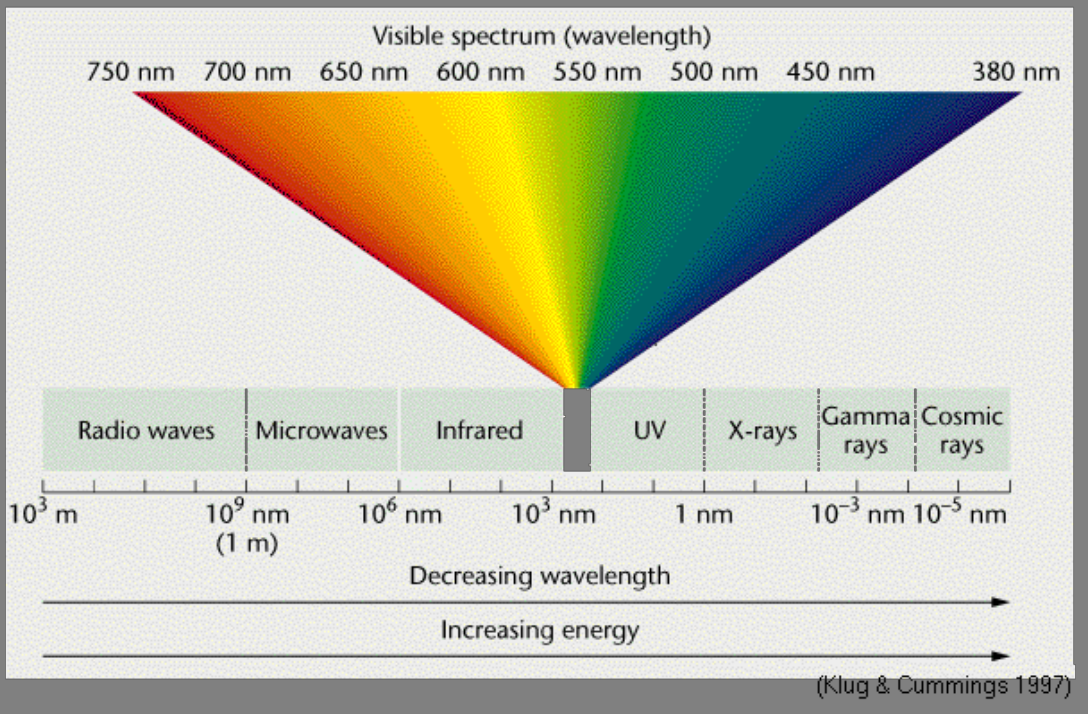
This image from NASA's Spitzer Space Telescope shows what lies near the sword of the constellation Orion -- an active stellar nursery containing thousands of young stars and developing protostars. Many will turn out like our sun. Some are even more massive. These massive stars light up the Orion nebula, which is seen here as the bright region near the center of the image. To the north of the Orion nebula is a dark filamentary cloud of cold dust and gas, over 5 light-years in length.

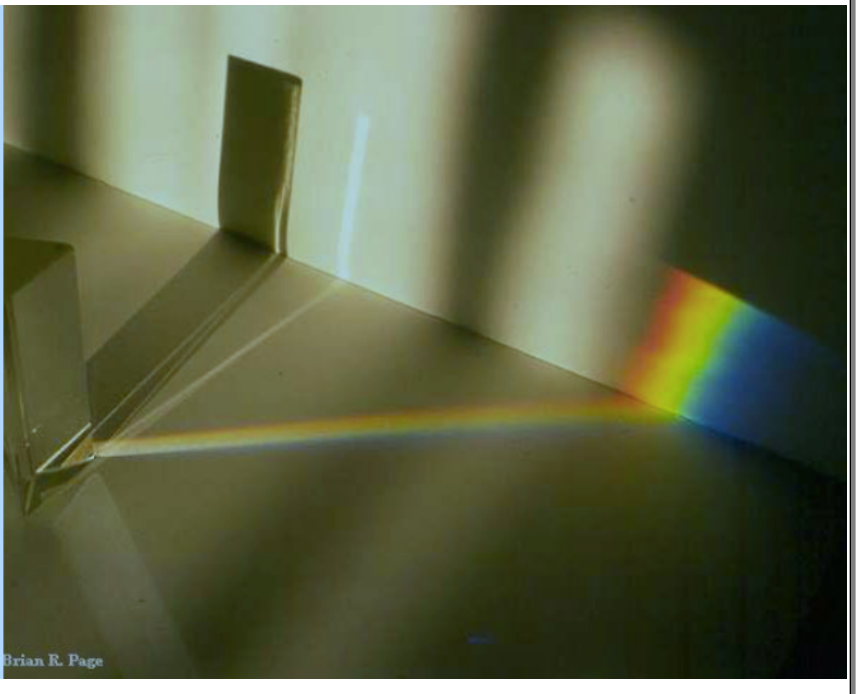
The 10 most common elements in the Sun:

