

Answer on Question #61889-Physics-Other

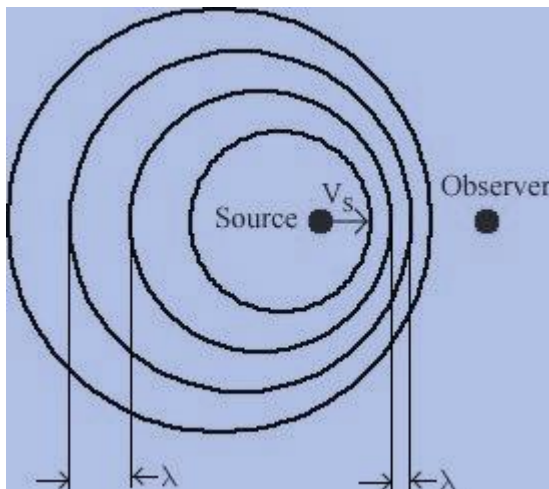
Explain Doppler effect and obtain expression for apparent frequency when the source as well as the listener are in motion.

Solution

The Doppler effect is an apparent change in frequency of a source of sound (or other waves) when there is relative motion of the source and the listener. A Doppler effect is observed in all types of waves, however the Doppler effect with regards to light is fundamentally different than for sound or other types of waves that require a medium to propagate.

Let's look at the Doppler effect for the case of sound waves:

1. First let's look at the case of a moving source and stationary observer.



The wavelength due to a stationary source is

$$\lambda = \frac{v}{f_s}$$

Where v is the velocity of sound in the medium and f_s is the frequency of the sound. If the source is moving to the right at a speed of v_s , then the distance between the peaks (the wavelength) is shortened and can be described by:

$$\lambda' = \frac{v}{f_s} - \frac{v_s}{f_s} = \frac{v - v_s}{f_s}$$

Now the frequency measured by the observer is

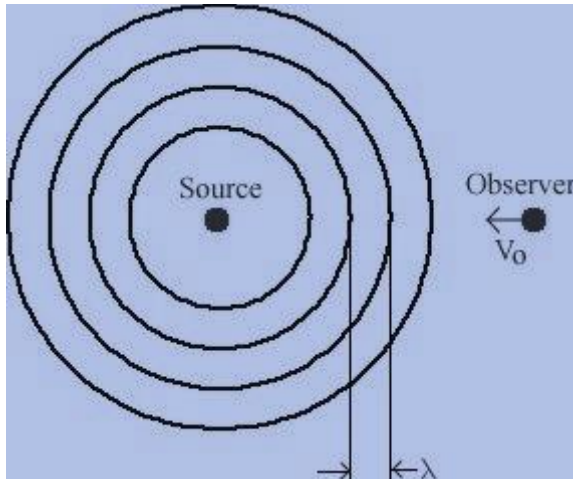
$$f_o = \frac{v}{\lambda'} = \left[\frac{v}{v - v_s} \right] f_s$$

So,

$$f_o = \frac{v}{\lambda'} = \left[\frac{1}{1 \pm \frac{v_s}{v}} \right] f_s$$

The plus/minus has been added to compensate for the direction of the source. The sign should be negative if the source is approaching the observer and positive if the source is moving away from the observer.

2. Now for a stationary source and a moving observer:



In the case of the moving observer the wavelength of the sound does not change, but the frequency as measured by the observer does change. This happens because the observer encounters a wavefront more frequently. The frequency as measured by the observer is

$$f_o = \frac{(v + v_o)}{\lambda}$$

Where v_o is the velocity of the observer.

The wavelength is speed of sound divided by the frequency, we can then rewrite the equation as:

$$f_o = \left[\frac{v + v_o}{v} \right] f_s$$

$$f_o = \left[1 \pm \frac{v_o}{v} \right] f_s$$

The plus or minus is added to compensate for the direction of the observer. The sign should be negative if the observer is approaching the source and positive if the observer is moving away from the source.