# FYI Telescopes for Different Types of Electromagnetic Radiation

The telescopes used by ancient astronomers such as Galileo, Newton, Brahe, and others only observed visible light. Today there are telescopes that observe every type of electromagnetic radiation.

**Optical telescopes** are used to observe visible light. Astronomical "seeing" refers to the blurring and twinkling of astronomical objects, such as stars, caused by turbulence in Earth's atmosphere. The astronomical seeing conditions on a given night at a given location describe how much Earth's atmosphere perturbs the images of stars as seen through a telescope. Ground-based optical telescopes can be used on clear nights, but it is also very valuable to send optical telescopes and cameras into space, where the electromagnetic waves are less affected by Earth's atmosphere. These telescopes are typically made with large **parabolic mirrors** that focus light to a point and then reflect the light onto another mirror (or mirrors) that then reflects the light onto a CCD or an eyepiece.

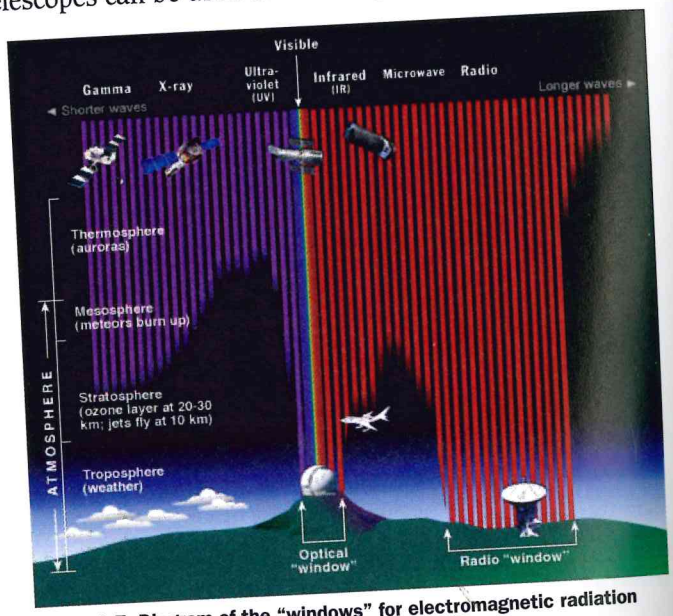


**Figure 3-7: Diagram of the "windows" for electromagnetic radiation through Earth's atmosphere**

Different wavelengths of electromagnetic radiation behave differently as they enter our atmosphere. A relatively narrow "window" of electromagnetic wavelengths around visible light reaches the ground. This window includes some of the longer- wavelength ultraviolet radiation, some of the shorter-wavelength infrared radiation, and all of the visible light region of the spectrum. There is also a sizeable "radio window" of radio wavelengths that are able to penetrate the atmosphere, and thus are observable with ground telescopes. Other portions of the electromagnetic spectrum are absorbed or reflected by our atmosphere, and are therefore not observable with ground-based telescopes. These wavelengths include the longer-wavelength infrared waves, many of the shorter radio waves, most ultraviolet radiation (especially the highest-energy, shortest-wavelength regions of the UV spectrum), and all x-rays (Figure 3-7).

**Figure 3-8: Photograph of a radio telescope**

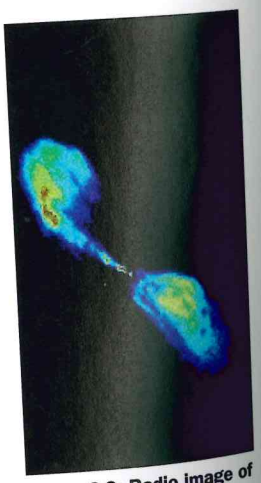

**Figure 3-9: Radio image of Centaurus A galaxy**

**Radio telescopes** are often large dishes that look like the satellite dishes used for TV. The dishes must be very large in order to make detailed images from the very long radio waves. Radio dishes are shaped like **parabolas** and direct the waves to a detector at the **focal point**. The detector turns the radio waves into electronic signals that are sent to a computer for analysis. Astronomers often make images from these signals so that they can visualize what the object would look like if we could see radio waves.

