SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

www.pbs.org/saf/1405

The Dark Side of the Universe

Activity 2: Grades 9-12

Spectroscopy

As a result of high temperature, stars emit light. Although it appears white, their light contains a spectrum of color. When separated, the individual colors can be used as a type of "fingerprint" to identify and analyze the star. When moving away from an observer, the star's color fingerprint appears more red (red shift). When moving toward an observer, the fingerprint appears more blue (blue shift). By analyzing these spectra, cosmologists can infer the manner and direction of universe expansion.

This activity page will offer:

- An introduction to spectroscopy
- An opportunity to construct a simple spectrometer
- Experience in comparing and contrasting spectra

Seeing the Spectra

A spectroscope is a tool that separates light into its component colors. Once separated, the bands are more easily distinguished and the pattern more accurately analyzed. In this activity, you'll construct a simple spectroscope using a discarded compact disc. You'll then use your tool to compare and contrast various spectra of light-emitting objects.

Materials

- Large shoe box (used for boots)
- Discarded compact disk (the give-away discs used in mail promotions work fine)
- Tape
- Index card
- Ruler
- Scissors

Procedure

1. Work with a partner. Take a large shoebox and remove the lid.
2. Set the box upright on one end.
3. Use your scissors to carefully cut a slot into one of the box ends. The slot should be about 6 cm. long and about 2 cm. wide.
4. Cut and index card in half. Place the card halves on both sides of the slot. Position them so they reduce the width of the slot to about 1 mm. Use tape to secure.
5. Tape a CD to the opposite inner side of the box. Make sure the rainbow-producing side is facing up. The CD should be positioned in the middle of the side. Use tape to secure.
6. Place the open box under a bright light so that light enters through the slit and strikes the CD.
7. Note where the light reflected off the CD surface strikes the box wall. Use a pencil to mark out this area.
8. Use a scissors to cut out the marked area, creating a viewing window into the box.
9. Close the box lid. Place the box under a bright incandescent light. Position it so that direct light spills through the slot. Look into the window. Record your observations.
10. Repeat step 9 but use a fluorescent lamp as your light source. If applicable, examine a neon light or similar light-emitting source. Record your observations.

Questions

1. What did you observe when you looked into the viewing window?
2. How did the incandescent spectrum compare to the fluorescent spectrum?
3. Did you observe the Doppler effect?

Colorful Extension

How might a colored filter affect the spectrum that you detect with your viewing device? Make a guess. Then, with your instructor's approval, perform the inquiry.

Reversing the Spread

Most likely you've played with a plastic or glass prism. As you observed, white light striking this triangular solid separated into its component colors. Suppose you had two prisms. Could you arrange them so that the rainbow formed by one is combined back into white light by the other? Think about it. Then, with a classroom set of these optical devices test your design.

Spectrum in a Glass

Place a mirror in a beaker half filled with water. Position this setup in direct sunlight. Search the walls and ceiling for rainbows created by this spectrum-producing device. Compare and contrast the projected bands of color. How are

the rainbows similar? How are they different?

Rainbows Too?

As you've observed, white light can be separated into a spectrum of colors by the finely spaced ridges of a compact disc. However, consider a rainbow. There are no compact discs in the atmosphere, yet the sun's light is split into its component bands of color. How does this happen? Use print and online resources to explore the origin of rainbows and report your understanding back to classmates in a colorful way.

Web Connection

The Universe According to Spectroscopy

http://edmall.gsfc.nasa.gov/2000invest/spectra2.html
This NASA-hosted site describes the use of spectroscopy in the study of the universe.

What is Spectroscopy?

http://loke.as.arizona.edu/~ckulesa/camp/spectroscopy_intro.html
This site offers a basic introduction to spectroscopy.

The Expansion of the Universe

http://astron.berkeley.edu/~mwhite/darkmatter/dopplershift.html
This site offers an introduction to Doppler shift as it pertains to the expansion of the universe.

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Questions

1. What did you observe when you looked into the viewing window?
   (A spectrum of color.)
2. How did the incandescent spectrum compare to the fluorescent spectrum?
   (The incandescent had more red, while the fluorescent had more blue green light.)
3. Did you observe the Doppler effect?
   (No. Although the spectrum was observed, the targets were not moving so no apparent shift in color was detected.)