

The Electromagnetic Spectrum

Workshop for Middle School Students
Harlem Children's Zone
March 9, 2007

Cornell Laboratory for Accelerator-based Sciences and Education

Standards Met:

New York State Intermediate Level Science – Learning Standard 4

Key Idea 4.4a: Different forms of electromagnetic energy have different wavelengths. Some examples of electromagnetic energy are microwaves, infrared light, visible light, ultraviolet light, X-rays and gamma rays.

Materials Needed:

Jump rope

Different light sources (Incandescent, fluorescent, UV)

Diffraction glasses (Rainbow Symphony Store)

Power source and gas tubes (Helium, Hydrogen, Neon, Mercury)

Overhead of Emission Spectrum

Colored pencils or markers

Engage:

We have all seen a rainbow. What do the raindrops do to sunlight? White light can be broken up into its component colors by other materials besides raindrops. Share some example (bubbles, oil, prisms, etc.) Use a prism on the overhead projector to illustrate how the light is bent and separated out into red, orange, yellow, blue, green, indigo, and violet. These colors are part of the electromagnetic spectrum called the visible spectrum.

Explore:

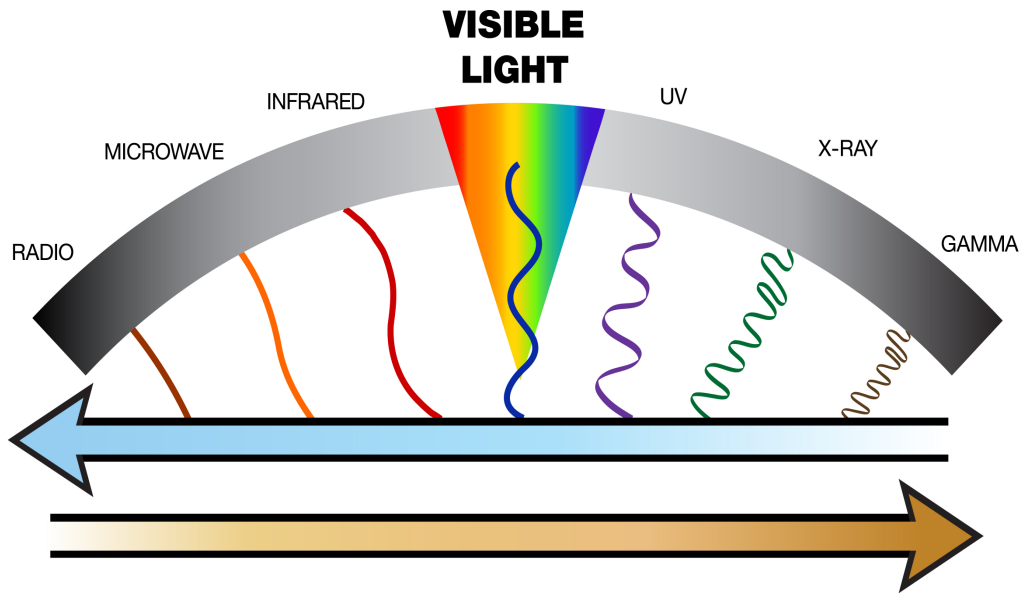
Distribute the diffraction grating glasses to each student. Tell them that the special plastic on the glasses is called diffraction film. The film contains tiny, parallel lines that allow white light to be separated and the component colors to be seen. Have the students look at various light sources through their glasses; incandescent, fluorescent, ultraviolet and red or blue filtered light. Share with the class what they see and why they think the colors (spectra) are slightly different in each different white light source.

Explain:

Ask the class to think about light and how light travels from its source (a light bulb) to your eyeball (a receptor). Ask them to think about how they would model this behavior using a jump rope. Have them turn to their neighbor and discuss. After a minute, ask for two volunteers from the audience to demonstrate how light travels using a jump rope. Have them demonstrate light at higher energy (more

waves per length of rope), and lower energy light (fewer waves per length of rope). Have students define a wavelength.

