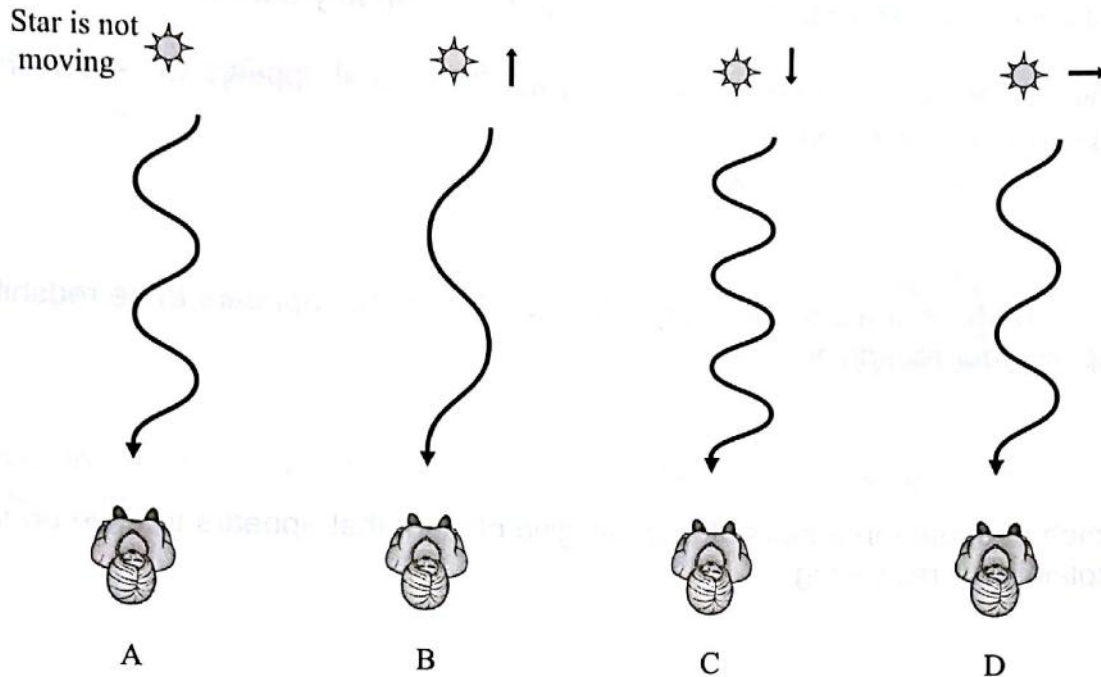


Because of the Doppler Effect, light emitted by an object can appear to change wavelength due to its motion toward or away from an observer. When the observer and the source of light are moving toward each other, the light is shifted to shorter wavelengths (blueshifted). When the observer and the source of light are moving away from each other, the light is shifted to longer wavelengths (redshifted).

Part I: Motion of Source



- 1) Consider the situations shown (A–D).
 - a) In which situation will the observer receive light that is shifted to shorter wavelengths?
 - b) Will this light be blueshifted or redshifted for this case?
 - c) What direction is the star moving relative to the observer for this case?
- 2) Consider the situations shown (A–D).
 - a) In which situation will the observer receive light that is shifted to longer wavelengths?
 - b) Will this light be blueshifted or redshifted for this case?
 - c) What direction is the star moving relative to the observer for this case?

- 3) In which of the situations shown (A–D) will the observer receive light that is not Doppler Shifted at all? Explain your reasoning.
- 4) Imagine our solar system is moving in the Milky Way toward a group of three stars. Star A is a blue star that is slightly closer to us than the other two. Star B is a red star that is farthest away from us. Star C is a yellow star that is halfway between Stars A and B.
- a) Which of these three stars, if any, will give off light that appears to be blueshifted? Explain your reasoning.
 - b) Which of these three stars, if any, will give off light that appears to be redshifted? Explain your reasoning.
 - c) Which of these three stars, if any, will give off light that appears to have no shift? Explain your reasoning.
- 5) You overhear two students discussing the topic of Doppler Shift.

Student 1: *Since Betelgeuse is a red star, it must be going away from us, and since Rigel is a blue star it must be coming toward us.*

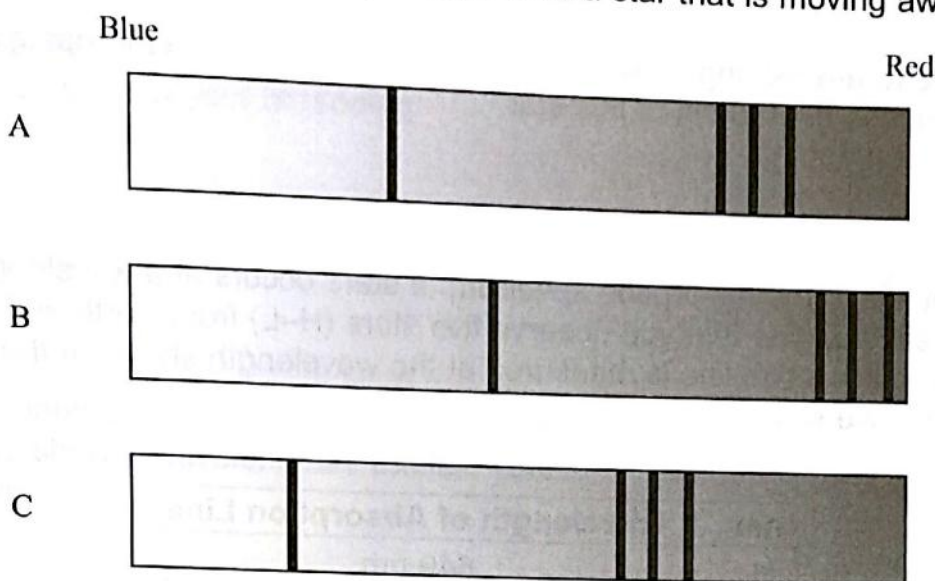
Student 2: *I disagree, the color of the star does not tell you if it is moving. You have to look at the shift in wavelength of the lines in the star's absorption spectrum to determine whether it's moving toward or away from you.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

Part II: Shift in Absorption Spectra

When we study an astronomical object like a star or galaxy, we examine the spectrum of light it gives off. Since the lines of a spectrum occur at specific wavelengths we can determine that an object is moving when we see that the lines have been shifted to either longer or shorter wavelengths. For the absorption line spectra shown on the next page, short-wavelength light (the blue end of the spectrum) is shown on the left-hand side and long-wavelength light (the red end of the spectrum) is shown on the right-hand side.