Element	Abundance (% of total number of atoms)	Abundance (% of total mass)
Hydrogen	91.2	71.0
Helium	8.7	27.1
Oxygen	0.078	0.97
Carbon	0.043	0.40
Nitrogen	0.0088	0.096
Silicon	0.0045	0.099
Magnesium	0.0038	0.076
Neon	0.0035	0.058
Iron	0.030	0.014
Sulfur	0.015	0.040


Visible spectrum (wavelength)
750 nm
700 nm
650 nm
600 nm
550 nm
500 nm
450 nm
380 nm
Radio waves
Microwaves
Infrared
UV
X-rays
Gamma rays
Cosmic rays
10^3 m
10^9 nm (1 m)
10^6 nm
10^3 nm
1 nm
10^{-3} nm
10^{-5} nm
Decreasing wavelength
Increasing energy
(Klug & Cummings 1997)

Spectral lines

- Isaac Newton:
  - Passed a beam of sunlight through a prism and showed that sun light was white light and made up of all the colors



Diffraction Gratings

- As light waves move through the slits they bend (diffraction)
- Bent waves interact
- Interactions can amplify (reinforce) or cancel each other out
- Modern spectroscopes use diffraction gradients

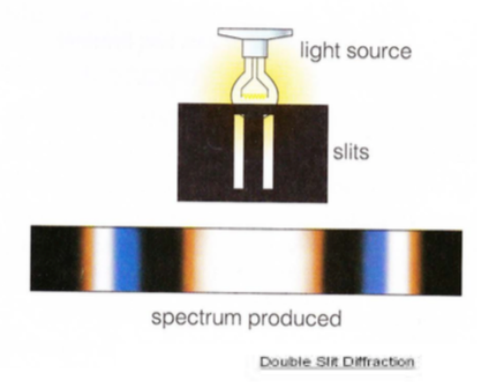
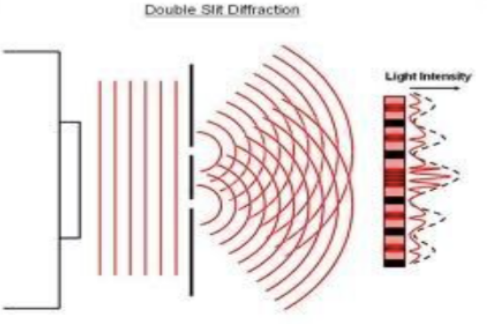
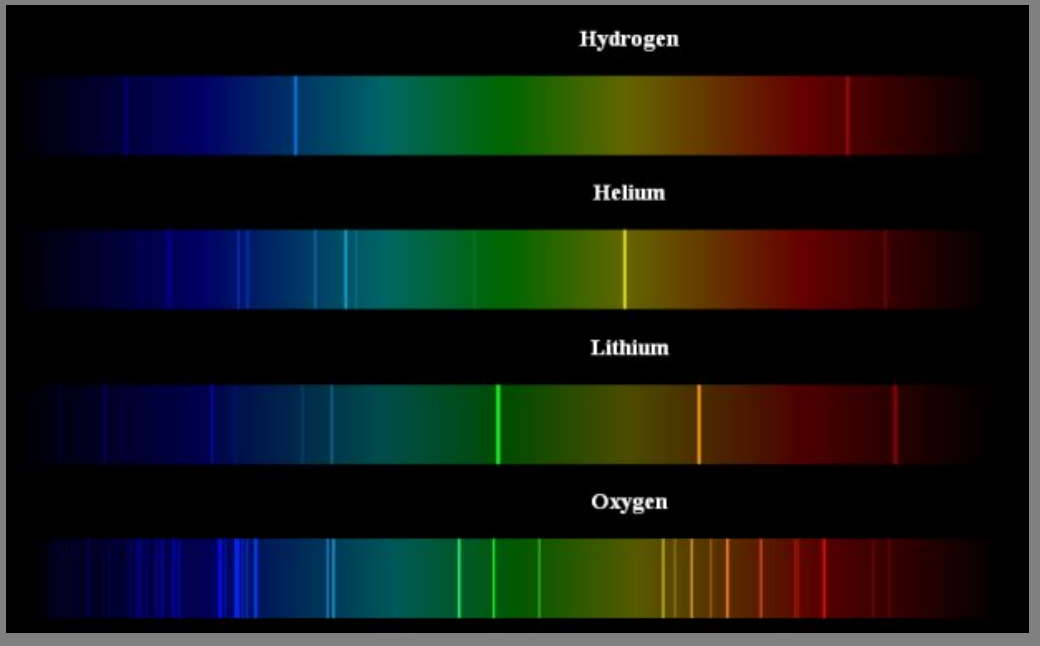


Figure 5.23 When white light passes through narrowly spaced slits, it is split into a spectrum. Notice that a spectrum has been produced on both sides of the white light (in the middle).

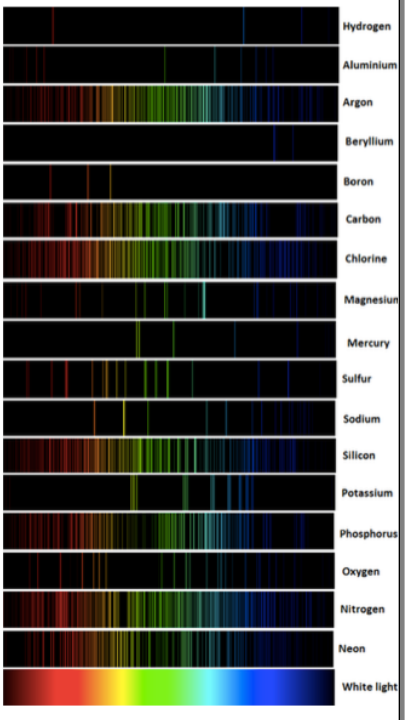


The Spectra of Different Elements



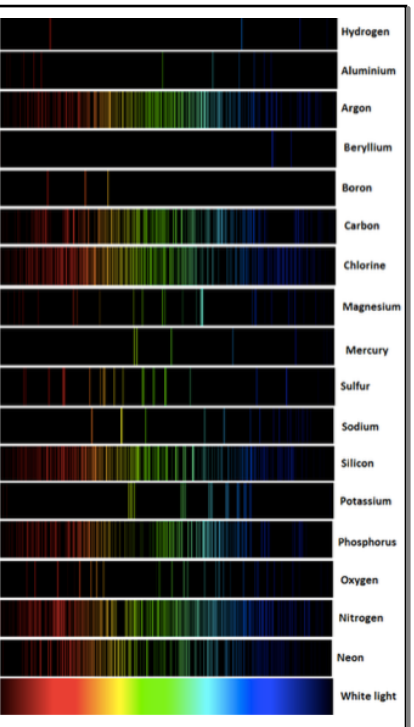
Gustav Kirchoff and Robert Bunsen Spectroscopy