Infrared and ultraviolet observers often use optical telescopes as well, but these telescopes must include a CCD that is sensitive to infrared or ultraviolet light. Only a few narrow bands of infrared light can be observed by ground-based observatories. To view the rest of the infrared universe, we need to use space-based observatories or high-flying aircraft. Infrared is primarily heat radiation, and special detectors cooled to extremely low temperatures are required for most infrared observations.

**Figure 3-10: Drawing of the Spitzer Space Telescope used for infrared astronomy**

Most of the ultraviolet light reaching Earth is blocked by our atmosphere's ozone layer and is very difficult to observe from the ground. To study light in this region of the electromagnetic spectrum, astronomers use high-altitude balloons, rockets, and orbiting observatories.

There are several x-ray observatories orbiting Earth. The most well-known is the Chandra X-ray Observatory. X-ray telescopes use a series of mirrors to focus the x-rays onto a detector that records the amount of x-ray radiation coming from astronomical objects. The x-rays are converted into electronic signals that enable astronomers to make images to visualize what the universe would look like if we had x-ray eyes.

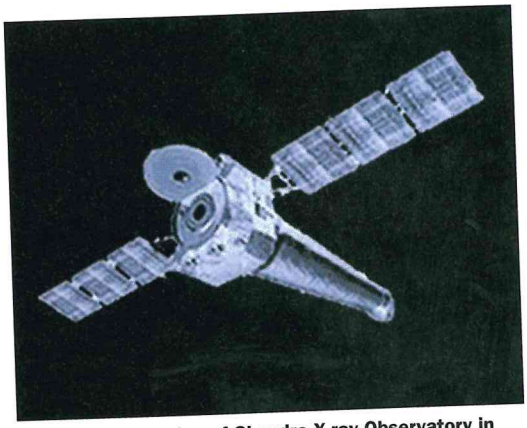

**Figure 3-11: Drawing of Chandra X-ray Observatory in space**

By using all of these observatories together, astronomers are able to build a complete picture not only of what our universe looks like in all forms of electromagnetic radiation, but also of the processes that are occurring within and around astronomical objects.

## Checking In

1. Why are different types of telescopes needed to observe different types of electromagnetic radiation?
2. Why do some observatories orbit Earth, while others can operate from Earth's surface?

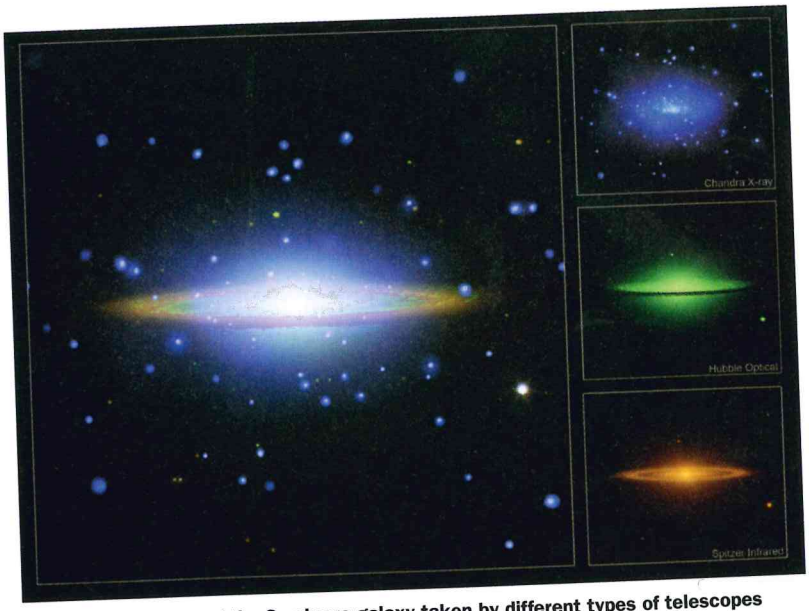


**Figure 3-12: Images of the Sombrero galaxy taken by different types of telescopes**