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Doppler Phenomenon for Electromagnetic Waves and New Equations for Quantum Relativity

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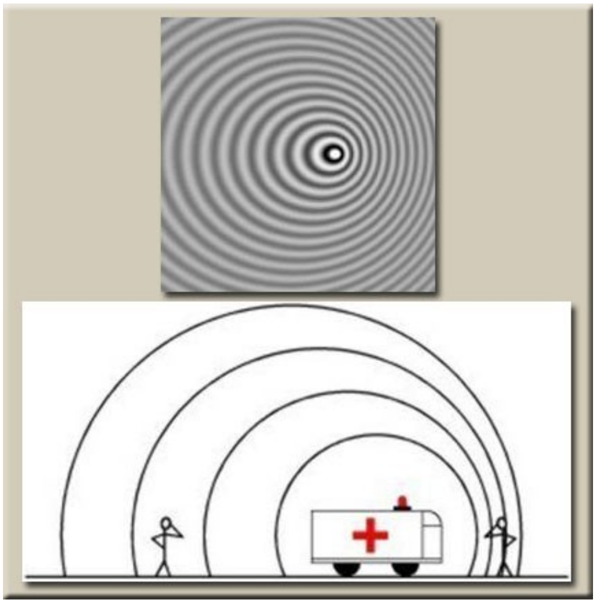
What is the Doppler effect?

Because of the Doppler phenomenon's importance in cosmology, it is necessary to have a short revision. Doppler phenomenon is considered in classic physic as changes in the frequency of a source of sound. According to this effect, whenever an observer is moving compared to a source of sound, he will receive a different frequency than emitted by that source. For example, if an ambulance with a given speed is moving toward us, its sound waves change because of its motion, and a higher frequency and shorter wavelength results. When it passes us and recedes in the distance, the sound changes because of lower frequency and longer wavelength.



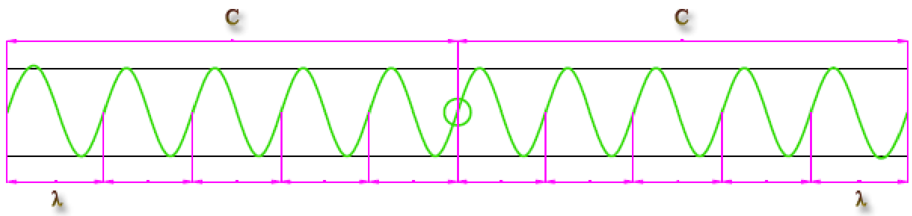
The Doppler Effect applies to light, where the spectrum will change from red to blue depending on its direction and speed. The behavior of light waves differs from that of sound and must be described by Special relativity. Based on a relativistic unification of physical rules in all inertia reference frames, the existence of any supreme reference frame in the universe is disallowed. Because of this, a source moving towards an observer or an observer moving toward a source gives the same result. In either case, there will be a displacement towards the blue spectrum. This is given by the following equation:

$$\lambda_0 = \sqrt{\frac{1-v/c}{1+v/c}}\,\lambda_e$$

Wher λ_0 is the received wave length, and λ_e is wavelength that is emitted by the light source. It is clear that in this situation, the wavelength received is shorter than it is when sent. If the source is moving away with an increase in the received light wavelength, there will be a displacement in absorption or emission as follows:

$$\lambda_0 = \sqrt{\frac{1+ v/c}{1- v/c}}\lambda_e$$

The display will differ under classic mechanic, relativity and quantum mechanics:



