THE ELECTROMAGNETIC SPECTRUM

GAMMA-RAYS

Gamma-rays have the smallest wavelengths and the most energy of any other wave in the electromagnetic spectrum. These waves are generated by radioactive atoms and in nuclear explosions. Gamma-rays can kill living cells, a fact which medicine uses to its advantage, using gamma-rays to kill cancerous cells.

Gamma-rays travel to us across vast distances of the universe, only to be absorbed by the Earth's atmosphere. Different wavelengths of light penetrate the Earth's atmosphere to different depths. Instruments aboard high-altitude balloons and satellites like the Compton Observatory provide our only view of the gamma-ray sky.

Gamma-rays are the most energetic form of light and are produced by the hottest regions of the universe. They are also produced by such violent events as supernova explosions or the destruction of atoms, and by less dramatic events, such as the decay of radioactive material in space. Things like supernova explosions (the way massive stars die), neutron stars and pulsars, and black holes are all sources of celestial gamma-rays.

ULTRAVIOLET WAVES

Ultraviolet (UV) light has shorter wavelengths than visible light. Though these waves are invisible to the human eye, some insects, like bumblebees, can see them. Scientists have divided the ultraviolet part of the spectrum into three regions: the near ultraviolet, the far ultraviolet, and the extreme ultraviolet. The three regions are distinguished by how energetic the ultraviolet radiation is, and by the "wavelength" of the ultraviolet light, which is related to energy.

The near ultraviolet, abbreviated NUV, is the light closest to optical or visible light. The extreme ultraviolet, abbreviated EUV, is the ultraviolet light closest to X-rays, and is the most energetic of the three types. The far ultraviolet, abbreviated FUV, lies between the near and extreme ultraviolet regions. It is the least explored of the three regions.

Though some ultraviolet waves from the Sun penetrate Earth's atmosphere, most of them are blocked from entering by various gases like Ozone. Some days, more ultraviolet waves get through our atmosphere. Scientists have developed a UV index to help people protect themselves from these harmful ultraviolet waves.

X-RAYS

As the wavelengths of light decrease, they increase in energy. X-rays have smaller wavelengths and therefore higher energy than ultraviolet waves. We usually talk about X-rays in terms of their energy rather than wavelength. This is partially because X-rays have very small wavelengths. It is also because X-ray light tends to act more like a particle than a wave. X-ray detectors collect actual photons of X-ray light - which is very different from the radio telescopes that have large dishes designed to focus radio waves.

The Earth's atmosphere is thick enough that virtually no X-rays are able to penetrate from outer space all the way to the Earth's surface. This is good for us but also bad for astronomy - we have to put X-ray telescopes and detectors on satellites. We cannot do X-ray astronomy from the ground.

ABOUT THE SPECTRUM

One of the characteristics of light is that it behaves like a wave. As a result, light can be defined by its wavelength and frequency. The frequency is how fast the wave vibrates or goes up and down. The wavelength is the distance between two peaks of the wave. Frequency and wavelength are inversely related, meaning that a low frequency wave has a long wavelength and vice versa.

Waves in the electromagnetic spectrum vary in size from very short gamma-rays smaller than the size of the nucleus of an atom, to very long radio waves the size of buildings.

We can only see light within a certain range of wavelengths and frequency. This range is called the visible spectrum. The frequency range of the visible spectrum is from 405 Terahertz to 790 Terahertz.

Because the electromagnetic waves traveling to the Earth from the Sun come in a variety of lengths, scientists consider them to be a spectrum. Thus, we refer collectively to all these waves as the electromagnetic spectrum. The electromagnetic spectrum simply refers to all the different sized waves of energy traveling outward from the Sun, as well as from many other objects in the Universe.

INFRA RED

Infrared light lies between the visible and microwave portions of the electromagnetic spectrum. Infrared light has a range of wavelengths, just like visible light has wavelengths that range from red light to violet. "Near infrared" light is closest in wavelength to visible light and "far infrared" is closer to the microwave region of the electromagnetic spectrum. The longer, far infrared wavelengths are about the size of a pin head and the shorter, near infrared ones are the size of cells, or are microscopic.

Far infrared waves are thermal. In other words, we experience this type of infrared radiation every day in the form of heat. The heat that we feel from sunlight, a fire, a radiator or a warm sidewalk is infrared. The temperature-sensitive nerve endings in our skin can detect the difference between inside body temperature and outside skin temperature. Shorter, near infrared waves are not hot at all - in fact you cannot even feel them. These shorter wavelengths are the ones used by your TV's remote control.

MICROWAVES

Microwaves have wavelengths that can be measured in centimeters! The longer microwaves, those closer to a foot in length, are the waves which heat our food in a microwave oven. Microwaves are good for transmitting information from one place to another because microwave energy can penetrate haze, light rain and snow, clouds, and smoke.

Shorter microwaves are used in remote sensing. These microwaves are used for radar like the doppler radar used in weather forecasts. Microwaves, used for radar, are just a few inches long.

Radar is an acronym for "radio detection and ranging". Radar was developed to detect objects and determine their range (or position) by transmitting short bursts of microwaves. The strength and origin of "echoes" received from objects that were hit by the microwaves is then recorded.

RADIO WAVES

Radio waves have the longest wavelengths in the electromagnetic spectrum. These waves can be longer than a football field or as short as a football. Radio waves do more than just bring music to your radio. They also carry signals for your television and cellular phones.

Many astronomical objects emit radio waves, but that fact wasn't discovered until 1932. Since then, astronomers have developed sophisticated systems that allow them to make pictures from the radio waves emitted by astronomical objects.

Radio telescopes look toward the heavens at planets and comets, giant clouds of gas and dust, and stars and galaxies. By studying the radio waves originating from these sources, astronomers can learn about their composition, structure, and motion. Radio astronomy has the advantage that sunlight, clouds, and rain do not affect observations.

VISIBLE LIGHT RAYS

What we are seeing when we see an object is reflected light. When light hits an object some wavelengths are absorbed by that object and some are reflected. We see these waves as the colors of the rainbow. Each color has a different wavelength. Red has the longest wavelength and violet has the shortest wavelength. When all the waves are seen together, they make white light.

When white light shines through a prism, the white light is broken apart into the colors of the visible light spectrum. Water vapor in the atmosphere can also break apart wavelengths creating a rainbow.

Shorter visible light wavelengths are bluer in color, while longer visible light wavelengths are redder in color. The wavelengths detectible by the human eye represent only about 3% of the total electromagnetic spectrum.