A Brief and Elementary Note on Redshift

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Abstract

A reasonable explanation of both redshifts: cosmological (without expansion of the universe) and intrinsic, is given using a single tired light mechanism. In the first case, the redshift is produced because the light interacts with microwaves. In the second, the interaction is with radio waves. And all this is compatible with a static universe with a space temperature of 2.7 ºK.

Key words: cosmological redshift, intrinsic redshift, tired light.

1. Introduction

Generally, it is considered that the universe was originated in the Big Bang, and since then it is expanding. In that theory, the redshift of the light emitted from distant galaxies, the so-called cosmological redshift, is interpreted as a Doppler effect and then considered as an indication of the expansion of the universe, following the law of Hubble.

The light redshift parameter is defined as

$$z = \frac{\nu_e - \nu_o}{\nu_o} \tag{1.1}$$

being ν_e and ν_o the light frequencies emitted and observed, respectively; but as $c = \lambda\nu$, being c the light speed in vacuum, λ the wavelength and ν the frequency, then also

$$z = \frac{\lambda_o - \lambda_e}{\lambda_e} \tag{1.2}$$

being λ_e and λ_o the light wavelengths emitted and observed, respectively.

For the relativistic Doppler effect [1] (p. 166)

$$z = \frac{1 + v\cos\theta/c}{\sqrt{1 - v^2/c^2}} - 1 \tag{1.3}$$

being v the speed of the light source and θ the angle of the motion. For a motion in the line of sight ($\theta = 0$) and with $v^2 << c^2$ (which corresponds to low redshift, $z << 1$)

$$z = \frac{v}{c} \tag{1.4}$$

The Hubble's law is stated as [1] (p. 486)

$$v_r = Hd \tag{1.5}$$

where v_r is the velocity of recession, namely the speed at which a light source moves away from the observer, due to the expansion of the space between both; H is the Hubble's constant, and d is the distance between the observer and the light source. For low redshift ($z << 1$) [1] (p. 486)

$$z = \frac{v_r}{c} = \frac{Hd}{c} \tag{1.6}$$

therefore, the redshift of the galaxies is proportional to their distances to the observer. That is, the greater the distance, the greater the redshift. From (1.4) and (1.6) we would have that $v_r = v$. As the distance from a galaxy to us, for a light signal, is

$$d = ct \tag{1.7}$$

being t the time, then

$$z = Ht \tag{1.8}$$

Hubble published his law in 1929 [2], and in that same year and in the same journal [3], Zwicky tried to explain, without success, the red shift of spectral lines through interstellar space by means of the gravitational "drag" of light. However, he coined the concept, after called "tired" light, of that the light would lose energy (by some type of mechanical interaction) in their journey. We think now that this concept can explain the cosmological redshift in a non-expanding universe, and also the intrinsic redshift [4], that is, the excess of redshift of the quasars. For a review of redshift and its interpretation in cosmology and astrophysics see, for example, [5]. The mechanism supposed here is the interaction between electromagnetic waves. For the case of cosmological redshift, the light waves interact with microwaves. And, for the intrinsic redshift, the light waves interact with radio waves. But we give only a brief and elementary explanation of the idea. The photon-photon interaction was introduced by Finlay-Freundlich in 1953 [6].

2. A tired light mechanism

The cosmic sources of thermal radiation emit (following the law of Stefan-Boltzmann) and absorb thermal radiation producing a thermal equilibrium at a temperature of 2.7 ºK [6], which corresponds to the temperature of the so-called cosmic microwave background radiation (CMBR). Then, the intergalactic space (IGS) is not a void, it contains at least electromagnetic microwaves. Now, we suppose that the light emitted by the cosmic light sources (stars, quasars, galaxies) when travels in the IGS interacts with the CMBR losing energy following a tired light mechanism equal to

$$E(t) = E(0)e^{-t/\tau} \tag{2.1}$$

being E the energy of the photon and τ a time constant. There is a transference (or discharge) of energy from the photon to the microwave. It is similar to the discharge of an electric capacitor. As $E = h\nu$, where h is the Planck's constant, then

$$\nu(t) = \nu(0)e^{-t/\tau} \tag{2.2}$$

$$z = \frac{\nu(0) - \nu(t)}{\nu(t)} = e^{t/\tau} - 1 \tag{2.3}$$

For $t/\tau << 1$

$$z = t/\tau \tag{2.4}$$

(and $z << 1$) which is the same as (1.8) with

$$\tau = 1/H \tag{2.5}$$

Therefore, in the IGS (as $\nu(0) = \nu_e$ and $\nu(t) = \nu_o$)

$$z = \frac{\nu_e - \nu_o}{\nu_o} = e^{Ht} - 1 \tag{2.6}$$

and substituting (1.7) into (2.6)

$$z = \frac{\nu_e - \nu_o}{\nu_o} = e^{(H/c)d} - 1 \tag{2.7}$$

and the redshift increases exponentially with the distance.

For the intrinsic redshift, we know that a quasar (quasi-stellar radio source) or a radio galaxy, are sources of electromagnetic radio waves, hence inside of a quasar the light interacts with those radio waves losing energy following (2.1), but with

$$\tau << 1/H \tag{2.8}$$

because the density of radio waves inside of the quasar is much greater than the density of microwaves in the IGS. This would explain the excess of redshift of the quasars and radio galaxies. Thus, for example, in the case of the pair quasar-galaxy NGC 7319 [7], where the galaxy has a low redshift, $z_G = 0.0225$, and the quasar (which is in front of the galaxy) a high redshift, $z_Q = 2.114$ (which is contrary to the expansion of the universe); we would have

$$z_G = z_{IGS} = 0.0225 \tag{2.9}$$

$$z_Q = z_{InsideQ} + z_{IGS} = 2.0915 + 0.0225 = 2.1140 \tag{2.10}$$

where both z_{IGS} and $z_{InsideQ}$ would be obtained with (2.3) but with (2.5) and (2.8) respectively.

3. Conclusion

We have given, in a very simple way, using a single tired light mechanism, a reasonable explanation of both redshifts: cosmological (without expansion of the universe) and intrinsic. In the first case, the redshift is produced because the light interacts with microwaves. In the second, the interaction is with radio waves. And all this is compatible with a static universe with a space temperature of 2.7 ºK.

As using this single tired light mechanism, another explanation of the redshift is possible and a simple alternative interpretation can be generated, we think that our hypothesis should be considered plausible.

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