Open Access Library Journal
2022, Volume 9, e8917
ISSN Online: 2333-9721
ISSN Print: 2333-9705

The Redshift Effect as an Electrodynamic Concept

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How to cite this paper: Man'kin, I. (2022) The Redshift Effect as an Electrodynamic Concept. *Open Access Library Journal*, **9**: e8917.
https://doi.org/10.4236/oalib.1108917

Received: May 23, 2022
Accepted: June 26, 2022
Published: June 29, 2022

Abstract

We discuss the nature of the redshift effect by assuming that the frequency and the speed of light decrease in time while it propagates from a stationary source of light relative to a stationary observer. This concept differs in a principal way from the modern model of the redshift effect, which states that the observed increase in the wavelength of emitted light from far-away objects is due to cosmological expansion of the universe. Precisely, an increase in the distance between a light source and the observer over time leads to the Doppler effect and as a result the redshift effect. We introduce a completely different explanation of the redshift effect: that the observed shift in the frequency does not arise as a result of the Doppler effect, but rather the "aging" of light: precisely the decrease in the photon's energy over time emitted by a stationary source to a stationary observer. In this case, as will be explained later, there is a need for an additional condition—a decrease in the speed of light as time passes. It can be assumed that if the fundamental physical constant c depends on time, other fundamental physical constants are also dependent on time.

Subject Areas

Fundamental Physics, Particle Physics, Quantum Mechanics, Theoretical Physics

Keywords

Redshift, Expansion of the Universe, Decrease of Speed of Light over Time, Doppler Effect

1. Introduction

Redshift is the increase in the wavelength of the spectrum of a source of light (*i.e.*

shifting the color lines to the left, towards the red color in the light spectrum) compared with the original spectral lines. Redshift is observed in the spectrum of far-away astronomical objects and in moder astrophysics is explained as a result of cosmological expansion of the universe. In modern science, redshift effect is derived from the increase in the distance between a source of light and its observer over time (Doppler effect).

The explanation of the redshift effect through the Doppler effect naturally leads to the concept of an expanding universe. Extrapolating such a motion backward in time, modern physics came to the conclusion that at some point in time t_0, the whole observable universe was concentrated in a single point (Big Bang Theory). A large amount of modern theoretical work is devoted to the study of the "early" universe during various short time intervals in the proximity of the singularity at time t_0.

In our opinion, singularities in physical theories can appear for at least two reasons:

1) an extrapolation process may only hold up to a certain limit;

2) the concept itself is not quite correct.

It's worth mentioning that in the work [1] the author points out that the Big Bang theory, despite its popularity in cosmology, has a considerable amount of opponents that offer alternative explanations for the redshift effect. In particular, in [1] they explore an explanation of the redshift effect based on a quantum mechanical interaction of a photon with particles constituting intergalactic gasses (plasma), as a result of which occurs a loss of energy in the photon and the associated increase in the light's wavelength. According to that author, an explanation of the redshift effect based on the classical theory of electromagnetism is not possible.

We show that based on Maxwell's equations of electromagnetism, the experimentally observed increase in the wavelength of light occurs as a result of the photon's loss of energy over time alongside the decrease of its speed.

2. Basic Relations

We begin by looking at the modern accepted theory of the redshift effect that is obtained from the Doppler effect when the distance between a moving source of radiation and a stationary observer increases over time.

In the general case, the relationship between the frequency ω_0 of a moving source and that of a stationary observer ω (*i.e.* the Doppler effect) is given by the following formula [2]:

$$\omega = \omega_0 \cdot \frac{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}{1 + \frac{v}{c} \cdot \cos\alpha} \tag{1}$$

where

v—speed of source of light;

α—the angle between observer's and beam's direction;

c—the speed of light.

If $\frac{v}{c} \ll 1$ and $\alpha \sim 0$, then:

$$\omega = \omega_0 \left(1 - \frac{v}{c}\right). \quad (2)$$

Now let us take a look at the redshift effect itself, observed experimentally and given by the following relation [2]:

$$\frac{\omega - \omega_0}{\omega_0} = -\frac{H}{c} \cdot r, \quad \omega = \omega_0 \left(1 - \frac{H \cdot r}{c}\right) \quad (3)$$

where

$H \cong 0.22 \times 10^{-17}\ \text{sec}^{-1}$—Hubble constant;

r—the distance between the source of light and the observer.

By comparing Equations (2) and (3) we get:

$$v = H \cdot r.$$

This is Hubble's law—the speed of galaxies expansion is proportional to their distance from the observer [2].

Below we discuss a new explanation of the redshift effect, not based on the Doppler effect. We begin our investigation starting only from Equation (3), assuming that light propagates from a stationary source to a stationary observer in time *t*, hence

$$r = c \cdot t.$$

And from Equation (3) it is given that:

$$\omega = \omega_0 \left(1 - H \cdot t\right). \quad (4)$$

This way it can be assumed that for a stationary source of light, redshift is obtained according to Equation (4) as a time dependent quantity, as a result of light beam traveling. Now let us look which conclusions can be made from this analysis.

