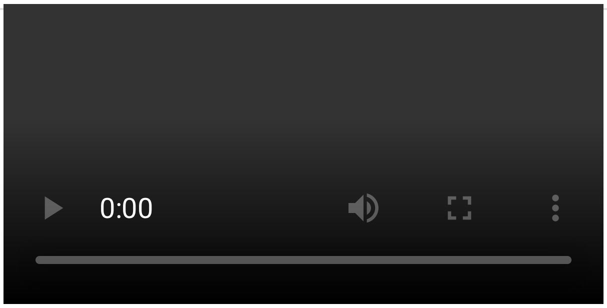
2.0: Light Introduction



Video Transcript

> ***An Introduction to the Electromagnetic Spectrum: Transcript***
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> *Something surrounds you, bombards you, some of which you can't see, touch, or even feel. Every day, everywhere you go, it is odorless and tasteless yet you use it and depend on it every hour of every day. Without it the world you know could not exist. What is it? Electromagnetic radiation.*
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> *These waves spread across a spectrum from very short gamma rays to X-rays, Ultraviolet rays, visible light waves, even longer infrared waves, microwaves, to radio waves which can measure longer than a mountain range. This spectrum is the foundation of the information age and of our modern world. Your radio, remote control, text message, television, microwave oven, even a doctors X-ray all depend on waves within the electromagnetic spectrum.*
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> *Electromagnetic waves or EM waves are similar to ocean waves in that both are energy waves, they transmit energy. EM waves produced by the vibration of charged particles and have electrical and magnetic properties, but unlike ocean waves that require water, EM waves travel through the vacuum of space at the constant speed of light. EM waves have crests and troughs like ocean waves. the distance between crests is the wavelength. While some EM wavelengths are very long and are measured in meters, many are tiny and are measured in billionths of a meter (nanometers). The number of these crests that pass a given point within one second is described as the frequency of the wave. One wave or cycle per second is called a Hertz (Hz). Long EM waves such as radio waves have the lowest frequency and carry less energy. Adding energy increases the frequency of the wave and makes the wavelength shorter. Gamma rays are the shortest, highest energy waves in the spectrum.*
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> *So, as you sit watching TV not only are there visible light waves from the TV striking your eyes but also radio waves transmitting from a nearby station and microwaves carrying cellphone calls and text messages, and waves from your neighbors wifi, and GPS units in the cars driving by. There is a chaos of waves from all across the spectrum passing through your room, right now.*

Almost everything that we know about the Universe ultimately comes from the light we observe. Looking at the night sky from a dark location is a breathtaking experience. But the Universe contains much more than is visible to the naked eye!

To go beyond the limitations of our eyes, we build telescopes and detectors that help us expand our physical perceptions. Some of these are the familiar visible-light telescopes seen at mountain-top observatories; they allow us to see fainter objects with more detail than our eyes alone could see. We also use sophisticated radio antennas and receivers—radio telescopes. In fact, there are different telescopes for all of the types of light in the electromagnetic spectrum: radio waves, microwaves, infrared light, visible light, ultraviolet light, x-rays, and gamma-rays. Each kind of light has a different amount of energy and interacts differently with matter. By looking at what happens to light when it is emitted or absorbed by various types of objects, or when the light emitter is moving through space, we can determine important physical properties of astronomical objects, such as temperature, density, and chemical composition.

In this chapter we will examine the nature of light, also called electromagnetic radiation because it is comprised of oscillating electromagnetic fields. Light travels as a wave, but it is often detected as a particle. These particles of light are called photons, and each carries a definite amount of energy related to wavelength of the photon.

Radiation is the term that astronomers use for any method of energy transport that can carry information across empty space (as opposed to the bulk transport of energy in matter, such as the bubbles in boiling water). This is what astronomers mean when they talk about radiation, not just radiation that is harmful to humans, though it is certainly the case that some types of light are quite harmful. Examples of harmful light are ultraviolet, x-rays and gamma rays.

In addition to simply looking with our eyes, we can also measure the properties of light in a variety of more quantitative ways. If you have ever seen a rainbow or looked through a prism, you know that light comes in a spectrum of many different colors. Using spectroscopy (spreading light into different colors), we can learn a wealth of information about astronomical objects. The information that can be encoded within spectra includes temperature, chemical composition and density. We can take pictures with specialized detectors similar to digital consumer cameras that record extremely faint astronomical sources and provide information about their positions in space and their energy output. The latter process is called photometry, and it is how astronomers acquire an understanding of energy flows into and out of celestial objects.
