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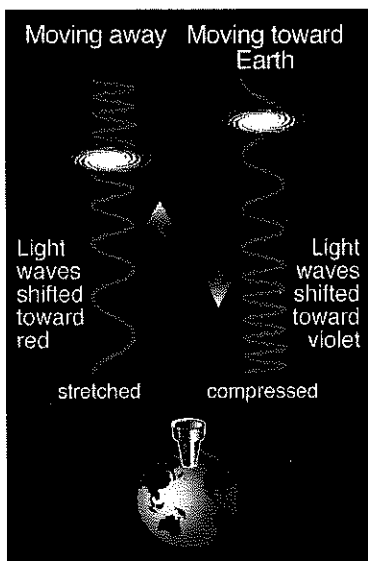


Doppler Shift



You learned about Doppler shift as it relates to sound in Unit 7. The Doppler shift is also an important tool used by astronomers to study the motion of objects, such as stars and galaxies, in space. For example, if an object is moving toward Earth, the light waves it emits are compressed, shifting them toward the blue end (shorter wavelengths, higher frequencies) of the visible spectrum. If an object is moving away from Earth, the light waves it emits are stretched, shifting them toward the red end (longer wavelengths, lower frequencies) of the visible spectrum. In this skill sheet, you will practice solving problems that involve light and doppler shift.

Understanding Doppler shift



Astronomers use a spectrometer to determine which elements are found in stars and other objects in space. When burned, each element on the periodic table produces a characteristic set of spectral lines. When an object in space is moving very fast, its spectral lines show the characteristic patterns for the elements it contains. However, these lines are *shifted*.

If the object is moving away from Earth, its spectral lines are shifted toward the red end of the spectrum to a longer wavelength. If the object is moving toward Earth, its spectral lines are shifted toward the blue end of the spectrum to a shorter wavelength.

EXAMPLE ▶

By analyzing the shift in wavelength, you can also determine the speed at which a star is moving. The faster a star is moving, the larger the shift in wavelength. The following proportion is used to help you calculate the speed of a moving star. The speed of light is a constant value equal to 3×10^8 m/sec. The first problem is done for you.

$$\frac{\text{The speed of a star}}{\text{The speed of light}} = \frac{\text{The difference in wavelength}}{\text{The stationary value for wavelength}}$$

The spectral lines emitted by a distant galaxy are analyzed. One of the lines for hydrogen has shifted from 450 nm to 498 nm. Is this galaxy moving away from or toward Earth? What is the speed of galaxy?

$$\frac{\text{The speed of a star}}{3 \times 10^8 \text{ m/sec}} = \frac{498 \text{ nm} - 450 \text{ nm}}{450 \text{ nm}}$$

$$\text{The speed of a star} = \frac{48 \text{ nm}}{450 \text{ nm}} \times 3 \times 10^8 \text{ m/sec} = 0.11 \times 3 \times 10^8 \text{ m/sec} = 3.2 \times 10^7 \text{ m/sec}$$

The galaxy is moving away from Earth at a speed of 33 million meters per second.

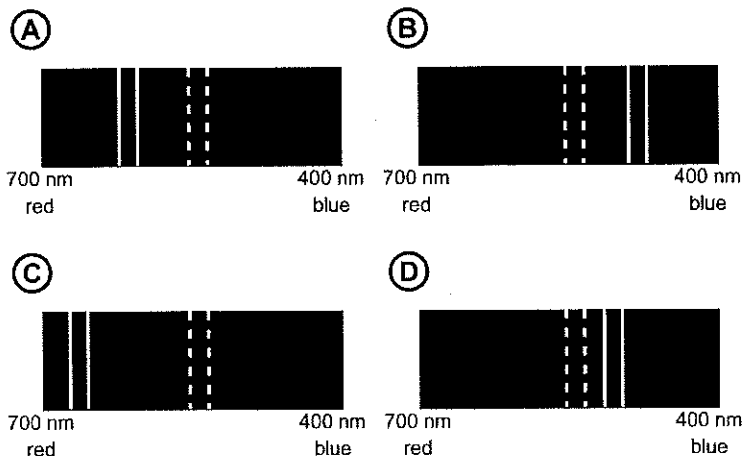
PRACTICE 

1. One of the spectral lines for a star has shifted from its stationary value of 535 nm to 545 nm.
 - a. What is the difference in wavelength?
 - b. What is the speed of this star?
 - c. Is the star moving away from or toward Earth?
2. One of the spectral lines for a star has shifted from its stationary value of 560 nm to 544 nm.
 - a. What is the difference in wavelength?
 - b. What is the speed of this star?
 - c. Is the star moving away from or toward Earth?
3. An astronomer has determined that two galaxies are moving away from Earth. A spectral line for galaxy A is red shifted from 501 nm to 510 nm. The same line for galaxy B is red shifted from 525 nm to 540 nm. Which galaxy is moving the fastest? Justify your answer.
4. Does the fact that both galaxies in the question above are moving away from Earth support or refute the Big Bang theory? Explain your answer.

5. The graphic to the right shows two spectral lines from an object that is not moving. Use an arrow to indicate the direction that the spectrum would appear to shift if the object was moving toward you.



6. The graphic to the right shows the spectral lines emitted by four moving objects. The spectral lines for when the object is stationary are shown as dotted lines on each spectrum. The faster a star is moving, the greater the shift in wavelength. Use the graphic to help you answer the following questions.



- a. Which of the spectra show an object that is moving toward you?
 - b. Which of the spectra show an object that is moving away from you?
 - c. Which of the spectra show an object that is moving the fastest away from you?
 - d. Which of the spectra show an object that is moving the fastest toward you?
7. A star is moving away from Earth at 7×10^6 m/sec.
 - a. The stationary wavelength of a spectral line is 450 nm. What is the difference in wavelength between the stationary and shifted line?
 - b. Is the spectral line be shifted to a shorter or longer wavelength?
 - c. What is the wavelength of the shifted line?