SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

www.pbs.org/saf/1405

The Dark Side of the Universe

Activity 2: Grades 5-8

Doppler Shift

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:

- Background on Doppler and its use in cosmology
- A model of the Doppler effect

Modeling the Shift

Imagine a star emitting light waves. Like ripples of water, the light waves travel outward in all directions from their source. If the source moves, the ripple patterns in front of the movement get squished together. At the same time, the patterns behind the star get separated from each other. In this activity, you'll construct a simple model that illustrates this concept underlying red shift.

Materials

- Long and wide elastic band
- Tape
- Marker
- Ruler
- Safety goggles

Procedure

1. Work with a partner. Take an elastic band. Use a scissors to carefully open the loop into one continuous length.

2. Use a ruler to create a series of lines, one centimeter apart, across the band.
3. Cut out a small paper circle to represent a star.
4. Use tape to attach this circle to the middle of the band.
5. Put on safety goggles.
6. One student holds both ends of the elastic. The elastic is pulled so that a moderate stretch in placed in the fabric.
7. The other student grasps the star and moves it about one inch toward one end of the elastic. Observe the change in appearance of the distance scale on both sides of the star.
8. The star is now moved twice the distance. Again, observe how this movement affects the marked distances on either side of the star.

Questions

1. What did the marks on the elastic band represent?
2. What scenario was represented when the star remained at the center of the elastic band?
3. What scenario was modeled when the star was pushed to one direction? What happens to the wavelength?

Hum That Tune

Close your eyes and imagine the sound of a race car speeding by. Model the sound by humming it. At first, the whine of the engine is high-pitched. However, as the car passes you, the sound quickly flattens. Explain this change in apparent pitch using the Doppler Effect.

Row Boat Doppler

Can you communicate the Doppler Effect using a rowboat scenario? Imagine sitting in a stationary rowboat in the middle of a very still lake. You raise the oars out of the water. Water drips from them onto the lake's surface. The splashing of the drops produces a series of concentric ripples. Now imagine how this pattern might change if the rowboat were moving forward and the oars were lifted above the water. Explain this in terms of Doppler. Could you model these observations using an overhead projector?

Doppler Radar

Have you watched a televised weather report recently? If so, you probably heard the term Doppler radar. Use print and online resources to explore this meteorologists' tool. How does Doppler radar work? Where does the effect fit in? How does this improve a meteorologist's ability to make forecasts?

Web Connection

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.

Red Shift

http://www.arachnoid.com/sky/redshift.html
This site presents a simple overview of the red shift.

Light-Doppler Effect

http://library.thinkquest.org/C006027/html-ver/op-dop.html
This site offers basic Doppler equations that can be used to calculate changes in observed frequencies and wavelengths.

Academic Advisors for this Guide:
Suzanne Panico, Science Teacher Mentor, Cambridge Public Schools, Cambridge, MA
Anne E. Jones, Science Department, Wayland Middle School, Wayland, MA
Gary Pinkall, Middle School Science Teacher, Great Bend Public Schools, Great Bend, KS
Cam Bennet Physics/Math Instructor Dauphin Regional Comprehensive Secondary School Dauphin, MB Canada

SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

www.pbs.org/saf/1405

The Dark Side of the Universe

Activity 2: Grades 5-8

Doppler Shift

Questions

1. What did the marks on the elastic band represent?
   (Wavelength.)
2. What scenario was represented when the star remained at the center of the elastic band?
   (A stationary light emitter. The wave pattern remained the same, with waves at the front and back equidistant.)
3. What scenario was modeled when the star was pushed to one direction? What happens to the wavelength?
   (Motion in the direction of the push. The wave patterns in front of the push become compressed. The wave patterns behind the push become stretched out.)