- Vaporized elements give off different colors when heated to incandescence
  - Sodium gives off a yellow color while mercury gives off a bluish color
- Kirchoff and Bunsen heated various chemicals to incandescence and passed the light emitted through a spectroscope
- Discovered not all the colors present and there were black gaps between the colors



Gustav Kirchoff and Robert Bunsen Spectroscopy

- Each spectrum is unique and can be used to identify the element
- The study of spectra is called spectroscopy



- Heated gas of an element emits specific colors of light

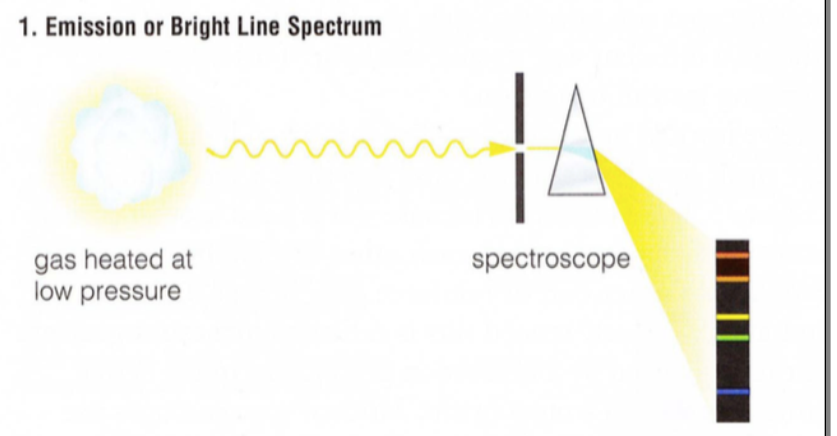


Figure 5.20 If you heat a gas at low pressure (a mercury vapour lamp, for example), it produces a spectrum that is only a set of bright lines of certain colours on a black background. This is called an *emission*, or *bright line spectrum*.

2. Continuous Spectrum

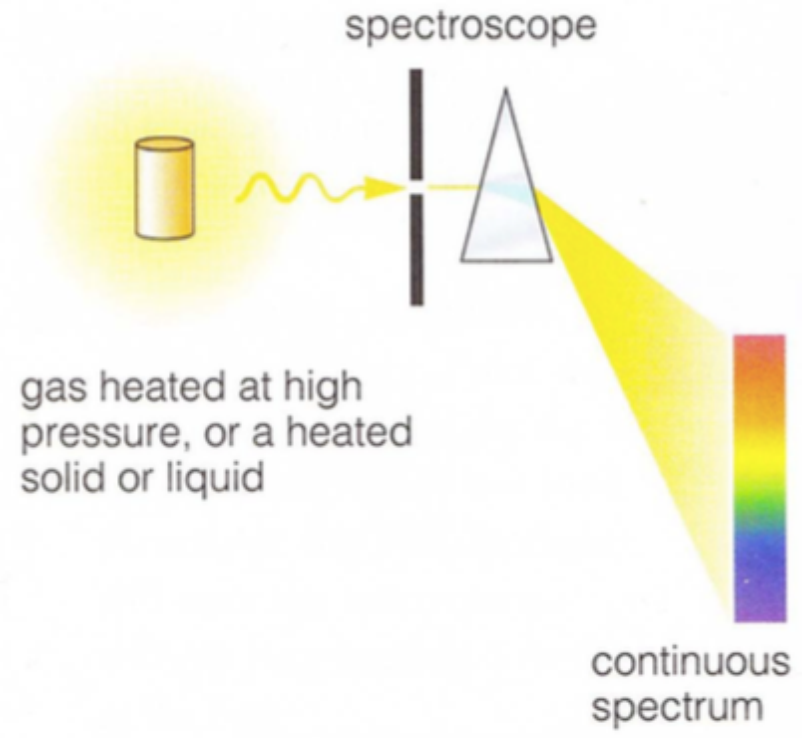


Figure 5.21 If you heat a solid, liquid, or a gas at high pressure, the resulting spectra contain all the colours blending into one another. These are called *continuous spectra*. A rainbow that you see in the sky is an example of a continuous spectrum.