The colors that we see (the visible spectrum) are only a portion of the electromagnetic spectrum. Place transparency of the below diagram of the electromagnetic spectrum with the visible part of the spectrum enlarged on the overhead projector.



We call the colors we see the *visible* spectrum because it consists of the wavelengths of light that our eyes (receptors) are sensitive to; that humans can see. Some animals have receptors (eyes) that are sensitive to other wavelengths of light. (Examples: Bees see in the spectrum including ultraviolet, which is invisible to humans. Snakes in the pit viper family, like rattlesnakes, have sensory "pits" which are used to image infrared light.)

Go over the electromagnetic spectrum with the class. What devices make use of the microwave region of the spectrum? What devices make use of the radio wave region of the spectrum? The X-ray region? The wavelengths of these regions are longer or shorter than the wavelength found in the visible region of the spectrum and are therefore not visible to the human eye. In other words, the human eye is not a receptor of these wavelengths of light.

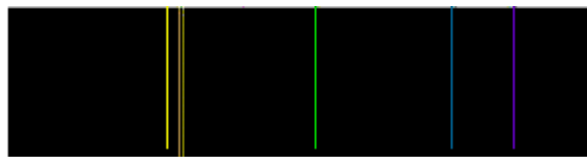
Scientists have built tools that allow them to view objects using wavelengths of light that are otherwise invisible. Can you think of an example of a tool that does this? (Examples: Infrared or "night vision" goggles, ultraviolet and infrared photography).

Elaborate:

As seen in the image above, visible light (and invisible light) is comprised of a series of different wavelengths. The shorter, more frequent (higher energy)

wavelengths correspond to the color violet. The longer, less frequent (lower energy) wavelengths correspond to the color red. Different wavelengths of light register in our eyes as different colors.

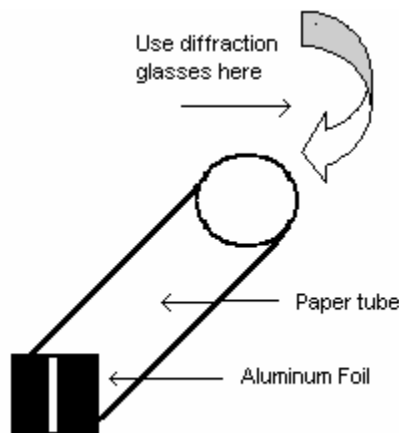
Scientists have built tools that allow them to study the visible spectrum more closely. One such tool, called a spectroscope, is an instrument that works much like the diffraction film used above. A spectroscope is used to separate the light from a hot gas or other light source into its constituent colors. These colors appear as bands or spectral lines. The arrangement of these spectral lines can be used to identify materials. Particular light frequencies from certain materials give rise to sharply defined bands on the scale which can be thought of as fingerprints.



Example of Spectral Lines emitted from a Mercury Lamp

Activity One:

For this activity, students will work independently to build a spectroscope. Students will use a paper-towel tube, aluminum foil, scissors and the distributed diffraction glasses to assemble this device. Students will place a small slit in the center of the aluminum foil, wrap the foil around one end of the tube, and hold the foil-free end up to their eye while looking through their glasses.

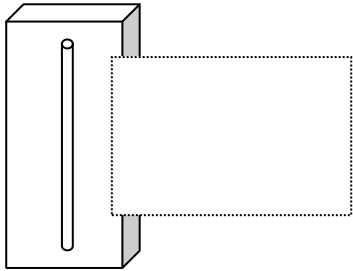


Activity Two:

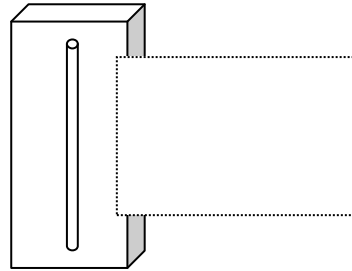
For the following activity, students will work in small groups (3-4 students) and will be assigned to a work station. At the station, students will use their spectroscope to look at a gas bulb. The identity of the gas inside the bulb will be withheld. Students will work together to create a diagram of the spectral lines emitted by their unknown gas. They will share their results with the rest of class.

