Five Stars Pathway
Afterschool Science Curriculum

Detecting Invisible Light

Multiverse

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SPACE SCIENCES LABORATORY
UNIVERSITY OF CALIFORNIA
Berkeley

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Detecting Invisible Light

Age Range
Ages 10+

Number of Participants
~ 15

Duration
Part I: 20 mins
Part II: 40-60 mins
Discussion: 10+ mins

Special Notes

- Part I or Part II can be run independently, although it is most effective to do both pieces. You may consider breaking up Parts I and II of the lesson into two days.
- Part I (source and detector matching) can be done with just the printed cards. **Many of the additional materials listed are used only for Part II of this activity.** Although extending the activity to include the discussion on shields involves gathering more material, it is a very effective way of directly demonstrating the different types of light to participants.
- We recommend that you conduct the "Exploring the Electromagnetic Spectrum" lesson first — http://multiverse.ssl.berkeley.edu/fivestars#emspectrum.
- This lesson is adapted from the SOFIA Active Astronomy curriculum.

Overview

In this activity, participants work in small groups to identify the connections between different sources of light and their relevant detectors. The activity has a follow up exploration component wherein participants experiment with various types of materials to identify effective shields for different wavelengths of light. This helps increase understanding of the different types of wavelengths of light, how they can be used in everyday life, and how shielding detectors from different types of light can be both helpful and a hindrance.

Activity Goals

Participants will:

- Recall that there are many different types of light in the electromagnetic or EM spectrum (all of which are emitted by the Sun).
- Understand that a "source" is an object that emits light, and a "detector" is one that collects light.
- Realize that different types of light require different types of detectors.
- Learn that light of different wavelengths can be shielded by different materials.

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Detecting Invisible Light

Notes for Preparation

If you have previously developed the EM spectrum poster in "Exploring the Electromagnetic Spectrum," http://multiverse.ssl.berkeley.edu/fivestars#emspectrum, you should display it for this activity.

The materials for Part I are reused in Part II. Part II requires additional materials.

- Print and cut out one set of source-detector cards per group. If you wish to reuse these, you may want to laminate them for durability. The cards should be printed single-side only.
- Print one data sheet per group or per participant.

Part I

- All materials should be placed in one easily-accessible place, such as the center of a table around which participants can sit; they will be shared among participants. If there is a large group (>15) then it may be necessary to have more than one of some of the materials (e.g., black lights, remote controls, flashlights, UV beads.)
- If you are transitioning from Part I to Part II, ask the participants to assist in setting up the stations using the materials from Part I to help with room control.

Part II

- Materials from Part I are set up in pairs at separate stations (pairs are described in the "Lesson Plan for Part I).
- Shielding of different types (materials listed under Part II), should be accessible for all stations. Either distribute different shielding materials at each station, place all shielding materials in a communal area, or give each small group a set of shielding materials.

Materials

Source/Detector Pairs (for Part I and II)

- One set of "Cards: Electromagnetic Sources & Detectors" per group. Small versions of the cards are included at the end of this lesson plan and larger versions can be downloaded at: http://bit.ly/186XwIp
- One "Data Sheet: Light Sources & Detectors" per group OR per participant. Copy of the data sheet is included at the end of this lesson and can also be downloaded at: http://bit.ly/1QEO6r6
- Fluorescent black light
- UV beads, Styrofoam packing peanuts, powdered detergent in a ziplock bag, glow-in-the-dark stars, etc.
- Heat lamp
- Cell phone (can use participant's own)
- Radio
- Flashlight
- Remote control
- TV/VCR or other device controlled by remote control

NOTE: Black lights and UV beads are available from online vendors such as www.teachersource.com or http://www.scientificsonline.com/. (We strongly advise against the use of incandescent black light bulbs—they can become very hot and care must be taken to ensure participants do not touch the bulb. A fluorescent tube can be much more effective and safe, though you should still advise participants not to stare directly into the fluorescent bulbs or hold them close to their skin).

Additional Materials for Part II

Many pet stores carry heat lamps.

