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The visible light spectrum includes all light waves with a wavelength smaller than that of

Electromagnetism Light is part of a spectrum of electromagnetic energy that includes radio waves, microwaves, infrared radiation, visible light, ultraviolet "light", x rays, and gamma rays. Electromagnetic energy travels as waves that vary in wavelength. Radio waves and microwaves lie at the longer end of the spectrum of electromagnetic energy (kilometers and meters to centimeters and milimeters), while x rays and gamma rays have very short wavelengths (billionths or trillionths of a meter). Infrared radiation, what we experience as heat when we hold our hand near a warm object, is somewhat longer wavelengths than visible light. Visible light is simply electromagnetic radiation in a range of wavelengths that our eyes are sensitive to. Visible wavelengths range from 0.0007 milimeters for red light, through orange, yellow, green, and blue, to 0.0004 milimeters for violet light. Ultraviolet is shorter wavelengths than violet. Light carries information in ways you may not realize. Cell phones use light to send and receive calls and messages. Wireless routers use light to send pictures of cats from the internet to your computer. Car radios use light to receive music from nearby radio stations. Even in nature, light carries many kinds of information.   Telescopes are light collectors, and everything we know from Hubble is because of light. Since we are not able to travel to a star or take samples from a faraway galaxy, we must depend on electromagnetic radiation — light — to carry information to us from distant objects in space. The Hubble Space Telescope can view objects in more than just visible light, including ultraviolet, visible and infrared light. These observations enable astronomers to determine certain physical characteristics of objects, such as their temperature, composition and velocity. The electromagnetic spectrum consists of much more than visible light. It includes wavelengths of energy that human eyes can't perceive. What Is the Electromagnetic Spectrum? The electromagnetic spectrum describes all of the kinds of light, including those the human eye cannot see. In fact, most of the light in the universe is invisible to our eyes. The light we can see, made up of the individual colors of the rainbow, represents only a very small portion of the electromagnetic spectrum. Other types of light include radio waves, microwaves, infrared radiation, ultraviolet rays, X-rays and gamma rays — all of which are imperceptible to human eyes. All light, or electromagnetic radiation, travels through space at 186,000 miles (300,000 kilometers) per second — the speed of light. That's about as far as a car will go over its lifetime, traveled by light in a single second! How We Measure Light Light travels in waves, much like the waves you find in the ocean. As a wave, light has several basic properties that describe it. One is frequency, which counts the number of waves that pass by a given point in one second. Another is wavelength, the distance from the peak of one wave to the peak of the next. These properties are closely and inversely related: The larger the frequency, the smaller the wavelength — and vice versa. A third is energy, which is similar to frequency in that the higher the frequency of the light wave, the more energy it carries. Your eyes detect electromagnetic waves that are roughly the size of a virus. Your brain interprets the various energies of visible light as different colors, ranging from red to violet. Red has the lowest energy and violet the highest.   Beyond red and violet are many other kinds of light our human eyes can't see, much like there are sounds our ears can't hear. On one end of the electromagnetic spectrum are radio waves, which have wavelengths billions of times longer than those of visible light. On the other end of the spectrum are gamma rays, with wavelengths billions of times smaller than those of visible light. Scientists use color as a tool to convey information. Read the article Scientists use different techniques with telescopes to isolate different types of light. For example, although our eyes cannot see ultraviolet light from a star, one way to perceive it is to let the star's light pass through a filter on a telescope that removes all other kinds of light and fall on a special telescope camera sensitive to ultraviolet light. Comparison of different types of light, including wavelength size, and frequency. What Different Types of Light Tell Us To study the universe, astronomers employ the entire electromagnetic spectrum. Different types of light tell us different things. See interactive examples Radio waves and microwaves, which have the lowest energies, allow scientists to pierce dense, interstellar clouds to see the motion of cold gas. Infrared light is used to see through cold dust; study warm gas and dust, and relatively cool stars; and detect molecules in the atmospheres of planets and stars. Most stars emit the bulk of their electromagnetic energy as visible light, that sliver of the spectrum our eyes can see. Hotter stars emit higher energy light, so the color of the star indicates how hot it is. This means that red stars are cool, while blue stars are hot. Beyond violet lies ultraviolet (UV) light, whose energies are too high for human eyes to see. UV light traces the hot glow of stellar nurseries and is used to identify the hottest, most energetic stars. X-rays come from the hottest gas that contains atoms. They are emitted from superheated material spiraling around a black hole, seething neutron stars, or clouds of gas heated to millions of degrees. Gamma rays have the highest energies and shortest wavelengths on the electromagnetic spectrum. They come from free electrons and stripped atomic nuclei accelerated by powerful magnetic fields in exploding stars, colliding neutron stars, and supermassive black holes. This highly