A note about the light red shift

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Abstract

In this brief and very simple note, we consider that the nature of the light red shift is related with the variation of the gravitational field with the distance and not necessarily with the expansion of the universe.

Introduction.-

In the theory of the Big Bang, the light red shift is interpreted as a Doppler effect and then considered as an indication of the expansion of the universe.

However, we are going to consider that nature of the red shift is related with the variation of the gravitational field with the distance and not necessarily with that expansion.

The red shift.-

We assume that in a gravitational field the interval ds has the form [1]

$$ds^2 = c^2\, d\tau^2 - b\, a^2(\tau)\, (dx^2 + dy^2 + dz^2) = c^2\, d\tau^2 - b\, a^2(\tau)\, dr^2$$

being c the velocity of the light in the vacuum, τ the proper time, b an integration constant, $a(\tau)$ the scaling factor, x, y, and z the space coordinates and r the distance.

From, $0 = ds^2 = c^2\, d\tau^2 - b\, a^2(\tau)\, (dx^2 + dy^2 + dz^2) = c^2\, d\tau^2 - b\, a^2(\tau)\, dr^2$, we obtain that the velocity of the light is

$$dr/d\tau = c/b^{1/2}a(\tau)$$

Now, we put the observation point at the origin of the reference system, r = 0. We consider a light signal emitted from the point r in the time interval between τ and $\tau + d\tau$, and that arrives at the point r = 0 in a time interval between τ_0 and $\tau_0 + d\tau$.

Then, for the light emitted at the moment τ and that arrives at the point r = 0 at the moment τ_0 we have that $d\tau/a(\tau) = b^{1/2}dr/c$ and

$$\int_{\tau}^{\tau_0} d\tau/a(\tau) = \int_{r}^{0} b^{1/2}dr/c = b^{1/2}/c \int_{r}^{0} dr = b^{1/2}/c\, [r]_r^0 = b^{1/2}/c\, (0 - r) = -b^{1/2}r/c$$

Also, for light emitted at the moment $\tau + d\tau$ and that arrives at the point r = 0 at the moment $\tau_0 + d\tau$ we have that

$$\int_{\tau+d\tau}^{\tau_0+d\tau} d\tau/a(\tau) = \int_{r}^{0} b^{1/2}dr/c = -b^{1/2}r/c$$

Consequently

$$\int_{\tau}^{\tau_0} d\tau/a(\tau) = \int_{\tau+d\tau}^{\tau_0+d\tau} d\tau/a(\tau)$$

$$F(\tau_0) - F(\tau) = F(\tau_0 + d\tau) - F(\tau + d\tau)$$

$$F(\tau + d\tau) - F(\tau) = F(\tau_0 + d\tau) - F(\tau_0)$$

$$d\tau\, F'(\tau) = d\tau\, F'(\tau_0)$$

$$F'(\tau) = F'(\tau_0)$$

$$d\tau/a(\tau) = d\tau_0/a(\tau_0)$$

$$a(\tau)/d\tau = a(\tau_0)/d\tau_0$$

And using the light angular frequency, $\omega = d\theta/d\tau$ and $\omega_0 = d\theta/d\tau_0$, being θ the angle, we have

$$a(\tau)\omega/d\theta = a(\tau_0)\omega_0/d\theta$$

$$a(\tau)\, \omega = a(\tau_0)\, \omega_0$$

$$\omega = (a(\tau_0)/a(\tau))\, \omega_0$$

Hence, the light angular frequency ω at the point of emission is not equal to the light angular frequency ω_0 at the point of observation.

Now, we introduce the light red shift parameter z like

$$z = (\omega - \omega_0)/\omega_0$$

We have that

$$z = (\omega - \omega_0)/\omega_0 = (\omega/\omega_0) - 1 = (a(\tau_0)/a(\tau)) - 1$$

and $z > 0$ if $a(\tau_0) > a(\tau)$. Also, $z > 0$ if $\omega > \omega_0$, that is, if the energy of the light emitted $\sum \hbar\omega$ is grater than that of the light received $\sum \hbar\omega_0$, being $\hbar = h/2\pi$, and h is the constant of Planck.

Conclusion.-

We conclude that the nature of the light red shift is related with the variation of the gravitational field with the distance and not necessarily with the expansion of the universe.

References

[1] A. A. Logunov, The Theory Of Gravity, www.arxiv.org/gr-qc/0210005.