Detector Shielding—a collection of materials that will shield light:

- Trash bags
- Overhead transparency or sheet of acrylic
- Aluminum foil
- Wire mesh
- Plastic wrap
- Black paper
- White paper
- Wax paper
- Cloth of different colors, thicknesses and textures (for example: sheer scarf, wool sweater, thin shirt, etc.)

Detecting Invisible Light

Lesson Plan for Part I -- Invisible World: Detecting Light

Exploration - Matching the Source/Detector Pairs

1. Distribute one set of source-detector cards per group of participants. Each group or individual should have their own data sheet.
2. Begin by using probing questions to remind participants about the different types of light found in the EM spectrum, and what "detectors" we depend on.
   - What kind of light do we use in everyday life, both visible and invisible?
   - When is light helpful to us? When can it be unhelpful?
   - What do you think a detector is?
   - Do you think sources and detectors have to be in the same room to work? (Some examples to consider: radio stations and radios being very long distances apart, the same with cell phones and cell phone towers.)
3. The goal is to have groups match the detectors to the sources using the match cards. They can explore possible matches using the communal props. For example, notice how holding the UV beads in front of a flashlight has no effect. When holding them under a black light, the UV beads change color. This is most likely a source-detector pair.
4. While focusing on problem solving, discussion and teamwork, groups or individuals fill out their data-sheets with the source-detector pairs. If possible, they should try to identify or guess what type of light is being used for each pair (for example, black light and UV bead pair use ultraviolet light). See 'Notes About Sources and Detectors' for solutions.
5. Once the groups have completed their sheets, have them share their results as a large group. You can prompt discussion by asking them why they chose the pairs they did, and how they knew about the type of light being used. Whether a group's answer was correct or incorrect, discussing the process that led to their answer may help all the participants reach a deeper understanding of sources and detectors.

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Lesson Plan for Part II -- Invisible World: Shielding Light

Identify What Shields Light

1. Setup: place the source and detector pairs at different stations around the room (one source and detector pair per station. Stations should be set up so 2-3 people can access the station at any given time.
2. Distribute detector-shielding materials so they are accessible for all stations—give each small group a set of shielding materials or place shielding materials in a communal area.

★ **Station 1 – Visible light**
- **Source:** Flashlight
- **Detector:** Your eye or cell phone camera (need an object to shine the light on, like a book, person, or anything)

★ **Station 2 – Infrared light**
- **Source:** Remote control (for example, TV remote)
- **Detector:** The object that the remote controls (for example, a television)

★ **Station 3 – Radio**
- **Source:** Any radio station
- **Detector:** Radio

★ **Station 4 – Ultraviolet light**
- **Source:** Fluorescent black light
- **Detector:** Any one of UV beads/Styrofoam peanuts/powdered detergent in ziplock bag/glow-in-the-dark stars

★ Station 5 – Microwaves
- **Source:** cell phone
- **Detector:** cell phone

3. Participants spend approximately five minutes at each station in their small groups (monitor situation to make sure the time is not too long or too short).
4. Each group begins by identifying how the source and detectors work, for example, recognizing that a radio picks up a signal being emitted from a radio station, or that a TV "detects" the light being emitted from the remote control (See 'Notes About Sources and Detectors' at the end of lesson).
5. Have small groups investigate the effects of different shielding materials by blocking the path of the different light sources. For most stations, this will be straightforward. For example, putting a trash bag between the flashlight and the paper will block the light, but putting an acrylic sheet in the light path won't have any effect. Some materials transmit light of different wavelengths but others behave differently with other wavelengths. For some stations, such as radio or microwave, wrapping the detector in the shield will prove to be more effective, as the source of the light signal is being emitted from a large distance away (cell phone signal must first be picked up by a tower and then redirected to the receiving cell phone).
6. Participants record their findings on their data sheet.

