ACTIVITY 11

Exploring the Properties of the TV Monitor and Remote Control

Goal
We now explore the properties of a small device that allows us to see infrared light.

Preparation:
In this activity we will use a remote control such as the one used to operate a TV or VCR. To prepare for this activity you should learn a little about how the remote control communicates with the TV or VCR. To do so complete the following activities at home.

This part of the investigation can be done at home.

? Most remote controls have a plastic section that is dark but different from the black plastic that covers the rest of the remote. The signal leaves the remote through this section. Cover this part of the remote control. Does the TV still respond?

? Usually you can find the place where the signal is received. It will have dark material covering it. Does the TV respond when it is covered?

? Will the TV respond if someone stands between the remote control and the TV? Try several different positions.

? Can the TV be controlled if the signal is transmitted through glass and bounced off a mirror?

? Based on these results describe how the signal coming from the remote is similar to and different from visible light.

The answers to these questions indicate that signal coming out of the remote behaves as light does. No light is visible when you activate the remote. However, the remote is sending out a low-energy light signal to communicate with the TV. Most remote controls emit infrared (IR) light, for which each photon has an energy that is less than 1.6 eV. When the remote is activated, pulses of infrared light leave the remote control. When this light is received by the device, it is interpreted and the TV, VCR, or CD player responds.

Large amounts of infrared light may be detected as heat. The heat you feel from a fireplace, sunlight, or the ground is all sources of infrared light. The eyes of some living organisms like rattlesnakes are sensitive to infrared light. Thus, they see very small temperature variations in their environment. However, the amount of infrared light coming from a remote control is very small, so we do not feel any heat.

Sometimes remote controls fail to function correctly. The first check that is made by repair people is to see if the remote control is emitting infrared light. Of course, the repair people cannot see infrared light, and carrying rattlesnakes is considered impractical.

Fortunately, a small material enables them to "see" indirectly the infrared light. This IR detecting material converts infrared signals to visible light. At first the process may seem similar to fluorescence because it is converting light of one energy to light of another energy. However, IR detection is different from fluorescence in one very important way. In fluorescence a solid emits a lower energy photon than it absorbs; the rest of the energy goes to other forms. In IR detection the material is emitting *higher* energy photons than it absorbs. (Figure 11-1)

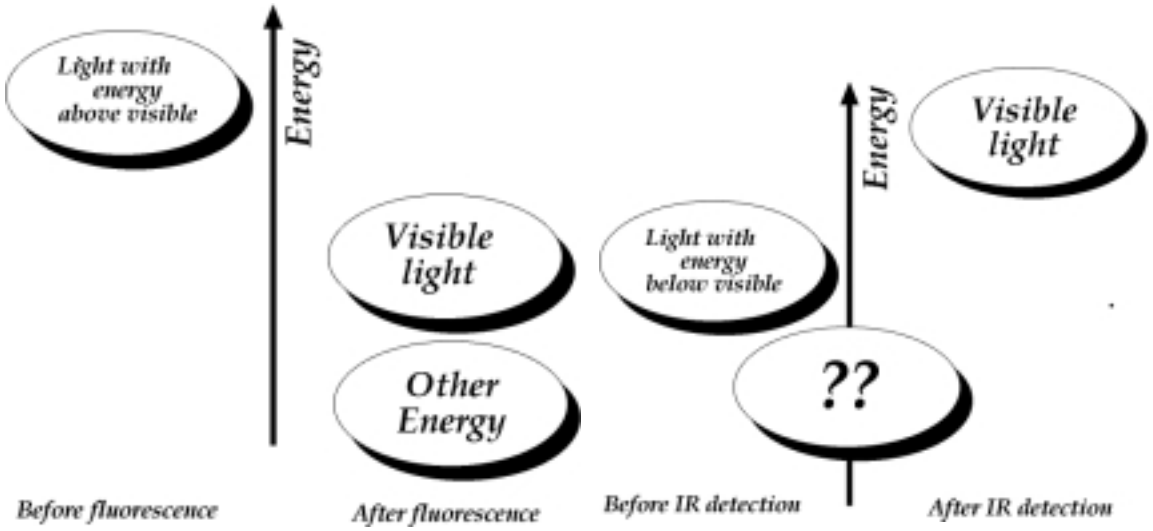

Figure 11-1: The difference between fluorescence and infrared detection is in the changes in the energy of photons. We have included a question mark because you do not yet know how the energy changes in the IR detection process.

To begin your investigations use either a remote control or an LED which emits infrared light. Expose the card with the IR detecting material to room light for a few minutes. Then activate the remote or increase the voltage on the LED. Describe below what you see coming from the material.

