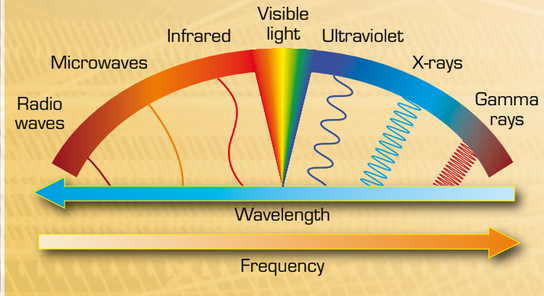
*X-rays and gamma rays are some other wavelengths of the **electromagnetic spectrum**. They are very energetic and have extremely short wavelengths. X-rays and gamma rays are absorbed by Earth's **atmosphere**. This means devices which detect them have to be sent into space.*

How does an X-ray telescope work?

X-ray telescopes are attached to high-altitude balloons and **satellites**. Normal reflectors do not work with X-rays, which are absorbed by the mirror instead of reflected into the eyepiece. X-ray telescopes contain many highly curved mirrors coated with iridium (a hard metal) or gold. The mirrors are placed inside one another and positioned so that the X-rays strike them at a very low, glancing angle.

Wilhelm Röntgen
(1845–1923)

Wilhelm Röntgen was a German physicist. He discovered X-rays in 1895 and, only weeks later, took the first X-ray photograph – of his wife's hand (right). He was honoured for his work in 1901 when he became the first person to win the Nobel Prize in Physics.



This diagram shows the types of radiation that make up the electromagnetic spectrum. X-rays and gamma rays are at one end of the spectrum, with the smallest wavelengths and the highest frequencies.

How does a gamma ray telescope work?

The Large Area Telescope (LAT), which is the main instrument of the *Fermi Gamma-ray Space Telescope*, has four main parts. The Anticoincidence Detector detects unwanted cosmic rays (particles which are not gamma rays). The Precision Tracker determines which direction the gamma rays are coming from and the Calorimeter measures how much energy they have. The Data Acquisition System then analyses the information collected by the other three components.

The *Fermi Gamma-ray Space Telescope*, launched in 2008, aims to find out how stars and galaxies were formed in the early universe. Seen here is *Fermi's* Large Area Telescope.

What do X-ray and gamma ray telescopes see?

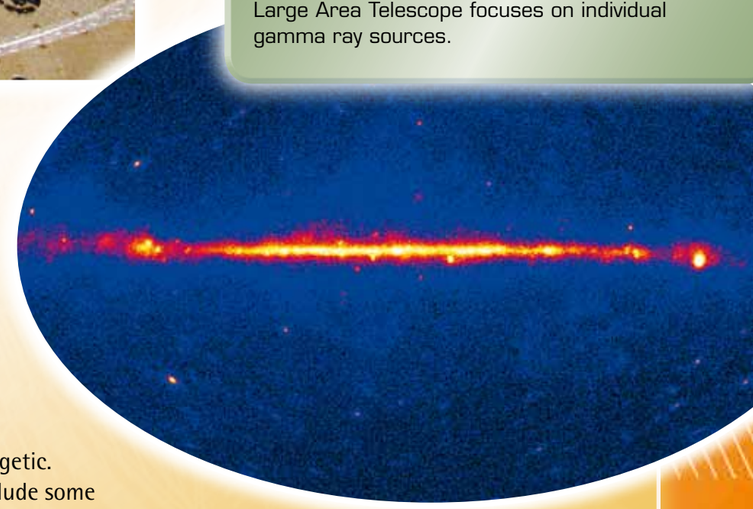
For an object to give off X-rays and gamma rays it must be extremely energetic. Sources of X-rays and gamma rays include some of the most powerful objects in the universe, such as **black holes**, **supernovae** and **neutron stars**. Ordinary stars, such as the Sun, also produce X-rays and gamma rays.

What discoveries have X-ray and gamma ray telescopes made?