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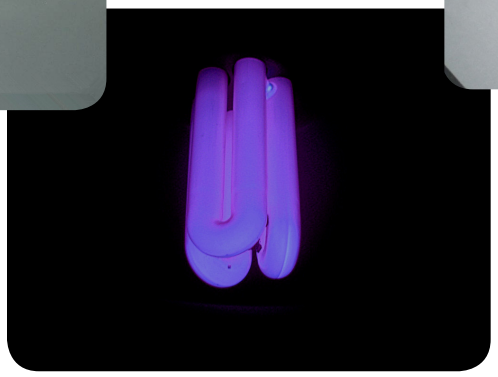
Part II: Follow-Up Discussion

1. Discuss the results that groups discovered about the shields. Refer to the poster created in "Lesson #2: Exploring the EM Spectrum" during this discussion to remind participants that the invisible light from the sources is part of the electromagnetic spectrum.
   - What surprised you?
   - What did not surprise you?
   - What shields were particularly effective?
   - What shields were not good at blocking the light source?
2. Ask participants questions regarding the differences between materials that block some light and let other light through (like how a black trash bag can block visible light but let infrared light through, or how a clear acrylic sheet will block infrared but let visible light through).
   - Did you notice any trends or patterns with the shields?
   - Were there materials that blocked all the light sources?
   - Were there materials that blocked no light?
   - Were there materials that did not block any light source at all?
3. Extend the discussion to how sources and detectors are important in our everyday life. Notice any change in opinions from the opening discussion.
   - How is shielding used in your everyday life ? (like how windows or sunglasses can have a UV protective coating, or how you can't change the TV channel through a concrete wall.)
   - In what way is shielding helpful? How can it be annoying?



Left to right: acrylic sheet, fluorescent black light, TV remote control

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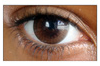
Notes About Sources and Detectors

SOURCE	DETECTOR	TYPE OF LIGHT	HOW THEY WORK
Radio Station	Radio	Radio	Radio stations take music or the sound of someone's voice, encode it and transmit it with radio waves. Your radio device receives the radio waves and decodes the message. Both the transmitter and receiver use antennas to radiate and capture the radio signal.
Cell Phone (outgoing)	Cell Phone (incoming)	Microwave	Microwave waves carry an electrical signal from your phone to a cell tower and on to the receiving phone. The microwave signal is interpreted by the receiver's phone.
Remote Control	TV	Infrared	A remote control sends out pulses of infrared light that represent specific binary codes. These binary codes correspond to commands, such as changing the channel or turning the volume up or down.
Flashlight	Eye/Paper/ Cellphone Camera	Visible	Visible light emitted by the flashlight illuminates an object (such as a book) by bouncing visible light off of it into our eye/cell phone camera.
Blacklight	UV Beads/ Styrofoam Peanuts/ Powdered Detergent in a Ziplock Bag/Glow-in-the-Dark Stars	Ultra-violet	These detectors contain a chemical that changes color when exposed to ultraviolet light. The black light emits purple (violet) light but it also emits invisible ultraviolet light that you can't see (UV is next to the violet end of the visible spectrum). So, when the black light shines on these objects, the UV light makes the chemical change color.
X-ray Machine	Film	X-ray	X-rays have a very short wavelength that can penetrate through skin and muscles easily. However, the high-density bones absorb many more X-rays, making them stand out from muscles in an X-ray film.
Banana	Geiger counter	Gamma ray	Bananas are high in potassium-40 which is radioactive with a half life of more than a billion years. Potassium-40 decays in two ways. The more infrequent (11% of the time) type of decay results in the conversion of a proton to a neutron, which spits out a very low amount of gamma rays in the process. A standard banana experiences about 14 decays per second. Although this is a measurable amount of gamma radiation, it would take more than 5 million bananas to give you radiation sickness. Bananas are not the only radioactive food – potatoes, nuts and kidney beans are other examples.

Data Sheet: Light Sources and Detectors

Source	Detector	Type of Light	Shield

Cards: Electromagnetic Sources and Detectors

Source Blacklight 	Detector UV Beads 
Source Cell phone 	Detector Cell phone 
Source Radio station 	Detector Radio 
Source Flashlight 	Detector Eye 
Source Remote control 	Detector TV 
Source X-ray machine 	Detector Film 
Source Banana 	Detector Geiger counter 

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