3.6.1.1: Doppler Shift

The movement of a source of waves does *not* change the speed of the waves. Neither does the movement of a receiver of waves. However, if the source or receiver is moving, the waves will appear to have a different *frequency*. For example if you are moving towards a sound source you catch up with the next peak in the wave sooner than you would expect because you are moving towards it. This effect is called the ***Doppler Shift*** and occurs for both light and sound. For sound, if the object moves towards you the frequency seems higher. If the object is moving away the frequency seems lower.

> **Note**
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> It isn't the loudness we are talking about here, which also increases as the source gets closer and decreases as the source moves away; the Doppler shift is about frequency, not volume.

The Doppler shift for light changes the frequency or color of the light. Objects moving at high speed towards you will have their color shifted a little towards the blue end of the spectrum while objects moving away have colors shifted towards the red end of the spectrum. This cannot be seen with the eye but can be measured and is used in astronomy to determine the speed and direction of stars and galaxies. The Doppler shift tells us that most galaxies are moving away from ours which tells us the universe is expanding.

Police radar and weather radar both use the Doppler Effect to measure the speed of something. For a stationary object (a car, a raincloud) the reflected radar beam returns with the same frequency it originally had. Measuring how long it takes for the beam to get back gives us the distance to the object but not its speed. If the object (car, raincloud) is moving the Doppler Effect will cause a shift in the returning frequency. A computer compares the outgoing and reflected beam to determine not only how far away the object is (from the time it takes to return), but also how fast it is moving (from the Doppler shift in frequency). For weather radar the amount of reflected radar also tells us something about the water content in the cloud. Hail and snow have different reflection patterns than rain so radar can also tell us what is in the cloud in addition to distance and speed.

Video/audio examples:

- Doppler shift of a fire engine. Notice that the loudness is NOT what is important; the change in *pitch* is the Doppler effect.
- For a source traveling faster than the speed of sound the waves pile up into a shock wave which produces a sonic boom.
- Once piece of evidence (there are others) that the universe is expanding is the Doppler shift of light from stars.
- Sound waves with frequencies above 20,000 Hz are called *ultrasound* sound waves. You may be familiar with pictures of unborn children made using ultrasound. The Doppler shift can also be used with ultrasound to see the movement of blood in the heart. This is known as echo cardiology.
- Directions for building your own radar detector and a lecture on how it works.