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Frequency Shift that is Caused By Observer Movement

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Abstract: The non-linear Doppler effect shows that the acceleration is able to change the spectral image of a sample. The effect may have great influence on cosmologic theories especially to Hubble dilatation of space. The recent examination of the Fine structure constant shows that the constant was not being stable over the time. One explanation is that the acceleration of the dilatation of space has influence on it so we may conclude that it was changing over the time. The article also shows that derivation of the non-linear Doppler effect can be done without any relativistic premise. The formula (8) also shows that the Doppler effect is connected with all time derivatives not with the just first one.

Keywords: Doppler, non-linear, frequency shift.

With watching a light wave we can conclude the next equation is valid:

$$\frac{\overbrace{c}^{\ell}}{f_0} = \frac{\overbrace{c-v}^{\ell}}{f_1} \quad . \tag{1}$$

Whereas:

c = speed of light,

f = the source frequency,

f_0 = the frequency noticed by observer,

v = velocity of observer related to source.

Regarding the Taylor series we have:

$$\ell(t) = \sum_{k=0}^{\infty} \left. \frac{d^k \ell(t)}{dt^k} \right|_{t=0} \cdot \frac{t^k}{k!} \quad . \tag{2}$$

We also have:

$$\frac{d\ell(t)}{dt} = c - v(t) \quad . \tag{3}$$

Consequently:

$$\frac{d^k \ell(t)}{dt^k} = \frac{d^{k-1}}{dt^{k-1}}\left(c - v(t)\right) \quad . \tag{4}$$

We know that the following formula is valid because all are happening during a wave's period:

$$t = \frac{1}{f} \quad . \tag{5}$$

Regarding (2), (4) and (5) it can be written that

$$\frac{c}{f_0} = \sum_{k=1}^{\infty} \left. \frac{d^k \ell(t)}{dt^k} \right|_{t=0} \cdot \frac{1}{f_1^k \cdot k!} = \sum_{k=1}^{\infty} \left. \left(\frac{d^{k-1}}{dt^{k-1}} \cdot (c - v(t)) \right) \right|_{t=0} \cdot \frac{1}{f_1^k \cdot k!} \quad . \tag{6}$$

Further is obtained:

$$\frac{c}{f_0} = \left. \left(\frac{1}{f_1} \cdot \left(\sum_{k=0}^{\infty} \frac{1}{(k+1)!} \cdot \left(\frac{d}{f \cdot dt} \right)^k \right) \cdot (c - v(t)) \right) \right|_{t=0} \quad . \tag{6}$$

As the following formula is valid:

$$\sum_{k=0}^{\infty} \frac{x^k}{(k+1)!} = \frac{e^x - 1}{x} \quad . \tag{7}$$

It is obtained that the final implicit formula of frequency shift:

$$\frac{c}{f_0} = \frac{1}{f_1} \cdot \left(\frac{e^{\left(\frac{d}{f \cdot dt}\right)} - 1}{\left(\frac{d}{f_1 \cdot dt} \right)} \right) \cdot (c - v(t)) \quad . \tag{8}$$

Approximation with first two items, velocity and acceleration, of the Taylor approximation of the previous formula may have practical application:

$$\frac{c}{f_0} = \frac{1}{f_1} \cdot \left(1 + \frac{d}{2 \cdot f_1 \cdot dt} \right) \cdot (c - v(t)) \quad . \tag{9}$$

Further is obtained:

$$\frac{c}{f_0} = \frac{1}{f_1} \cdot \left(c - v - \frac{a}{2 \cdot f_1} \right) \quad . \tag{10}$$

Whereas:

c = speed of light,
f_0 = the source frequency,
f_1 = the frequency noticed by observer,
v = velocity of the observer related to source,
a = acceleration of the observer related to source.

Formula (10) can be solved on $\mathbf{f_1}$:

$$f_1 = \frac{f_0 \cdot \left(1 - \frac{v}{c}\right)}{2} + \frac{\sqrt{f_0^{\,2} \cdot \left(1 - \frac{v}{c}\right)^2 - \frac{2 \cdot f_0 \cdot a}{c}}}{2} \quad . \tag{11}$$

It is interesting that acceleration causes non-linear deformation of the spectrum and thus the spectrum of the chemical elements may be deformed significantly by strong acceleration.
The approximation of equation (11) is:

$$f_1 = \frac{f_0}{2} + \frac{\sqrt{c \cdot f_0 \cdot (c \cdot f_0 - 2 \cdot a)}}{2 \cdot c} + v \cdot \frac{f_0}{2 \cdot c} \cdot \left(\frac{\sqrt{c \cdot f_0 \cdot (c \cdot f_0 - 2 \cdot a)}}{2 \cdot a - c \cdot f_0} - 1 \right) \quad . \tag{12}$$

The less accurate approximation yields:

$$f_1 = f_0 \cdot \left(1 - \frac{v}{c}\right) - \frac{a}{2 \cdot |c - v|} \quad . \tag{13}$$

It can be noticed that the frequency spectra could be changed only by acceleration and that it may explain the change of α constant of the fine structure. If we chose only linear form of equation (6) and consequently (8) we obtain classic linear Doppler effect:

$$\frac{c}{f_0} = \frac{1}{f_1} \cdot (c - v(t)) \quad . \tag{14}$$

The formula (8) can be used for derivation of third Newton low:

Derivation of the Third Newton Low

Let's start from formula for light linear momentum:

$$P = \frac{h \cdot f_1(f_0, v)}{c} = \frac{h}{c} \cdot f_0 \cdot \left(1 - \frac{v}{c}\right) \quad . \tag{15}$$

Whereas:
h = Planck constant,
P = photon momentum,
c = speed of light,
v = scalar velocity of source related to observer,
f_0 = original frequency.

⇒

$$F = \left|\frac{d\bar{P}}{dt}\right| = \frac{h}{c} \cdot \frac{d}{dt}\left(f_1\left(\frac{m_0 \cdot c^2}{h}\right)\right) = -\frac{h \cdot f_0 \cdot a}{2 \cdot c^2} - \frac{h \cdot f_0^{\,2} \cdot \left(1 - \frac{v}{c}\right) \cdot a + h \cdot f_0 \cdot \dot{a}}{2 \cdot c^2 \cdot \sqrt{f_0^{\,2} \cdot \left(1 - \frac{v}{c}\right)^2 - \frac{2 \cdot f_0 \cdot a}{c}}} \quad . \tag{16}$$

$$\Rightarrow \qquad F = -\frac{m_0 \cdot a}{2} - \frac{1}{2} \cdot \frac{m_0 \cdot \left(1 - \frac{v}{c}\right) \cdot a + \frac{h}{c^2} \cdot \dot{a}}{\sqrt{\left(1 - \frac{v}{c}\right)^2 - \frac{2 \cdot h}{c^3 \cdot m_0} \cdot a}} \quad . \tag{17}$$

In approximation:

$$F = \left|\frac{d\vec{P}}{dt}\right| = \frac{h}{c} \cdot \frac{d}{dt}\left(f_1\left(\frac{m_0 \cdot c^2}{h}\right)\right) = -m_0 \cdot a - \frac{h \cdot a^2}{2 \cdot c \cdot |c - v|} - \frac{h \cdot \dot{a}}{2 \cdot c} \tag{18}$$

Whereas:

$$f_0 = \frac{m_0 \cdot c^2}{h} \quad . \tag{19}$$

The formula shows that the Doppler effect is sufficient for theoretical derivation of the 3rd Newton's low.

References:

1. "Cherenkov's particles as Magnetones," Journal of Theoretics Vol. 4-4.

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