Absorption spectra

- Cooler gas of an element will absorb specific wavelength of light

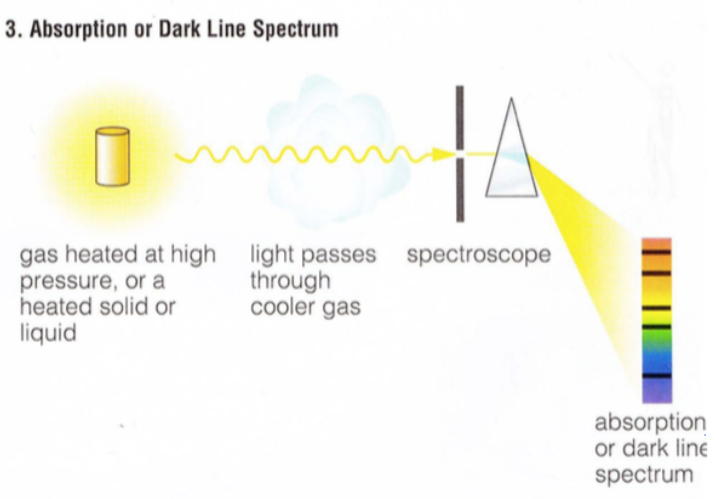
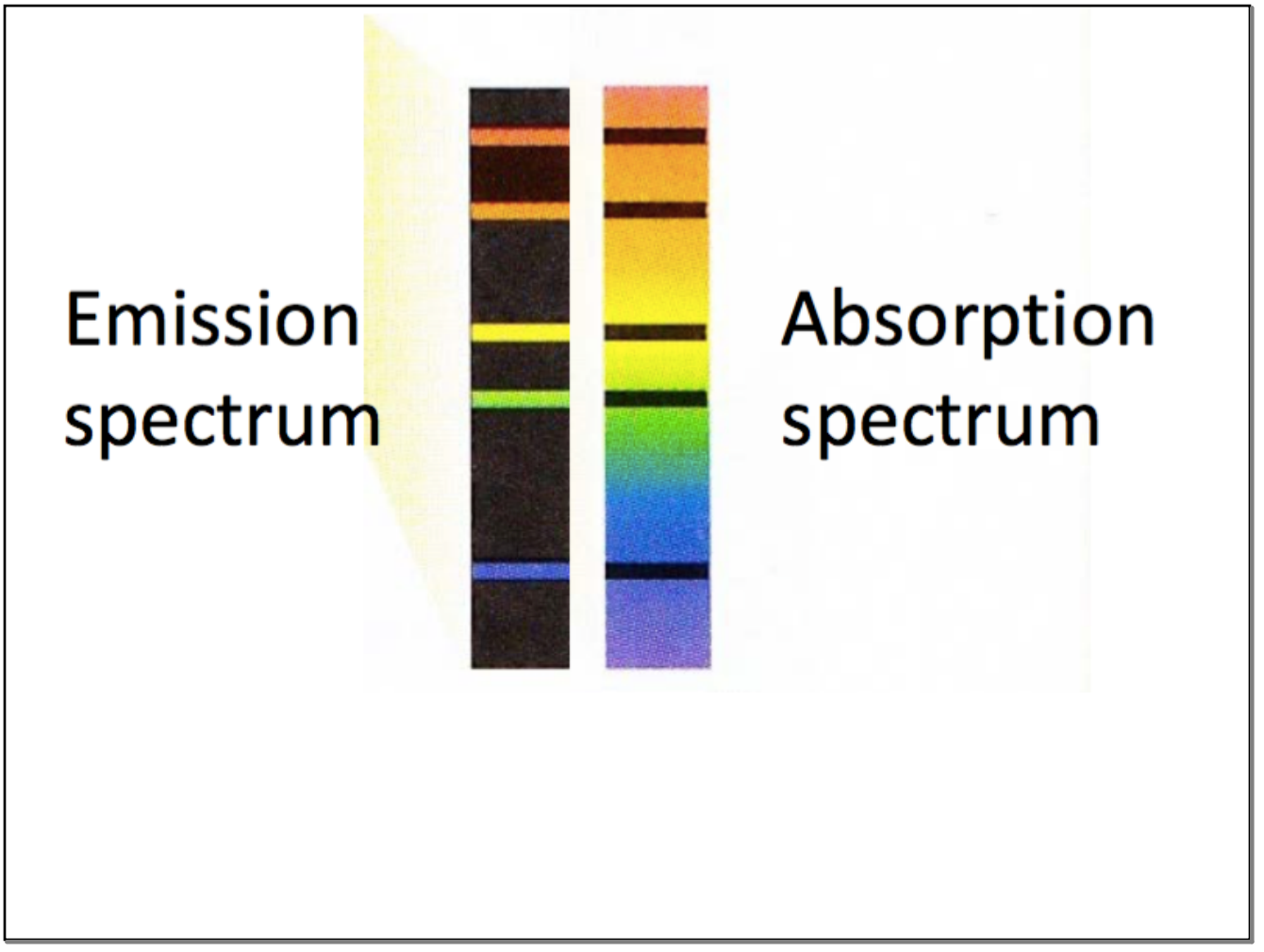
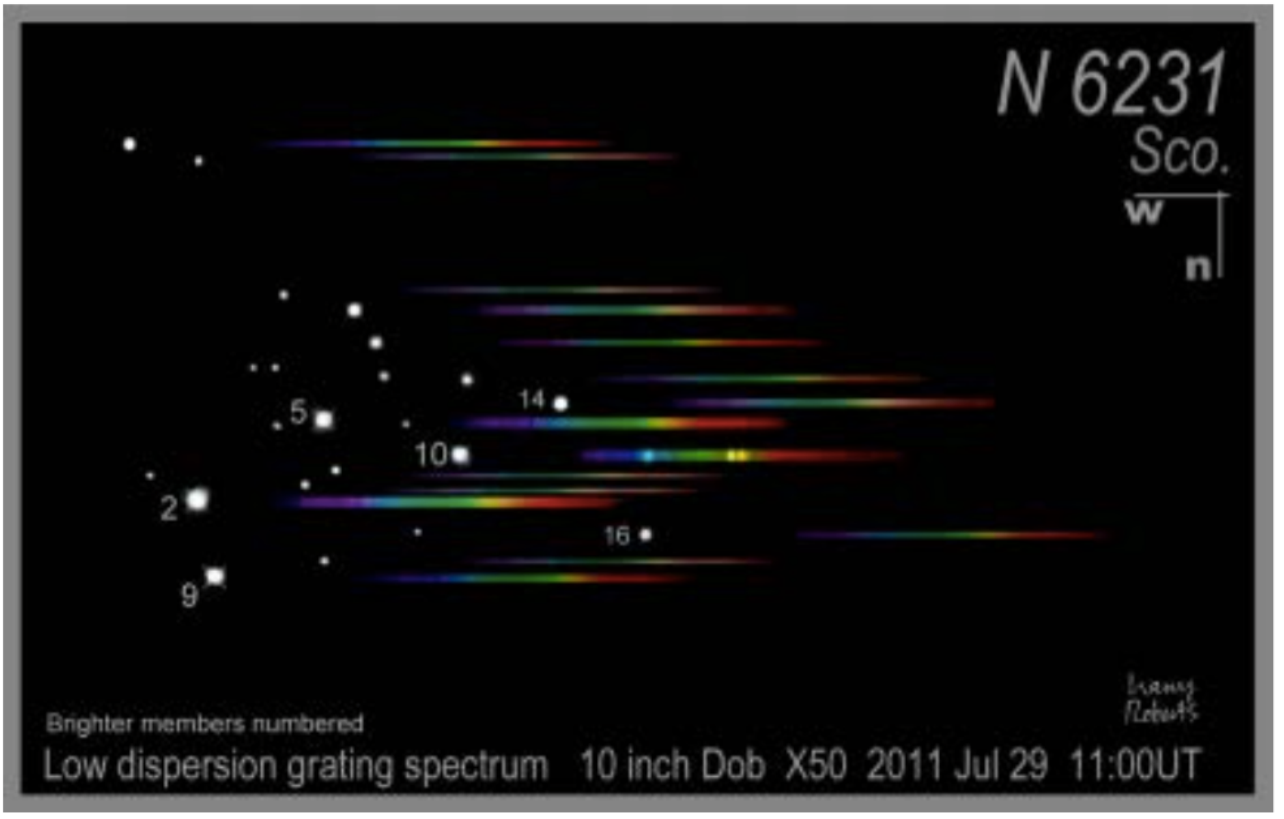


