

What's beyond the rainbow?

A laboratory experiment from the
Little Shop of Physics at
Colorado State University



Overview

Light is a form of electromagnetic radiation. The rainbow of colors from red to violet is the spread of different wavelengths that makes up visible light.

Of course, there is more to the story...

Theory

All forms of electromagnetic radiation (radio waves, microwaves, infrared, visible light, ultraviolet, x rays) are really the same basic physical phenomenon: They are waves of electric and magnetic fields.

But they behave very differently. There are two big differences between different parts of the spectrum: Wavelength and energy.

The red end of the rainbow corresponds to long wavelength and low energy; the violet end of the spectrum, short wavelength and high energy. And the electromagnetic spectrum beyond the rainbow is even more extreme.



Here is a photo of trees, water and sky through the infrared goggles. Note the odd patterns of what is dark and what is light.

Necessary materials:

- Rainbow glasses
- IR goggles
- Ceramic heat lamp
- Ultraviolet light (blacklight)
- Thermal imaging camera (optional)

This is an open-ended exploration that can be done in many different ways which would use different equipment. The thermal imaging camera, in particular, is hard to find. If you can find one, it's great, but if you can't, you can make the same point by feeling emitted thermal radiation.

Beyond the violet is the range of very high energy. The photons of ultraviolet light are so energetic that they can damage cells. X rays are even worse, of course; that's why you need to limit exposure.

Beyond the red is a much mellower place. The photons of infrared are so wimpy that they can only warm you up. Radio waves are so weak that they can actually go right through you.

In these experiments, we'll get a chance to "see" the electromagnetic waves that exist beyond the rainbow...

Doing the Experiment

This is an open-ended exploration that can

take many forms.

SAFETY NOTE I: The only real safety note is this: Students will often be walking around wearing special glasses or goggles, making it hard to see where they are walking. You need to be certain that they have a wide-open area where they are free to move around without bumping into anything!

SAFETY NOTE II: When wearing the infrared goggles, be certain that NO ONE SHOULD LOOK AT THE SUN!!! Though the goggles reduce the radiation that comes into your eyes, the sun gives off a good deal of infrared, enough to cause irritation.

SAFETY NOTE III: DON'T LOOK AT THE SUN!!! Have we mentioned this?

Here are some things you can do:

- Have your students wear the rainbow glasses to explore the spectrum of visible light. Talk about the different parts of the rainbow.
- Use the infrared goggles to see beyond the rainbow... Your eyes are actually weakly sensitive to the infrared. Go outside and look around. What you are seeing is how the world looks in infrared. How does it look? Plants are light; they reflect infrared. The sky is dark; not much infrared is scattered to light the sky. Clouds are light. How about clothing? Some things that are dark in visible light are dark in the infrared; some things that are light in visible light are dark in the infrared. And some things are actually transparent to the infrared...
- Use the thermal imaging camera in a room in total darkness. You can still see, because the camera picks up the radiation that objects emit. Hot things are bright, cool things are dim. Heat something up, and notice the radiation that it emits. That's how it cools off!
- Turn on the ultraviolet light and see its effects: Objects in the room will fluoresce due to the ultraviolet radiation. It's clearly real, but you can't see it directly.

Summing Up

This is an important experiment to give your students some experience with the spectrum of electromagnetic waves. Students know about visible light, but they don't really know about the other forms. It's important that you give them a chance to explore these other parts of the spectrum before you talk about them, otherwise your discussion will be too abstract for your students to be able to comprehend.

Besides, it's cool. Seeing beyond the rainbow is a lot of fun.

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: <http://cmmmap.colostate.edu>

Little Shop of Physics: <http://littleshop.physics.colostate.edu>