For the three absorption line spectra shown below (A, B, and C), one of the spectra corresponds to a star that is not moving relative to you, one of the spectra is from a star that is moving toward you, and one of the spectra is from a star that is moving away from you.

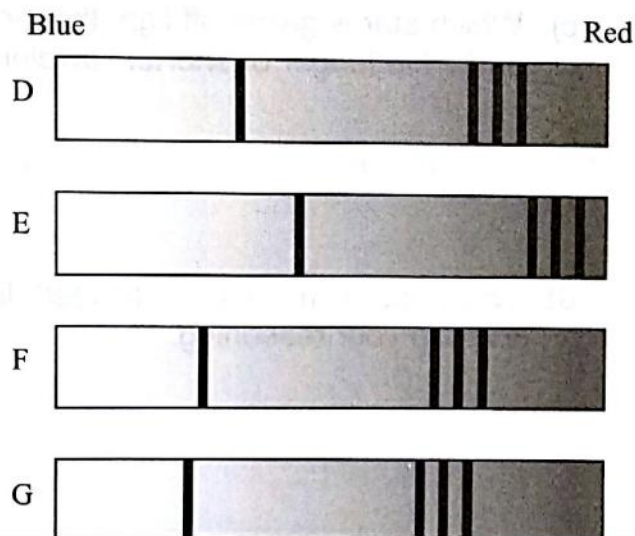


- 6) Which of the three spectra above corresponds with the star moving toward you? Explain your reasoning.
- 7) Which of the three spectra corresponds with the star moving away from you? Explain your reasoning.

Part III: Size of Shift and Speed

If two sources of light are moving relative to an observer, the light from the star that is moving faster will appear to undergo a greater Doppler Shift.

Consider the four spectra at the right. The spectrum labeled F is an absorption line spectrum from a star that is at rest. Again, note that short-wavelength (blue) light is shown on the left-hand side of each spectrum and long-wavelength (red) light is shown on the right-hand side of each spectrum.



Doppler Shift

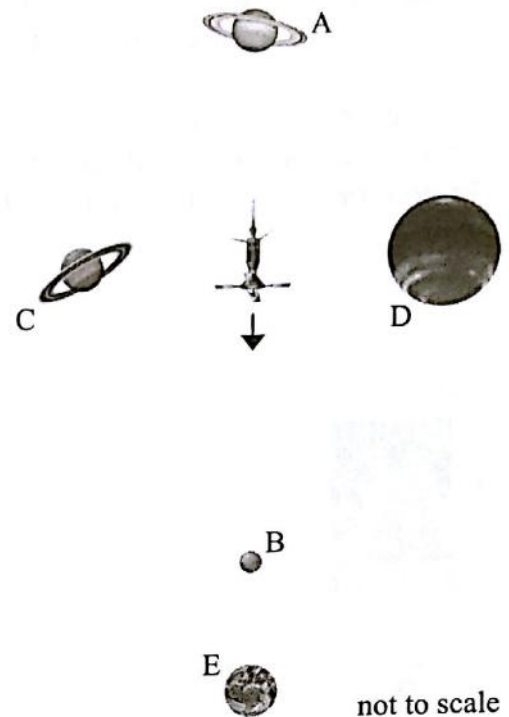
- 8) Which of the four spectra would be from the star that is moving the fastest? Would this star be moving toward or away from the observer?
- 9) Of the stars that are moving, which spectra would be from the star that is moving the slowest? Describe the motion of this star.
- 10) An important line in the absorption spectrum of stars occurs at a wavelength of 656 nm for stars at rest. Imagine that you observe five stars (H–L) from Earth and discover that this important absorption line is measured at the wavelength shown in the table below for each of the five stars.

Star	Wavelength of Absorption Line
H	649 nm
I	660 nm
J	656 nm
K	658 nm
L	647 nm

- a) Which of the stars are giving off light that appears blueshifted? Explain your reasoning.
- b) Which of the stars are giving off light that appears redshifted? Explain your reasoning.
- c) Which star is giving off light that appears shifted by the greatest amount? Is this light shifted to longer or shorter wavelengths? Explain your reasoning.
- d) Which star is moving the fastest? Is it moving toward or away from the observer? Explain your reasoning.

- 11) The figure at right shows a spaceprobe and five planets. The motion of the spaceprobe is indicated by the arrow. The spaceprobe is continuously broadcasting a radio signal in all directions.

- a) Which planets will receive a radio signal that is redshifted? Explain your reasoning.



- b) Which planets will receive a radio signal that is shifted to shorter wavelengths? Explain your reasoning.

- c) Will all the planets receive radio signals from the spaceprobe that are Doppler shifted? Explain your reasoning.

- d) How will the size of the Doppler Shift in the radio signals detected at Planets A and B compare? Explain your reasoning.

- e) How will the size of the Doppler Shift in the radio signals detected at Planets E and B compare? Explain your reasoning.