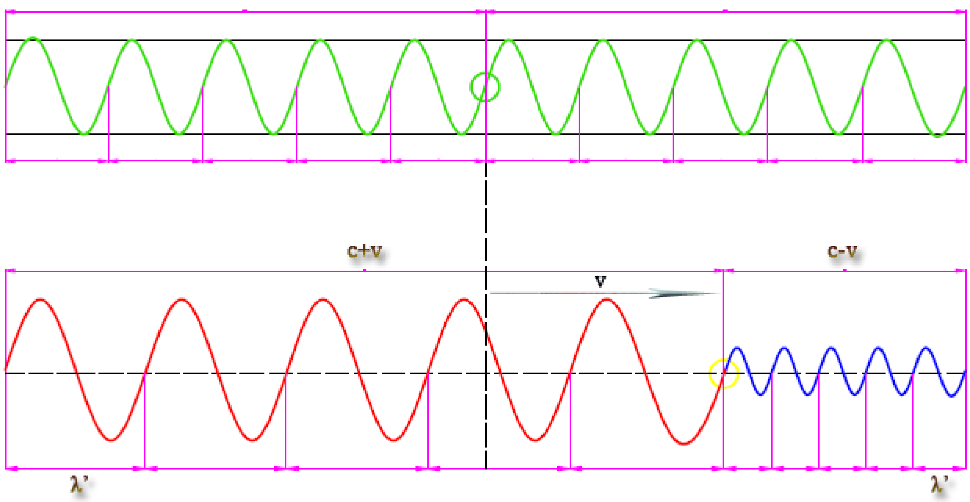
In the picture below, the source of the green spectrum (central circle) is the spotted harmonic. Its wavelength and frequency are:

$$c = \lambda f$$

$$\lambda = \frac{c}{f}$$

$$f = \frac{c}{\lambda}$$

C is light speed, **λ** is the wavelength, and **f** is the frequency of the electromagnetic wave. Now if the source of the green spectrum is displaced by the speed **v**, we have:



1)

$$\lambda' = \frac{c \pm v}{f} = \frac{c \pm v}{c/\lambda} = \frac{\lambda(c \pm v)}{c}$$

$$\lambda' = \frac{(c \pm v)}{c}\lambda$$

2)

$$\lambda' = \frac{c}{f'} = \frac{c \pm v}{f}$$

$$fc = f'(c \pm v)$$

$$f' = \frac{c}{(c \pm v)}f$$

$$f' = \frac{v}{(v \pm v_s)}f$$

λ' is the received wavelength, **v** is the speed of the source, **λ** is the wavelength at source, **f** is source frequency and **f '** is the received frequency. In the last equation, **v** is the speed of the wave – for example sound – and $\mathbf{V_s}$ is wave or sound source speed. The above equations are referred to as the classic equations for the Doppler Effect. For example, a police car is dispatching a wave with a frequency of 4000 Hz and moving along with an observer at a 72km/hour speed. At a considerable distance from another observer, what is the sound frequency? The speed of sound in air is 340m/s:

$$f = 4000Hz$$

$$v_s = 72km/h = 20m/s$$

$$v = 340m/s$$

$$f' = ?$$

$$f' = \frac{340}{340 \pm 20} \times 4000 = \frac{340}{360 \& 320} \times 4000$$

$$f' = 3777.7 \& 4250Hz$$

But as we know, by increasing the speed of the light source, time will slow and length will contract, so the observer beside the light source won't register the difference in frequency and wavelength and also will determine the previous result in light speed measurement. But in the view of the other observer not moving with the light source, the greater the increase in speed, the slower in time passes and length is shortened, giving a decrease in frequency of the spectrum. This means moving towards the yellow spectrum from the green spectrum requiring changes in the measurement units of length and time. This spectrum is understood by observations based on the Fitzgerald-Lorentz contraction. The classic equation will change to the following equation where **f''** is the frequency of the source spectrum moving with **V** speed.

$$\lambda' = \frac{c \pm v}{f''}$$

As we know the units of frequency is cycle per second and by slowing time, the frequency of the source spectrum will be decreased for observers in relative motion. This means:

$$t = \frac{t'}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$f = \frac{f''}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$f'' = f\sqrt{1 - \frac{v^2}{c^2}}$$