detailed image of the Crab Nebula combines data from telescopes spanning nearly the entire breadth of the electromagnetic spectrum. The picture includes data from five different telescopes: the Spitzer Space Telescope (infrared) in yellow; the Karl G. Jansky Very Large Array (radio) in red; Hubble Space Telescope (visible) in green; XMM-Newton (ultraviolet) in blue; and Chandra X-ray Observatory (X-ray) in purple. Last Updated: May 30, 2019 The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of EM radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays and gamma-rays. You know more about the electromagnetic spectrum than you may think. The image below shows where you might encounter each portion of the EM spectrum in your day-to-day life. The electromagnetic spectrum from lowest energy/longest wavelength (at the top) to highest energy/shortest wavelength (at the bottom). (Credit: NASA's Imagine the Universe) Radio: Your radio captures radio waves emitted by radio stations, bringing your favorite tunes. Radio waves are also emitted by stars and gases in space. Microwave: Microwave radiation will cook your popcorn in just a few minutes, but is also used by astronomers to learn about the structure of nearby galaxies. Infrared: Night vision goggles pick up the infrared light emitted by our skin and objects with heat. In space, infrared light helps us map the dust between stars. Visible: Our eyes detect visible light. Fireflies, light bulbs, and stars all emit visible light. Ultraviolet: Ultraviolet radiation is emitted by the Sun and are the reason skin tans and burns. "Hot" objects in space emit UV radiation as well. X-ray: A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag. Hot gases in the Universe also emit X-rays. Gamma ray: Doctors use gamma-ray imaging to see inside your body. The biggest gamma-ray generator of all is the Universe. Is a radio wave the same as a gamma ray? Are radio waves completely different physical objects than gamma-rays? They are produced in different processes and are detected in different ways, but they are not fundamentally different. Radio waves, gamma-rays, visible light, and all the other parts of the electromagnetic spectrum are electromagnetic radiation. Electromagnetic radiation can be described in terms of a stream of mass-less particles, called photons, each traveling in a wave-like pattern at the speed of light. Each photon contains a certain amount of energy. The different types of radiation are defined by the the amount of energy found in the photons. Radio waves have photons with low energies, microwave photons have a little more energy than radio waves, infrared photons have still more, then visible, ultraviolet, X-rays, and, the most energetic of all, gamma-rays. Measuring electromagnetic radiation Electromagnetic radiation can be expressed in terms of energy, wavelength, or frequency. Frequency is measured in cycles per second, or Hertz. Wavelength is measured in meters. Energy is measured in electron volts. Each of these three quantities for describing EM radiation are related to each other in a precise mathematical way. But why have three ways of describing things, each with a different set of physical units? Comparison of wavelength, frequency and energy for the electromagnetic spectrum. (Credit: NASA's Imagine the Universe) The short answer is that scientists don't like to use numbers any bigger or smaller than they have to. It is much easier to say or write "two kilometers" than "two thousand meters." Generally, scientists use whatever units are easiest for the type of EM radiation they work with. Astronomers who study radio waves tend to use wavelengths or frequencies. Most of the radio part of the EM spectrum falls in the range from about 1 cm to 1 km, which is 30 gigahertz (GHz) to 300 kilohertz (kHz) in frequencies. The radio is a very broad part of the EM spectrum. Infrared and optical astronomers generally use wavelength. Infrared astronomers use microns (millionths of a meter) for wavelengths, so their part of the EM spectrum falls in the range of 1 to 100 microns. Optical astronomers use both angstroms (0.00000001 cm, or 10-8 cm) and nanometers (0.0000001 cm, or 10-7 cm). Using nanometers, violet, blue, green, yellow, orange, and red light have wavelengths between 400 and 700 nanometers. (This range is just a tiny part of the entire EM spectrum, so the light our eyes can see is just a little fraction of all the EM radiation around us.) The wavelengths of ultraviolet, X-ray, and gamma-ray regions of the EM spectrum are very small. Instead of using wavelengths, astronomers that study these portions of the EM spectrum usually refer to these photons by their energies, measured in electron volts (eV). Ultraviolet radiation falls in the range from a few electron volts to about 100 eV. X-ray photons have energies in the range 100 eV to 100,000 eV (or 100 keV). Gamma-rays then are all the photons with energies greater than 100 keV. Show me a chart of the wavelength, frequency, and energy regimes of the spectrum Why do we put telescopes in orbit? The Earth's atmosphere stops most types of electromagnetic radiation from space from reaching Earth's surface. This illustration shows how far into the atmosphere different parts of the EM spectrum can go before being absorbed. Only portions of radio and visible light reach the surface. (Credit: STScI/JHU/NASA) Most electromagnetic radiation from space is unable to reach the surface of the Earth. Radio frequencies, visible light and some ultraviolet light makes it to sea level. Astronomers can observe some infrared wavelengths by putting telescopes on mountain tops. Balloon experiments can reach 35 km above the surface and can operate for months. Rocket flights can take instruments all the way above the Earth's atmosphere, but only for a few minutes before they fall back to Earth. For long-term observations, however, it is best to have your detector on an orbiting satellite and get above it all! Updated: March 2013