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The Doppler effect of spectral lines and shift of the frequency of light in space

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Introduction

The Doppler effect of spectral lines in space is the change in the frequency of light emitted by an illuminated celestial body, which moves closer or farther away from the Earth in vacuum. A description of the change in light frequency is realized with the assumption that an illuminated celestial body in vacuum moves closer or farther away from the observer in vacuum. In this case, the propagation of light of the moving celestial body toward an observer also occurs in vacuum. Everywhere on Earth and in the surrounding space there is matter, so the choice of vacuum for the Doppler effect and the propagation of light from the moving celestial body toward the observer is not correct. From the observation of space as we know it, such as galaxies and stars, the area between the celestial bodies consists of a vacuum, but in some restricted spaces of the universe there is a transparent mass - gas, that moves at high speed against Earth. These spaces in universe filled by gas were called “intergalactic bubbles of gas” by astronomers. The propagation of light on the trajectory from an illuminated celestial body toward the observer takes place not only in a vacuum, but alternately also in the gases of intergalactic bubbles, respecting the laws of optics. The topic of the propagation of light in the universe is a very broad topic. For further information, please see reference [1], [2] and [3].

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The Doppler effect in space

The Doppler effect in space is described with the assumption, that an illuminated celestial body in vacuum moves closer or farther from the observer in vacuum an the propagation of light from the moving celestial body toward the observers also takes place in vacuum. This situation is denoted as “*Doppler effect 1*”. The change in the light frequency is expressed by the equation for *Doppler effect 1:*

$$\nu_{h1} = \nu_h \left(1 \pm \frac{v}{c_h}\right)$$

The identification of the parameters of light in equations is stated at the end of the article. The change in the frequency of light expressed by the equation of “*Doppler effect 1*” can be observed in space only in the close vicinity of a moving celestial body. The explanation is contained in “*Doppler effect 2*”.

The entire change in the frequency of light from a moving celestial body comprises two changes in light frequency. The first change of the light frequency is caused by the celestial body moving toward or away from the Earth and it takes place in vacuum. This change is described in “*Doppler effect 1*”. The second change of light frequency occurs during the propagation of light on the trajectory between a moving celestial body and the observer in vacuum and, alternately, also through moving gases in intergalactic bubbles of gas. The entire change in the frequency of light comprising two changes is denoted as “*Doppler effect 2*”. *The Doppler effect 2* is shown in **Fig. 1.**

The light exiting the light source moving in vacuum causes a change in the frequency of the light source $\mathbf{n}_h$ to frequency $\mathbf{n}_{h1}$ as in *Doppler effect 1*, as expressed by the equation (1):

$$\nu_{h1} = \nu_h \left(1 \pm \frac{v_1}{c_h}\right) \qquad (1)$$

The light entering from the vacuum to gas in bubble 2 causes the change in light frequency from $\mathbf{n}_{h1}$ to frequency $\mathbf{n}_{h2}$ in gas in bubble 2. Respecting the law of the light refractive index in gas in bubble 2, the change in the frequency of light can be expressed by equation (2), in the movement of the gas in bubble 2 toward the light source:

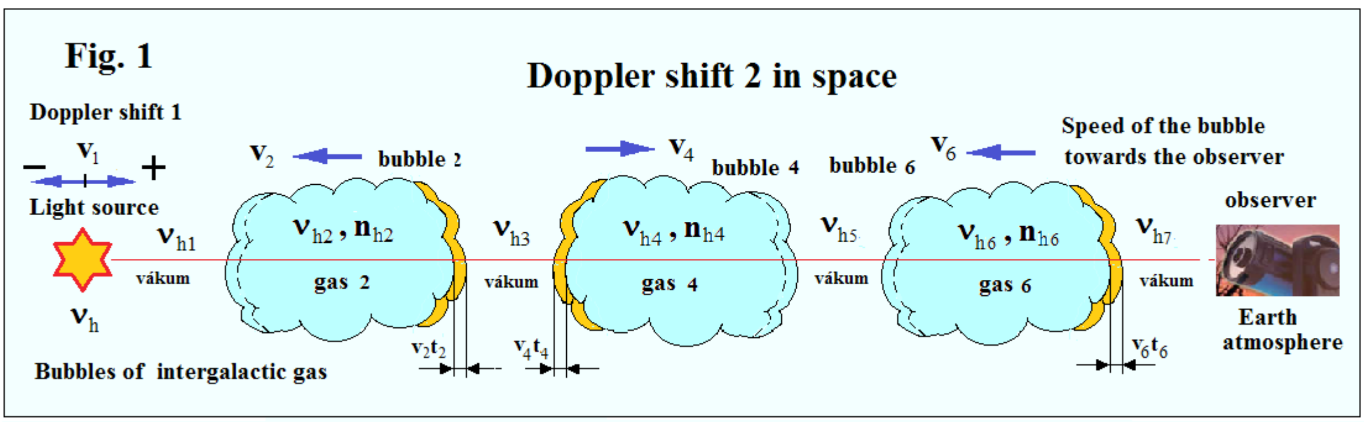
$$\nu_{h2} = \nu_{h1} \left(1 + \frac{v_2}{c_h} n_{h2}\right) \qquad (2)$$

