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The Multi-wave Universe

I will use the complete lesson for students. For teachers I will concentrate on the Infrared camera part of the lesson (items 6-15 under Lesson). If time allows I will do the complete lesson for teachers. For the public I will only do the Infrared camera part (items 6-15 under Lesson), adjusting the lesson as needed depending on time.

Objectives

Participants will:

- Investigate the electromagnetic spectrum.
- Directly analyze the visible, Infrared, and Ultraviolet light and specific examples of how to detect each form of energy.
- Comprehend what a wavelength is
- Evaluate the other forms of energy by studying the electromagnetic spectrum.
- Learn about night sky and some celestial objects found in different seasons

Timeline

1 hour total

CLASSROOM SETTING	**30 minutes**
An introduction to visible light and the electromagnetic spectrum?	15 minutes
Diffraction gratings	10 minutes
The electromagnetic spectrum	5 minutes
What is infrared light and how do we detect it?	10 minutes
What is UV light?	5 minutes
DOME SETTING	**30 minutes**
Introduction to the night sky.	10 minutes
Point out celestial objects using stars, followed by images of object in different wavelengths.	20 minutes
TOTAL	**60 minutes**

Background

There is more to the Universe than meets the eye. Visible light makes up only a tiny fraction of the light/energy in the Universe. This lesson/presentation introduces the different types of light/energy/wavelengths found in the Universe and provides students with visuals of what celestial objects look like in these different wavelengths.

Astronomy is the study of space and objects in space. Astronomers typically cannot go to the celestial objects that they study so they study the light they receive from the object. Therefore, understanding light is very important for astronomers.

There are many forms of light in the Universe, most of it is invisible light, or light we cannot see with our eyes. The electromagnetic spectrum describes all of the forms of energy/light.

To understand the electromagnetic spectrum you need to know what a wavelength is. Light in any energy form can act like a wave, travelling at a constant speed of $3X10^8$ m/s. A wavelength is the distance between two successive peaks of a wave. The further apart the wave peaks are the longer the wavelength, and the closer together the wave peaks are the shorter the wavelength.

The entire electromagnetic spectrum includes Gamma Rays, X-Rays, Ultraviolet, Visible, Infrared, Microwaves, and Radio Waves. One main difference between these different types of radiation is their wavelength. The wavelength increases from Gamma Rays, which have the shortest wavelength, to Radio Waves, which have the longest wavelength. When these different forms of light are placed side by side in order of increasing or decreasing wavelength they make up the electromagnetic spectrum.

Visible light is in the middle of the electromagnetic spectrum and is the light that we detect with our eyes. Even though visible light is so important to humans on Earth it only makes up a tiny portion of the entire electromagnetic spectrum. Our eyes are our own little light detectors. The main, natural source of visible light is the Sun. Other sources of visible light, both natural and man-made, are light bulbs, flashlights, lightening, fire, etc. Visible light is also called white light.

White light is actually a combination, or mixture, of the colors of the rainbow: red, orange, yellow, green, blue, and violet. When the visible colors are in order scientists call this the visible spectrum. Our eyes are not sensitive enough to distinguish the visible colors individually, that’s why we see white light coming from a visible light source. In order to see each individual color scientists use special instruments. One instrument that separates white light into each separate color is a prism. Another instrument is called a diffraction grating. A diffraction grating acts like a prism, but is a clear piece of plastic with hundreds of parallels lines etched into the plastic. In order to see the lines you need to look at it through a microscope. As the white light travels through air and hits the grating, the wavelength of each color is dispersed, causing each color to leave the grating at different angles, creating a rainbow effect.

The energy/light that has a slightly longer wavelength than visible light is Infrared light, which is located next to the red end of the visible spectrum. This is one of the invisible forms of energy. Even though our eyes can't "see" Infrared radiation our skin can detect it in the form of heat.

Infrared radiation is heat radiation. With the use of an Infrared camera you can "see" heat and how it is distributed. A thermal Infrared camera detects Infrared energy and converts it into an electronic signal, which is then processed to produce a thermal image and perform temperature calculations.

