A Note of Widening on the Redshift Mechanism

June 23, 2010.

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Abstract

A single tired light mechanism has been proposed for explaining the cosmological redshift without expansion of the universe and also the intrinsic redshift, that is, the excess of redshift of the radio sources. In this note of widening, we show that the mechanism would be similar to the discharge of an electric capacitor, to the radiation loss by fast electrons and to the radioactive nuclei decay.

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

1. Introduction

In a recent paper [1], a reasonable explanation of both redshifts: cosmological (without expansion of the universe) and intrinsic, is given using a single tired light mechanism. The mechanism supposed is the interaction between electromagnetic waves. For the case of cosmological redshift, the light waves interact in the intergalactic space (IGS) with the microwaves of the so-called cosmic microwave background radiation (CMBR). And, for the intrinsic redshift (namely, the excess of redshift of the radio sources), the light waves interact inside of the radio sources (quasars, radio galaxies, etc.) with radio waves. And all this is compatible with a static universe with a space temperature (of thermal equilibrium) of 2.7 ºK (which is the temperature of the CMBR). The mechanism would be similar to the discharge of an electric capacitor, to the radiation loss by fast electrons and to the radioactive nuclei decay.

2. The tired light mechanism

The interaction is a transference of energy from the photon to the microwave in the IGS or to the radio wave inside of a radio source, following a tired light mechanism of the form [1]

$$E(t) = E(0)e^{-t/\tau} \tag{1}$$

where E is the energy of the photon, t the time and τ a time constant, whose value depends on the medium: $\tau = 1/H$, in the IGS, but $\tau << 1/H$, inside of a radio source, because the density of radio waves inside of the radio sources is much greater than the density of microwaves in the IGS.

It is similar to the discharge of an electric capacitor through the series resistance in an electric circuit [2] (p. 247)

$$q(t) = q(0)e^{-t/\tau} \tag{2}$$

q being the electric charge, and the time constant is $\tau = RC$, where R is the resistance and C the capacitance. Comparing (1) with (2), we see an analogy between E and q. We can go beyond because

$$E_C(t) = E_C(0)e^{-t/\tau} \tag{3}$$

E_C being the energy of the capacitor (which is proportional to its capacitance) with $\tau = RC/2$ (see appendix). And the capacitance of a parallel plate capacitor is $C = \varepsilon A / s$ where ε is the electric permittivity, A the plate area and s the plate separation. Then, for the photon, like an energy condenser, it would be $s = \lambda$, where λ is the wavelength. And the trajectory of the photon would be the circuit. Then, and since $1/R = G$ is the conductance, $\tau = \infty$ (open circuit, $R = \infty$) would correspond to the most "resistive" (least "conductive") medium, the vacuum, and $\tau = 0$ (short circuit, $R = 0$) for the least "resistive" (most "conductive") medium. Therefore, in the vacuum, the light would not lose any energy, whereas the cosmic objects with $\tau = 0$ would emit radio waves but not light.

However, we can consider our mechanism from a different point of view. Since the distance traveled by the photon is

$$d = ct \tag{4}$$

c being the light speed in vacuum, and

$$\delta = c\tau \tag{5}$$

δ being a distance constant, then, (1) is converted in

$$E(d) = E(0)e^{-d/\delta} \tag{6}$$

with $\delta = c/H$, in the IGS, but $\delta << c/H$, inside of a radio source.

And, now, our mechanism, seen like (6), would be similar, from a quantum mechanical point of view, to the radiation loss by fast electrons, where the mean energy $\langle E \rangle$ of an electron, with initial energy E_0, after having traversed a length x of the medium, is [3] (p. 74) [4] (p. 39)

$$\langle E \rangle = E_0 e^{-x/X_0} \tag{7}$$

X_0 being the so-called radiation length, which is inversely proportional to the density of atoms of the medium. The equation (7) is obtained from the framework of reference of the electron and considering that this one scatters the electromagnetic fields (of the atoms of the medium) which act like streams of photons. Therefore, comparing (6) with (7) we deduce that (in place of the electron) our visible light photon (acting like a particle of "effective mass" $h\nu/c^2$, where h is the Planck's constant and ν the frequency) scatters (in place of streams of photons) microwaves in the IGS or radio waves inside of the radio sources, losing energy following (6) (in place of (7)).

For last, as all the interactions considered between the photon and the electromagnetic waves are analogous except that the energy of the photon is continuously decreasing, we may postulate, simply, that in each interaction the decrease of energy of the photon is proportional to its energy, that is

$$dE = -E\frac{dt}{\tau} \tag{8}$$

$$dE = -E\frac{dx}{\delta} \tag{9}$$

and separating variables and integrating we obtain (1) and (6) (with $x = d$) respectively. Where (8) follows a law similar to the law of radioactive nuclei decay [3] (p. 176)

$$dN = -N\frac{dt}{\tau} \tag{10}$$

$$N(t) = N(0)e^{-t/\tau} \tag{11}$$

N being the number of radioactive nuclei and the time constant τ is the mean life time of a typical nucleus of the nuclei sample.

3. Conclusion

We can conclude, hence, that the single tired light mechanism proposed in [1] should be considered plausible because explains the observed redshifts: cosmological (without expansion of the universe) and intrinsic, and is compatible with a space temperature of 2.7 ºK. And, in addition, it is in accordance with various important physical phenomena like, for example, the discharge of an electric capacitor, the radiation loss by fast electrons or the radioactive nuclei decay.

Appendix

When an electric capacitor is disconnected from the battery, applying the Kirchhoff's voltage law (and the Ohm's law) to the closed electric circuit, we would have

$$v_R(t) + v_C(t) = 0 \tag{1}$$

$$R\frac{dq(t)}{dt}+\frac{q(t)}{C}=0 \tag{2}$$

$v_R(t)$ and $v_C(t)$ being the voltages in the resistance and in the capacitor respectively, R the resistance, C the capacitance, $q(t)$ the charge and t the time. From (2)

$$q(t)=q(0)e^{-t/RC} \tag{3}$$

and from (1), (2) and (3)

$$v_C(t)=\frac{q(t)}{C}=\frac{q(0)}{C}e^{-t/RC}=v_C(0)e^{-t/RC} \tag{4}$$

$$i_C(t)=\frac{dq(t)}{dt}=-\frac{q(0)}{RC}e^{-t/RC}=-\frac{v_C(0)}{R}e^{-t/RC} \tag{5}$$

$i_C(t)$ being the capacitor current.

The discharge of energy of the electric capacitor would be

$$E_C(t)-E_C(0)=\int_0^t dE_C(t)=\int_0^t dp_C(t)dt=\int_0^t v_C(t)i_C(t)dt=-\int_0^t\frac{v_C^2(0)}{R}e^{-2t/RC}dt=$$
$$=\frac{Cv_C^2(0)}{2}\left(e^{-2t/RC}-1\right) \tag{6}$$

where $E_C(t)$ and $p_C(t)$ are the energy and the power of the capacitor, respectively. And from (6), we have

$$E_C(t)=\frac{Cv_C^2(0)}{2}e^{-2t/RC} \tag{7}$$

$$E_C(0)=\frac{Cv_C^2(0)}{2} \tag{8}$$

that is

$$E_C(t)=E_C(0)e^{-t/\tau} \tag{9}$$

and the energy of the capacitor decreases exponentially with the time with a time constant

$$\tau=\frac{RC}{2} \tag{10}$$

Notice that $E_C(\infty) = E_C(0)e^{-\infty/\tau} = 0$.

References

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