

## The Electromagnetic Spectrum

[MUSIC PLAYING] For hundreds of years, astronomers saw only that part of the universe visible to our eyes. But visible light is a mere sliver of the broad range of light energy that the universe sends our way.

Electromagnetic energy exists on a spectrum varying according to the length of its waves. The shortest waves are called gamma rays. The longest are radio waves. Our eyes can only see the waves in the very middle of the spectrum-- visible light.

Since we are missing so much of the spectrum, we rely on scientific instruments to reveal the universe. Just beyond our range of vision on the short end of the spectrum, extreme ultraviolet light is absorbed by the ozone layer of our atmosphere. A satellite called the International Ultraviolet Explorer was the first craft to gather the rays in space and to see, for instance, the streams of gas between small clusters of stars.

Longer than visible light waves, infrared radiation may be absorbed by water and carbon dioxide and is best studied from mountains like Mauna Kea in Hawaii, where the air is relatively dry, or from space telescopes, like Hubble.

Our eyes see the Orion nebula as a group of stars obscured by dust and gas. Hubble's infrared image reveals young stars in full bloom. If we could see radio waves, the longest waves of all, we would see a sky full of galaxies instead of stars. But we need electronic equipment to pick them up.

Most radio waves do penetrate the atmosphere. So we can gather them up with ground-based dishes. A radio wave image of the galaxy Cygnus A shows red clouds of gas invisible to optical telescopes.

A remarkable NASA satellite called COBE is even helping us see the universe close to the beginning of time. Measuring infrared and microwave radiation, COBE picks up remnant heat from the Big Bang, called cosmic microwave background radiation. While we're seeing stars, COBE envisions a time before stars and galaxies even existed. Gathering the full range of electromagnetic energy gives us a richer view of the universe.

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