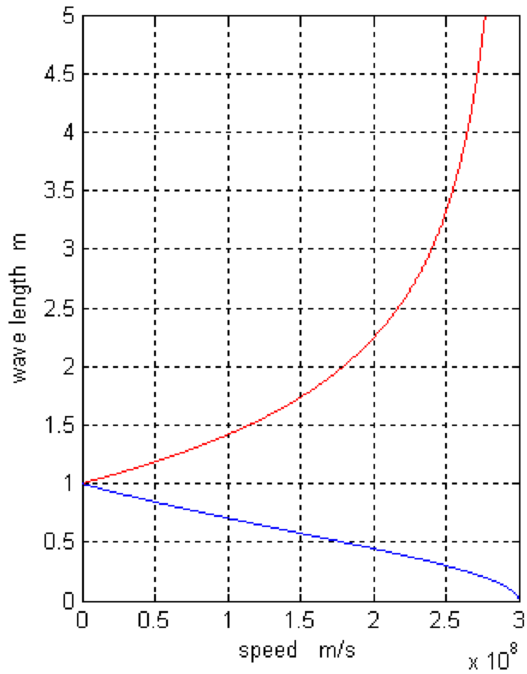
$$\lambda' = \frac{c \pm v}{f\sqrt{1 - \frac{v^2}{c^2}}}$$

$$f = \frac{c}{\lambda}$$

$$\lambda' = \frac{c \pm v}{\frac{c}{\lambda}\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\lambda(c \pm v)}{c\sqrt{1 - \frac{v^2}{c^2}}} = \frac{c \pm v}{\sqrt{c^2 - \frac{c^2v^2}{c^2}}}\lambda$$

$$\lambda' = \frac{c \pm v}{\sqrt{c^2 - v^2}}\lambda$$

t is time, **t'** is slowed time, and **f''** is frequency of on the moving source. It's ease and advantage compared to the old formula is that we just change a sign in the numerator of the equation which simplifies its meaning and application.



The above curve shows a shortening in wavelength by increasing the speed of the approaching source (blue tendency) and the upper curve shows lengthening of the wavelength by increasing speed of a source moving away from an observer (red tendency).

Now we compare the results of the new and old formulas:

	V=0	V=0.25c	V=0.5c	V=0.75c
$\sqrt{\dfrac{1-v/c}{1+v/c}}$	1	0.7745	0.5773	0.3779
$\dfrac{c-v}{\sqrt{c^2-v^2}}$	1	0.7745	0.5773	0.3779
$\sqrt{\dfrac{1+v/c}{1-v/c}}$	1	1.2909	1.7320	2.6457
$\dfrac{c+v}{\sqrt{c^2-v^2}}$	1	1.2909	1.7320	2.6457

$$\sqrt{\frac{1-\frac{v}{c}}{1+\frac{v}{c}}}=\sqrt{\frac{\frac{c-v}{c}}{\frac{c+v}{c}}}=\sqrt{\frac{c-v}{c+v}}=\sqrt{\frac{(c-v)(c-v)}{(c+v)(c-v)}}=\sqrt{\frac{(c-v)^2}{c^2-v^2}}=\frac{c-v}{\sqrt{c^2-v^2}}$$

$$\sqrt{\frac{(c-v)(c+v)}{(c+v)(c+v)}}=\sqrt{\frac{c^2-v^2}{(c+v)^2}}=\frac{\sqrt{c^2-v^2}}{c+v}$$

$$\Rightarrow\ \sqrt{\frac{1-\frac{v}{c}}{1+\frac{v}{c}}}=\sqrt{\frac{c-v}{c+v}}=\frac{c-v}{\sqrt{c^2-v^2}}=\frac{\sqrt{c^2-v^2}}{c+v}$$

$$\sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}}=\sqrt{\frac{\frac{c+v}{c}}{\frac{c-v}{c}}}=\sqrt{\frac{c+v}{c-v}}=\sqrt{\frac{(c+v)(c+v)}{(c-v)(c+v)}}=\sqrt{\frac{(c+v)^2}{c^2-v^2}}=\frac{c+v}{\sqrt{c^2-v^2}}$$

$$\sqrt{\frac{(c+v)(c-v)}{(c-v)(c-v)}}=\sqrt{\frac{c^2-v^2}{(c-v)^2}}=\frac{\sqrt{c^2-v^2}}{c-v}$$