Our bodies do not give off visible light but they do give off Infrared light. Anything that has a temperature, even "cold" things, will show up in an Infrared image. Cold objects just put out less heat than warm objects. The warmer something is the more heat it puts out and the colder something is the less heat it puts out. Hot objects glow more brightly in the Infrared because they put out more heat and cold objects put out less heat so they show up dark in an Infrared image. For this reason, the coldest object in the Infrared image will show up black and the hottest object in the Infrared image will show up white. The other parts of the image are assigned spectral colors, with blue being cool and yellow being warm.

Infrared imaging is used in many facets of life. Energy auditors use Infrared imaging to determine where there are energy leaks in a house or building. Military and security use it as a sort of "night vision". Ghost Hunters use it to try to locate supernatural beings. And astronomers use it to see through the gas and dust that is found throughout the Universe and to "look back" at the beginning of time.

On the violet side of visible light, at shorter wavelengths, is Ultraviolet light (UV). The Sun also gives off Ultraviolet light. UV light is good for humans: it gives us vitamins, it strengthens our bones and muscles, and has been shown to improve our moods. Too much UV light is not good. UV light is what causes sunburns, which can eventually cause skin cancer.

There are several ways to detect UV light. One way is with UV sensitive beads. These beads are colorful when exposed to UV light, and are white under non-UV light.

Celestial objects, the stars, nebulae, supernovae, galaxies, black holes all emit light in more than one wavelength. And some objects, like black holes, do not emit in visible light. So astronomers made instruments, like the IR camera and xray detectors, to be able to “see” the other forms of light. Some objects look less impressive in invisible light than they do in visible light, others looks really neat in invisible light.

In our neighborhood of the Solar System both Jupiter and the Sun have been imaged in visible, infrared, radio, x-ray, and ultraviolet light.

The Horsehead Nebula, which is an area of star formation, is found in the winter constellation of Orion the Huner. In visible light the pinkish glow behind the “horse’s head” is hydrogen gas and the dark head is thick dust that blocks out the light of background stars. The bright spots in the nebula are young, forming stars. This stellar nursery is 1500 light years away. Looking at the Horsehead Nebula in Infrared, sub-millimeter, and radio waves can give us another view of this stellar nursery.

Another type of nebula, the cat’s eye nebula, is categorized as a planetary nebula. This celestial object is created when a low mass star, like our sun, starts to die. It’s found in the constellation or draco and is 3.3 klys away. The rings of gaseous matter are created when the dying red giant star “puffs” away the surface layers of gas. Found in the center is a white dwarf star, the solid remainder of the low mass star.

Supernova 1987A is one of the most famous Type II supernova. It is the remains of the death of a massive star. This massive star exploded on February 24, 1987 in one of our satellite galaxies, the Large Magellanic Cloud, which is 168,000 light years away from us.

A galaxy is made up of billions of stars and gas and dust. There are three types of galaxies in the Universe: spiral galaxies, elliptical galaxies, and irregular galaxies. Our own Milky Way galaxy is a spiral galaxy. There is a band of light that looks like spilled milk that runs across our night sky. This is actually a part of a spiral arm of our Milky Way galaxy and what we are looking at aren’t the stars that reside in the spiral arms, but rather the gas and dust that also make up the spiral arms. Our neighboring galaxy, the Andromeda galaxy, is also a spiral galaxy that is slightly bigger than our Milky Way galaxy. The Andromeda galaxy is 2.54 million light years away and can be seen with the naked eye just below the constellation of Cassiopeia.

Vocabulary

Invisible light

Visible light

Electromagnetic spectrum

Radiation/energy/light

Wavelength

Infrared Radiation

Ultraviolet Radiation

Nebula

Type II supernova

White dwarf

Galaxy

X-rays

Gamma Rays

Radio Waves

Microwaves

Materials

Diffraction gratings

Source of white light (light bulb and stand)

White board

Electromagnetic poster

IR camera

Ice cubes

Hot liquid

Cup

Garbage bag

Plexi-Glass

Hair dryer

Camera Tripod

Projection screen

UV light

UV sensitive beads

String

Planetarium

Images of celestial objects in multiple wavelengths

Laser pointer