Figure 5.22 When continuous spectrum light, such as white light, passes through a cooler substance, the spectrum observed is a continuous spectrum with dark gaps between colours. This is called an *absorption* or *dark line spectrum*. It is the same type of phenomenon that Fraunhofer saw when he looked at the solar spectrum. It is called an absorption spectrum because the gas that the light passes through absorbs, or removes, some of the colours of light in the spectrum.


Emission spectrum
Absorption spectrum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Doppler Effect

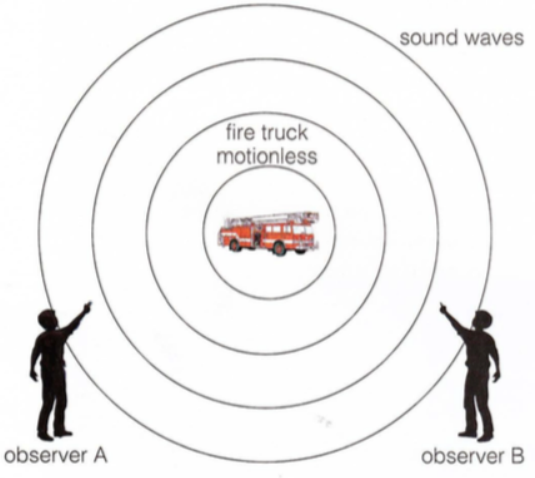

Figure 5.25A When the fire truck is not moving, the siren's sound has the same pitch in all directions because the sound waves are uniform.

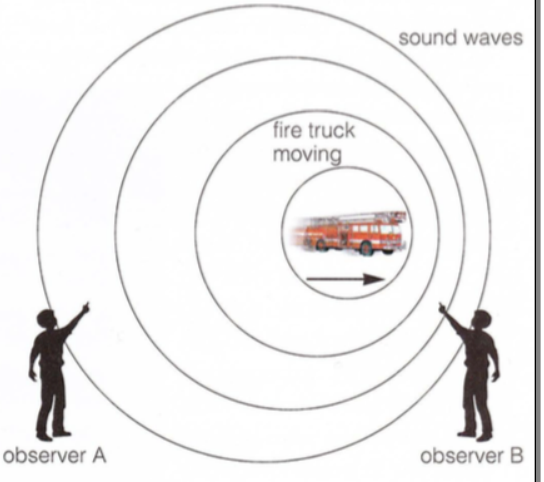

Figure 5.25B When the fire truck is moving quickly, the sound of the siren seems to change in pitch, becoming higher as the truck moves toward the observer and lower as it moves away from the observer.