Now, expose the IR detector card to an infrared heat lamp. This lamp emits very little visible light and a very large amount of infrared light. Once you have exposed the card to intense IR be careful to keep it out of visible light. Then, hold the infrared detector card close to the activated remote control for about 10 seconds. In the space provided below, record your observations.

Now allow some room light to fall on the card. Then, in a dark room expose the card to IR light from a remote control. Describe below what happens.

Now, allow some room light to fall on the card. Then, in a dark room expose the card to IR light from a remote control. Describe below what happens.

? Leave the IR light on. Does the light from the card decrease with time?

Expose the detecting material to the intense IR source again. Before exposing the material to visible light, cover one-half of the detecting material with the colored transparent material. Your instructor will tell you which color to use. While holding this transparency in place, expose the IR card to visible light.

Return to the dark. Then, activate the remote control and describe the results.

Color of Transparency _____

Results:

Compare your results with others who used other colors of the transparencies. Summarize the results below.

? Speculate about other sources of energy that might be involved in the emission of visible light from the card. Explain

? Speculate why the light emitted by the card decreases after a period of time in the dark room even though the IR light from the remote control is kept on it.

The IR detector card, like the fluorescent and phosphorescent materials, consists of solids with impurity atoms. An energy band model can explain the observed properties of the card.

Discuss in small groups how a possible energy band diagram could explain the properties of the IR detector card.

In the space provided below, sketch your prediction and identify the energy bands of the materials and the energy or energies absorbed by the card (along with their sources) as well as the energy emitted by the card.

In the next activity, we will use a computer program to construct a model that explains the operation of the IR detector card.

Homework

The television itself also displays some luminescence. In this homework assignment you can investigate the light emitting properties of theTV.

The general definition of a phosphor is a solid material which when provided sufficient energy emits light due to luminescence. Phosphors can be found in phosphorescent materials as well as inside the glass tubes of fluorescent lamps. Phosphors made of the same material as phosphorescent objects like glow-in-the-dark toothbrushes can also be found in electroluminescent materials. The green, faintly glowing night-lights that can be plugged into the household electrical outlet and theTimex© Indiglo© watches utilize the process of electroluminescence to emit this characteristic light.

Turn on a television or computer monitor. Keep it on for a few minutes. Make the room as dark as possible and then turn off theTV or the monitor.

? What happens to the screen after you turn it "off"?

? Approximately how long could this phenomenon be seen?

? What process does the TV screen use to emit light after it is first turned off? Explain.

The face of the TV screen or computer monitor is lined with phosphors. The TV screen is slightly phosphorescent in that the glow disappears rather quickly. When the TV is turned on, the phosphor coating absorbs high-energy electrons that are directed at them by a device inside the TV. The phosphor releases this energy over time in the form of visible light. This process of light emission is called cathodoluminescence. The name comes from cathode rays — a term used about 100 years ago to describe a beam of electrons. Our chart used to classify the different types of luminescence now has been modified to include cathodoluminescence. See Figure 11-2.

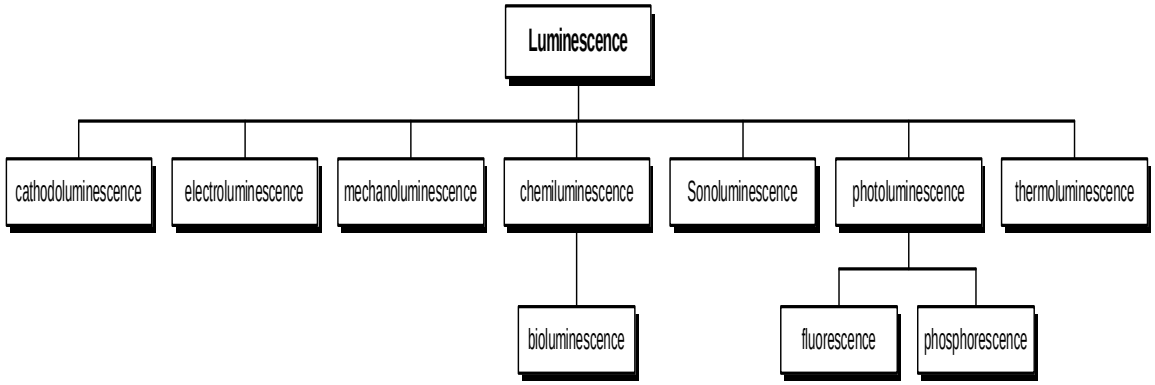

Figure 11-2: Types of Luminescence