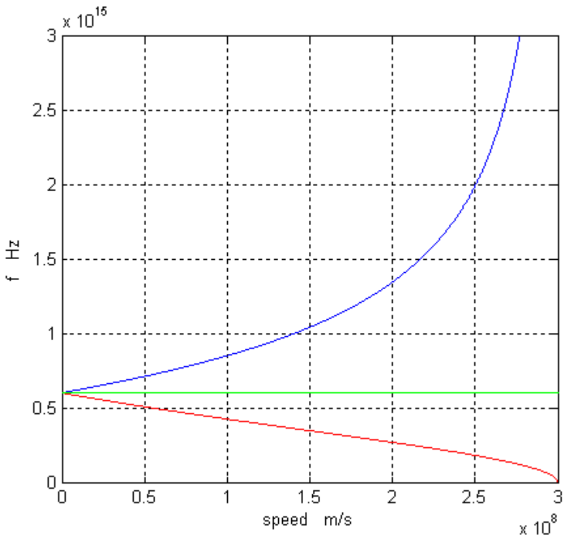
$$\Rightarrow\ \sqrt{\frac{1+\frac{v}{c}}{1-\frac{v}{c}}}=\sqrt{\frac{c+v}{c-v}}=\frac{c+v}{\sqrt{c^2-v^2}}=\frac{\sqrt{c^2-v^2}}{c-v}$$

As it is clear, the results are same and now assuming the accuracy of the equation, try to merge these equations with the equations in quantum mechanics to create new formulas:

$$f'=\frac{c}{\lambda'}=\frac{c}{\dfrac{c\pm v}{f\sqrt{1-\frac{v^2}{c^2}}}}=\frac{fc\sqrt{1-\frac{v^2}{c^2}}}{c\pm v}=\frac{\sqrt{c^2-\frac{c^2v^2}{c^2}}}{c\pm v}f$$

$$f'=\frac{\sqrt{c^2-v^2}}{c\pm v}f$$

The above equation shows the frequency of the received electromagnetic waves from a source which is moving away from the observer. That **f** is source frequency and **f'** is received frequency by the observer.



The upper curve shows frequency increase by increasing the speed of the source approaching the observer (blue tendency) and the curve below shows a frequency decrease by increasing the speed of source moving away from the observer (red tendency).

$$E = hf''$$

$$f'' = f\sqrt{1 - \frac{v^2}{c^2}}$$

$$E = hf\sqrt{1 - \frac{v^2}{c^2}}$$

$$\lim_{v \to c}\left(hf\sqrt{1 - \frac{v^2}{c^2}} \right) = 0$$

E is the photon energy and **h** is Planck's constant. The above equation and limit shows the energy of electromagnetic wave from a moveing source. As it is clear by approaching light speed, the energy of the radiant wave is decreased by the source, and this will cause a balance in the source and prevent explosion and mass conversion to energy. In fact by approaching light speed, the temperature will approach absolute zero which will be discussed in another paper.

$$E = hf'$$

$$f' = \frac{\sqrt{c^2 - v^2}}{c \pm v} f$$

$$E = hf\frac{\sqrt{c^2 - v^2}}{c \pm v}$$

This is the general and final equation to show the energy of electromagnetic waves received by a fixed observer. The general conclusion is that energy in some levels of space–time is quantized. Because the unit of frequency in Planck's formula is cycles per second, this means electromagnetic energy is quantized and packaged in time and its unit is the second and length is measured in meters

We can consider this package as mechanical; a bit like a photon or a string of **c.t** length where t=1 which will be discussed later.