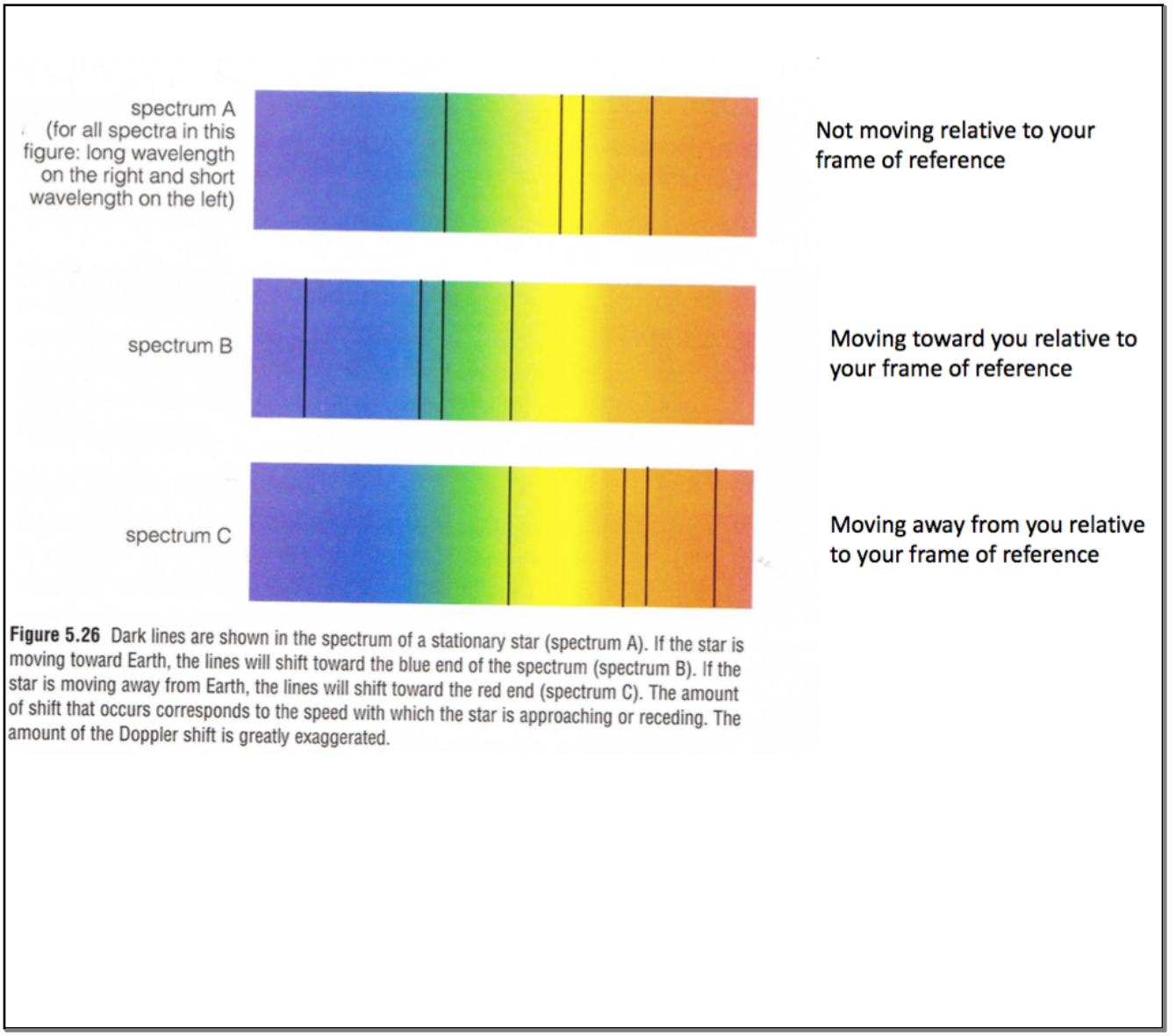

Figure 5.26 Dark lines are shown in the spectrum of a stationary star (spectrum A). If the star is moving toward Earth, the lines will shift toward the blue end of the spectrum (spectrum B). If the star is moving away from Earth, the lines will shift toward the red end (spectrum C). The amount of shift that occurs corresponds to the speed with which the star is approaching or receding. The amount of the Doppler shift is greatly exaggerated.