Can you "see" thermal radiation?

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

Overview

A normal incandescent bulb works like this: The filament inside the bulb gets hot. Hot objects emit electromagnetic radiation. And so the bulb glows.

Anything which is warm or hot gives off electromagnetic radiation. Really hot objects emit visible light. Cooler objects emit infrared; we call this "thermal radiation" because it is an important mechanism for transferring thermal energy.

Thermal radiation is much like visible light, but there's one big difference: You can't see it.

Or can you???

Necessary materials:

- Ceramic reptile heater
- Metal lamp stand
- Blindfold (optional)

You can do this experiment with a "heat lamp" which is really just a spotlight with a cooler than usual filament. But the ceramic heater is much nicer, because it has no visible glow at all. It gives off no visible light, but it gives off lots of thermal radiation!

Theory

Here's one vocabulary word that is really important: Radiation. Physicists use this term for whatever is given off by something that glows. The radiation spreads out from a source.

You can clearly see a pit in front of the snake's eye. At the bottom is a patch of tissue that is sensitive to temperature changes, allowing the snake to detect thermal radiation.

Visible light is radiation. So are x rays. Some radiation is dangerous, but most isn't; in fact, electromagnetic radiation is responsible for all life on earth!

Visible light and infrared are both kinds of electromagnetic radiation, but they have very different wavelengths. Visible light has very short wavelength, about 0.0005 mm! A typical infrared source emits electromagnetic waves with a wavelength of 0.010 mm, 20 times longer.

The other big difference is in the energy of the photons. A visible light photon has enough energy to cause a molecular transition, as it does when it strikes the retina of you eye. An infrared photon doesn't; a typical thermal radiation

photon can only wiggle molecules, it can't cause a transition. So infrared can only warm things up.

But you can still "see" it...

Doing the Experiment

This is a nice experiment to do when you are just beginning your discussion of radiation. Infrared and thermal radiation can seem very abstract; in this experiment, getting a chance to "see" it will help students get a handle on just how real it is!

> **SAFETY NOTE I: The ceramic radiant heaters get very hot! Don't let your students touch them.**
>
> **SAFETY NOTE II: You may choose to have the students do this experiment wearing blindfolds. If you do, please be certain to have your students use caution, so that they don't trip or fall or touch the hot bulb!**

The experiment goes like this:

- Have your students cover their eyes or wear blindfolds, and then hold their hands out in front of them.
- Move the ceramic heater (turned on!) near your students.
- Have them move their hands to see if they can tell where the heater is. It's pretty simple to do if they are close, a bit trickier if they are far away.

Students will quickly figure out how to move their hands to sense the infrared. They detect it by measuring the heating of their palms when the infrared strikes their skin.

This is just how certain snakes can "see" thermal radiation. Pit vipers, such as rattlesnakes, have a second set of "eyes" that contain sensitive tissue that can detect the thermal radiation emitted by warm prey animals. Such snakes can easily detect a warm mammal on the cool sand of the desert even in total darkness! They detect the thermal radiation that their prey emits.

Summing Up

This is a good introduction to thermal radiation. The story of energy transfer within the earth system is dominated by radiation, so it's important that students know that this form of energy is quite real!

For More Information

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

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