Student 5: Low Achieved

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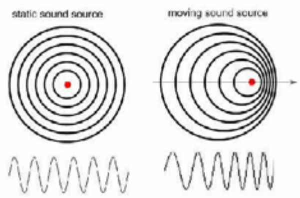
The definition of the Doppler effect is an increase (or decrease) in the frequency of sound, light or other waves as the source and observer move towards (or away from) each other. To relate the Doppler Effect to a real life scenario would be speed cameras/detectors. Speed cameras use the Doppler Effect by using the reflection of microwaves from a moving vehicle to measure the speed that it is going. Police use hand held radars to do the same thing, using the reflection of waves to find the speed of cars. These waves are shifted in frequency by the Doppler Effect, and the beat frequency between the directed and reflected waves provides a measure of the vehicle speed.

[1]To explain the Doppler Effect in the sense of radars, observers from the wave source (Police officer holding radar) will observe the waves from the source at the same frequency as the wave length does not change due to the source being at rest. If the source is moving towards the stationary observer, the frequency will change due to the motion of the source. The waves moving in the same direction as the source will have a shorter wave length and higher frequency due to the motion of the source, but the wave length behind the moving source will be longer but with a lower frequency due to the active source. An example of this is sirens or speed radars. As the stationary observer listens to the source from in front, the frequency will be high but as the source passes the observer the frequency will be lower.



(1)

The frequency changes due to the motion of the source is used with the equation **F=V/ λ**. This equation shows us that the frequency of the wave is dependant of the velocity of the source and we can also see the wavelength of the wave. An example of this is if the source of the waves were moving at a constant speed, then the only thing that can change the frequency is the wavelength. If the source is at a stationary velocity then it doesn't matter if the wavelength is big or small, the frequency can remain the same. Using this theory, we can see how the change in frequency is due to the motion of the source which will create the wavelength making it the Doppler Effect.

When using the Doppler Effect to measure the speed of a car, the reflected waves have different frequency than the incident waves since the vehicle is moving. The size of this frequency shift allows the speed to be recorded. The speed cameras/radars aren't only used to help police officers finding speed of cars, but also for professional spectator sport, for things such as the measurement of bowling speeds in cricket, speed of pitched baseballs, athletes and tennis serves. This speed is given by the following equation:

$$f' = f\left(\frac{v}{v \pm u_s}\right) \quad \text{moving source}$$

$$f' = f\left(\frac{v \pm u_o}{v}\right) \quad \text{moving observer}$$

$$\Delta f = \frac{v}{c} f$$

[2]

Where c is the speed of light, f is the emitted frequency of the radio waves and Δf is the difference in frequency between the radio waves that are emitted and those received back by the gun.[3]

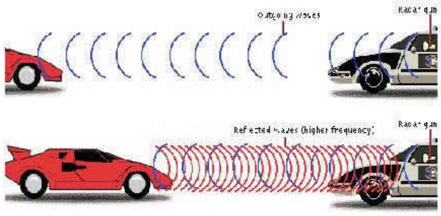
[4]With a 'stationary' radar, the returning waves are received while a signal with a frequency equal to this difference is created by

(2)

[1] http://www.plaindsp.com/unravelling-doppler-effect-plaindsp/
[2] https://en.wikipedia.org/wiki/Radar_gun#Doppler_effect
[3] https://en.wikipedia.org/wiki/Radar_gun#Doppler_effect
[4] https://prezi.com/ldelrjqnt0bu/edwin-hubble-and-the-doppler-effect/

mixing the received radio signal with a little of the transmitted signal. This is the Doppler Effect occurring as the frequencies are bounced off a moving vehicle letting the radar receive the speed. Since the radar gun is the ‘observer’ and the car is the ‘source’, the source will be letting off low frequency waves as the source comes to the radar. With the radar moving towards the observer (diagram) the radar will send lower frequency waves whilst the vehicle (source) will be emitting higher frequency waves to the radar for it to read.

With the moving radars, like in police cars, the radar will receive reflected signals from both the target vehicle and stationary background objects such as the road surface, nearby road signs, guard rails and streetlight poles. Instead of the radar gun comparing the signals with the source itself, it will compare the target with the background signals. The frequency difference between the transmitted signal and the background signal will give the true speed of the vehicle (source).



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Police radars are a good example of the Doppler Effect and how the returning frequencies and waves can determine the speed of traffic and other activities involving speed recorders. The physics behind the speed radars I thought was interesting as I researched about it as it gave me insight about what happens as the radars transmit waves and showed me about the frequencies and how they change in general terms of the Doppler Effect.