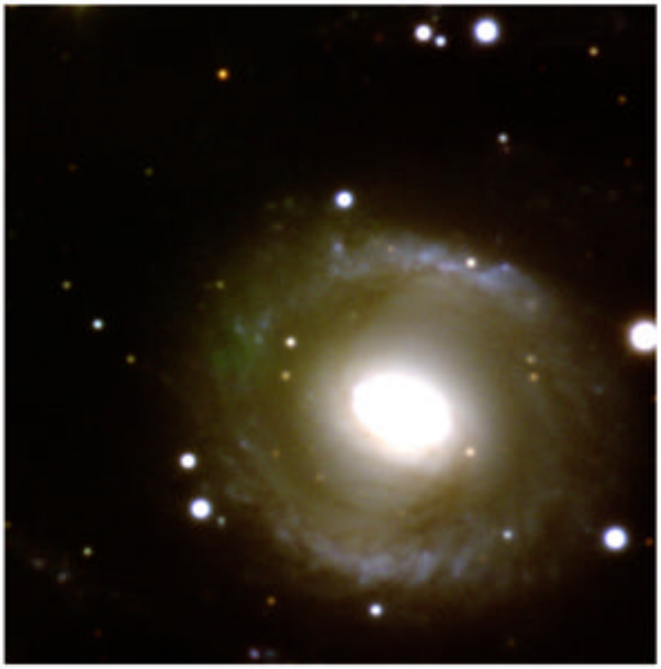
Expansion of the Universe—The Doppler Effect

Previsit Activity for Deep Space



Spiral Galaxy ESO 269-57 (VLT Kueyen + TC)

ESO PR Photo 19b/99 (7 April 1999)

courtesy ESO

Grades 9-12

CDE Standards

Science: 4.4

Math: 1,2,6

Preparation and Materials
Estimated Preparation Time: 10 minutes
Estimated Activity Time: Two class periods of 45 minutes each

Materials
Computer with Internet access

Learning Goals/Objectives
Students will

- Use the Doppler equation to determine the Doppler effect in a given problem
- Use knowledge of frequency and wavelength to answer questions about the Doppler effect

Connection to *Space Odyssey*
During your visit to *Space Odyssey,* ask a Galaxy Guide to bring out the Doppler effect demonstration to share with your students. This interactive clearly illustrates the Doppler effect using sound waves.

Advanced Preparation

Classroom Activity

1. Begin your discussion with the Doppler effect. Ask students if they've ever stood as a train approached and passed by them. What happened? Students should be able to verbalize that there was some shift in the sound—lower pitched when the train was moving away and higher pitched when the train was moving toward them.
2. Relate this example to the Doppler effect. Discuss how light and sound gets shifted when moving toward or away from us.
3. Have students draw a diagram to help them visualize the train scenario. First, have them draw a train that is stationary with sound "ripples" like the ripples in a pond when a raindrop hits it, propagating outwards. Each pulse of the sound wave is a like a new raindrop so you have concentric circles. Then, have them draw a train and two people standing at either end of the train, and one standing on the train as it moves. Ask the students to draw sound waves in front of the train with very short wavelengths (higher pitched) and behind the train with very long wavelengths (lower pitched). Then ask students what the person on the train hears.

4. Ask students to think of other examples when they've experienced the Doppler effect. In addition to the train, they may mention airport guide lights, racecars, sirens, Doppler radar, airplanes overhead, etc.
5. Draw an analogy of the Doppler shift in sound waves to the Doppler shift in light waves.
6. Tell students that studying the Doppler effect allows astronomers to determine whether a star is moving toward us or away from us, and how fast that movement is. The Doppler effect has ultimately provided the proof that the universe is expanding.
7. When astronomers look at spectra of stars, they know the rest wavelengths of the elements they see in them. Using the rest wavelengths, they can determine if spectral lines are shifted more toward the red (longer wavelengths) or toward the blue (short wavelengths).
8. Introduce the terms "redshift" and "blueshift." When dealing with visible light, shorter wavelengths are bluer so that when an object is coming toward us (short wavelengths) we call it blueshifted. Similarly, longer wavelengths are redder so that when an object is moving away from us (long wavelengths) we call it redshifted.
9. Astronomers also use the Doppler effect to detect planets around distant stars. See http://www.howstuffworks.com/planet-hunting2.htm for further information.
10. Break students into small teams. Allow students to work together to create a project to demonstrate how the Doppler effect works.
11. Give students time to build or design their projects and share them with classmates.

Variations/Extensions

1. Allow students to complete additional research on the Doppler effect. There are several activities and lessons for calculating the Doppler effect on the web, including at http://nasaexplores.com/show_912_teacher_st.php?id=030609115632
2. Have students make use of the JAVA applet below that illustrates the Doppler shift. These are powerful explanatory tools, and if you have the technology available, allowing the students to complete this exercise before they draw pictures is a great idea. Otherwise, see if you can at least demonstrate it to the class on a classroom computer. It is very easy to use.

Resources

Books

Bennett, Jeffrey, Megan Donahue, Nicholas Schneider, and Mark Voit. *The Cosmic Perspective*. San Francisco: Addison Wesley, 2002.

Web sites

http://www.howstuffworks.com/planet-hunting2.htm

http://astrosun.tn.cornell.edu/courses/astro201/doppler.htm

http://zebu.uoregon.edu/~soper/Light/doppler.html

http://www.astrocappella.com/doppler.shtml

http://lectureonline.cl.msu.edu/~mmp/applist/doppler/d.htm