A light beam is an electromagnetic wave, which its components are: $\boldsymbol{E}$—electric field intensity, $\boldsymbol{H}$—magnetic field intensity, both need to affirm the Maxwell equations [2]:

$$\text{I} \qquad \begin{aligned} rot\,\boldsymbol{H} &= \frac{1}{c} \cdot \frac{\partial \boldsymbol{E}}{\partial t}, \\ rot\,\boldsymbol{E} &= -\frac{1}{c} \cdot \frac{\partial \boldsymbol{H}}{\partial t}, \\ div\,\boldsymbol{E} &= 0, \\ div\,\boldsymbol{H} &= 0. \end{aligned} \quad (5)$$

By analyzing the beam as a form of a flat monochromatic wave that propagates in the *z* direction, we have:

$$\begin{aligned}&E_y, E_z = 0,\ \ H_x, H_z = 0,\\&E_x = A\cdot e^{j(\omega t+\beta z)},\ \ H_y = -A\cdot e^{j(\omega t+\beta z)},\end{aligned} \tag{6}$$

where

A, ω, β-constants;

$$\beta = \pm\frac{\omega}{c}. \tag{7}$$

In the case where $\omega = \omega(t)$, as shown in Equation (4), we obtain a solution that is similar to Equation (6), where:

$$\beta = \frac{\omega_0}{c_0} = const. \tag{7'}$$

Now, from the Maxwell equations:

$$\frac{\omega_0}{c_0} = \pm\frac{f'(t)}{c} \text{ where } f = \omega(t)\cdot t. \tag{8}$$

From Equation (8), considering Equation (4), we get:

$$\frac{c}{c_0} = 1 - 2Ht. \tag{9}$$

In this way, from the propagation of the beam, not only its frequency decreases, but the speed of light as well.

Strictly said, the value of c in the Maxwell equations is the speed of the electromagnetic wave only in a case where $\omega = const$. Here, where $\omega = \omega(t)$, this is not the case. Let us show it.

The phase velocity of the wave, v_p, is given by [2]:

$$\beta = \frac{\omega}{v_p} \text{ and } v_p = \frac{\omega}{\beta}.$$

Referring to Equations (4) and (7) we get:

$$\frac{v_p}{c_0} = \frac{\omega}{\omega_0} = 1 - Ht. \tag{10}$$

By comparing Equations (9) and (10) we see that:

$$v_p \neq c.$$

Because $c = c(t)$, a generalization for the Maxwell equations can be made, as shown next:

$$\text{II} \qquad \begin{aligned}&rot\,\boldsymbol{H} = \frac{\partial \boldsymbol{E}}{\partial(c\cdot t)},\\&rot\,\boldsymbol{E} = -\frac{\partial \boldsymbol{H}}{\partial(c\cdot t)},\\&div\,\boldsymbol{E} = 0,\\&div\,\boldsymbol{H} = 0.\end{aligned} \tag{5'}$$

Let us look for a solution, as shown above, as a form of a flat monochromatic wave, taking into account Equation (7'). Considering that:

$$\frac{\partial}{\partial(ct)} = \frac{1}{c' \cdot t + c}\frac{\partial}{\partial t}$$

we get a first order differential equation for c:

$$\overline{c}' + \frac{1}{t}\overline{c} = \frac{1}{t} - 2H \quad \text{where } \overline{c} = \frac{c}{c_0}.$$

This equation has a solution in the form of:

$$\overline{c} = 1 - Ht + \frac{\gamma}{t}$$

where

γ—an arbitrary constant.

By assuming that $\gamma = 0$, we get:

$$\overline{c} = \frac{c}{c_0} = 1 - Ht.$$

Interesting thing is, that in this case $v_p = c$ and c is the electromagnetic wave speed.

3. Conclusions

1) Redshift can be explained by noting a possible decrease in the wave frequency and the speed of light over time.

2) Photon's energy, $W = \hbar\omega$ ($\hbar$—Planck constant), is dependent on time:

$$\frac{W}{W_0} = 1 - Ht. \tag{11}$$

3) It can be assumed that if the fundamental physical constant c depends on time, other fundamental physical constants are also dependent on time. Due to the fact that the Hubble constant H is very small, the changes of all quantities over time are also small.

4) As time passes, because of the photon's "aging", its energy asymptotically decreases and tends to zero when $t = T$, and from Equation (11) we have:

$$1 - HT = 0,$$

$$T = \frac{1}{H} \cong 1.44 \times 10^{10} \text{ years} = 14.4 \text{ Billion years}.$$

This value, as shown, is the age of the universe.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Xu, Z. (2021) The Quantum Redshift Effect of Photon. *Journal of Modern Physics*, **12**, 2003-2030. https://doi.org/10.4236/jmp.2021.1214115

[2] Landau, L.D. and Lifshitz, E.M. (1980) The Classical Theory of Fields. Butterworth-Heinemann, Oxford.