The light exiting from the moving gas in bubble 2 into vacuum causes a change in the frequency of light in bubble 2 $\mathbf{n}_{h2}$ to frequency $\mathbf{n}_{h3}$ in vacuum as referred in equation (3):

$$\nu_{h3} = \nu_{h2}\left(1 - \frac{v_2}{c_h} n_{h2}\right) = \nu_h \left(1 \pm \frac{v_1}{c_h}\right)\left(1 + \frac{v_2}{c_h} n_{h2}\right)\left(1 - \frac{v_2}{c_h} n_{h2}\right) = \nu_h \left(1 \pm \frac{v_1}{c_h}\right)\left(1 - \frac{v_2^2}{c_h^2} n_{h2}^2\right)$$

(3)

The equation expresses the entire change in the light frequency from the moving light source in vacuum and the propagation of light away from the illuminated celestial body toward the observer in vacuum and, alternately, also through gas in two intergalactic bubbles of gas. As there are many intergalactic bubbles of gas between a moving light source and the observer, and we do not know the speeds of light in the gases in intergalactic bubbles toward the observer, the change of the frequency of light cannot be calculated from the equation of *Doppler effect 2*. I will not describe the analysis and method of measurement of the change of the light frequency in



space. I prefer to wait and hear the opinions of the readers. The question is: which description of the change of light frequency from the moving cosmic light source more precisely describes the real change in light frequency?

First description: the change in the frequency of light away from the moving light source in space occurs with the assumption that the illuminated celestial body is moving closer or farther from the observer in vacuum and the propagation of light on the trajectory away from the illuminated celestial body toward an observer occurs in vacuum and, alternately, also through gases in intergalactic bubbles as referred to in the equation *Doppler effect 2*.

Second description: the change in the frequency of light away from the moving light source in space occurs according to the metric expansion of space while the illuminated celestial body moves closer or farther away from the observer in vacuum and the propagation of light on the trajectory from the illuminated celestial body to the observer occurs in vacuum. The metric expansion of space is described according to the observation, measurements, and theory of the astronomer Edwin Hubble, who derived the interdependence between the distance of close galaxies and the Doppler effect of spectral lines toward the red end of the spectrum. In both descriptions, the change in the frequency of light occurs from a moving source of light in space and it increases with the increasing distance of the light source from an observer.

Identification of the parameters of light in air and in water during the measurements of light using an interferometer

The first index indicates the frequency of the light source in vacuum and the second index indicates the parameters of the gas in which the light is propagated.

„h“ Index indicating the light parameters of the helium laser

$\mathbf{c}_h$ Velocity of light of the helium laser in vacuum

$\mathbf{V}_h$ Frequency of light of the helium laser in vacuum

$\mathbf{V}_{h2}$, $\mathbf{V}_{h4}$, ..Frequency of light of the helium laser in gas 2, 4, ...

$\mathbf{n}_{h2}$, $\mathbf{n}_{h4}$, .. Absolute light refractive index of the helium laser in gas 2, 4, ...

References

[1] Brian Clegg : Před velkým třeskem , Argo a Dokořán, 2011

[2]https://sk.wikipedia.org/wiki/Medzigalaktick%C3%A1_hmota

[3]https://sk.wikipedia.org/wiki/Hubblova_kon%C5%A1tanta