Among the most interesting discoveries made by X-ray and gamma ray telescopes are gamma ray bursts. These are short, random flashes of gamma rays from deep space, whose cause is still unknown. Possible sources of gamma ray bursts include extremely massive stars exploding to become black holes and a pair of neutron stars colliding.

Techno-fact!

The *Fermi Gamma-ray Space Telescope* consists of two main instruments. The GLAST Burst Monitor detects gamma ray bursts from a wide section of the sky while the Large Area Telescope focuses on individual gamma ray sources.



The *Fermi Gamma-ray Space Telescope* captured this image of the gamma ray sky. This is what the sky would look like if the human eye could detect radiation 150 million times stronger than visible light.

Rockets

In order to use space to improve everyday life, we need to be able to get into space. Rocket technology lets us do this. A rocket is any vehicle that gets its power from a rocket engine. A rocket engine works by releasing mass at high pressure in one direction, which provides thrust in the opposite direction.

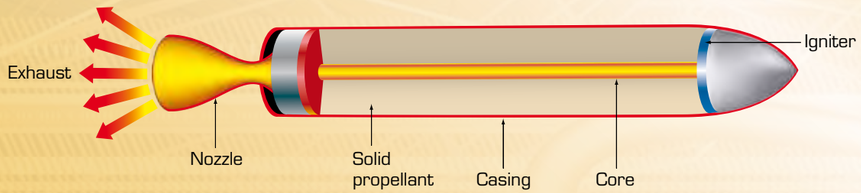
Different rocket engines

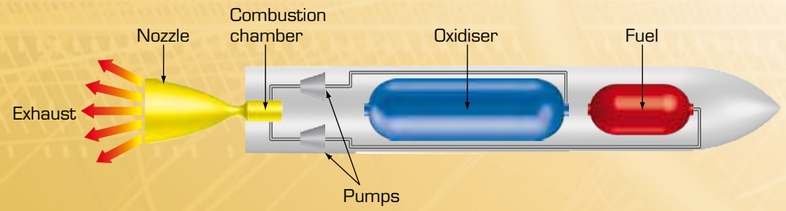
Most rocket engines get their energy from a chemical reaction. The chemicals used are called propellants. These consist of two chemicals, a fuel and an oxidiser, which helps the fuel burn better. In some rockets, the propellants are solid. These are known as solid rockets. Other types of rockets are called liquid rockets because their propellants are liquid.

Rocket engines in spacecraft

The main rockets in spacecraft are usually liquid rockets. The advantage of liquid rockets is that they can be turned off and restarted. On the other hand, liquid rockets malfunction more often because they are more complex. Liquid propellants can also leak and cause explosions. Solid rockets are often used as boosters, which provide extra thrust at lift-off.

When a solid rocket engine is ignited, its core heats up and the propellant around it starts to burn from the inside out. This sends exhaust out of the nozzle and creates thrust. Once ignited, the engine cannot be switched off.





In a liquid rocket engine, combustion takes place in a separate chamber. Combustion can be stopped by disconnecting the pumps between the propellants and the combustion chamber.

Famous space rockets

One of the best-known rockets is the United States's Saturn V, which took the first men to the Moon. The **Soviet Union**'s Soyuz range of rockets was first launched in 1966 and is still used today, particularly as a supply ship for the *International Space Station*. Europe's Ariane 5 rocket is used mainly for commercial purposes, such as launching communications **satellites**.

Robert Goddard invented the first liquid-fuelled rocket in 1926. It was propelled by a mixture of liquid oxygen and petrol.

Timeline: The rocket

1200s — The Chinese use gunpowder-powered rockets for weaponry and fireworks.

1903 — Russian mathematics teacher Konstantin Tsiolkovsky suggests how rockets might be used to reach outer space.

1926 — American Robert Goddard builds the first liquid-fuelled rocket.

1942 — A German V-2 rocket becomes the first man-made object to reach space.

1957 — A Soviet R-7 rocket launches *Sputnik 1*, the first artificial satellite.

1961 — A Vostok-K rocket launches the first human into space, Soviet astronaut Yuri Gagarin.