Evaluate:

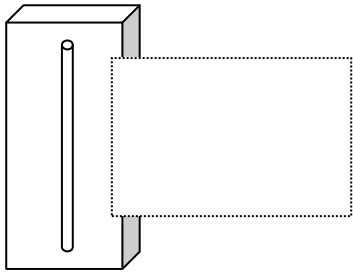
Groups will share the results from their small groups with the entire class (on the overhead projector). Groups will be evaluated on how closely their emission spectra diagrams match the actual spectral lines of the gas (provided at this time). Results from all four stations are shared with the rest of the class.



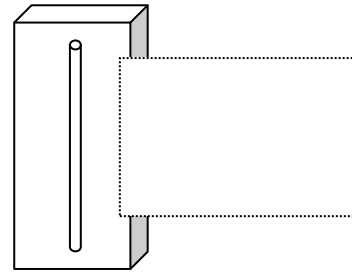
Station One



Station Two



Station Three



Station Four

Extension:

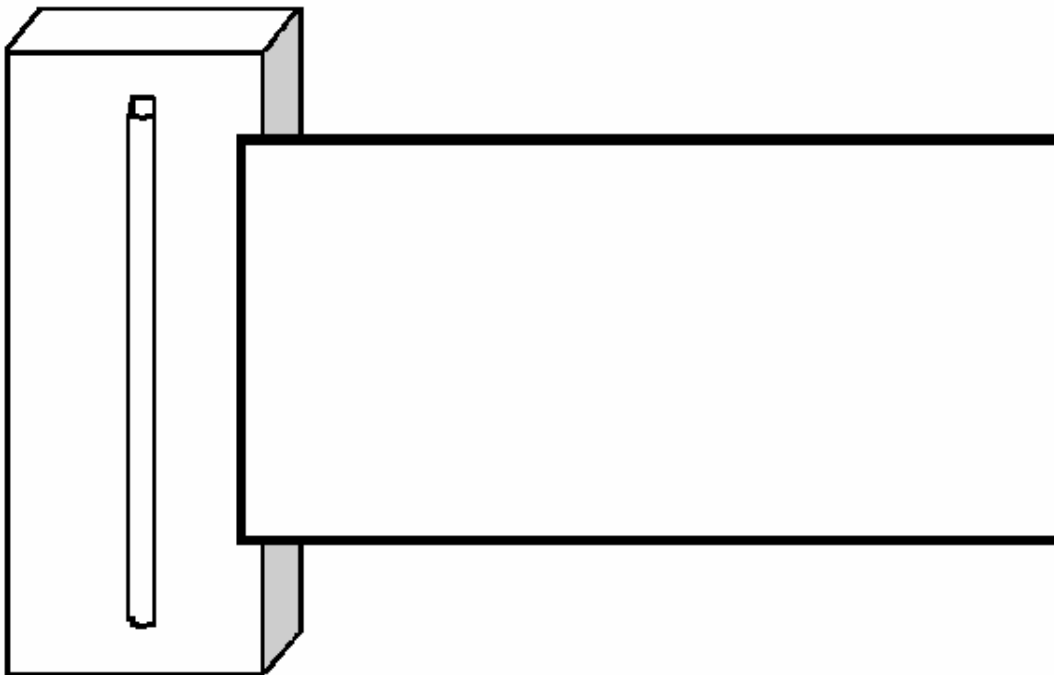
Engage students in a discussion on the spectral line analysis of stars. Spectral analysis tells us the chemical composition of stars as well as the motion of stars and galaxies. More information is available at:

http://imagine.gsfc.nasa.gov/docs/science/how_11/spectral_what.html

Spectral Line Emissions

Station # _____

Name of Gas: _____





INCANDESCENT BULB



HYDROGEN



HELIUM



MERCURY



NEON