ON THE THEORETICAL EVALUATION OF THE HUBBLE RED-SHIFT CONSTANT

(Letter to the Editor)

V. A. KRAT and I. L. GERLOVIN
Pulkovo Observatory, Leningrad, U.S.S.R.

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Abstract. The coefficient of the cosmological red-shift (H_0) is calculated on the basis of the new theory of fundamental field (theory of the physical vacuum). Its value $H_0 = 2.01 \times 10^{-17}$ is in a satisfactory agreement with its experimental values.

The metagalactic red-shift of spectral lines considered as the Doppler effect can be defined by

$$v = H_0 s, \qquad \frac{\lambda}{\lambda_0} = 1 + \frac{H_0}{c} s, \tag{1}$$

where v is the velocity of radiating object; λ, the wavelength; c, the velocity of light; s, the distance; and H_0, the red-shift constant.

In order to evaluate H_0 using a model of the Universe we must adopt the hypothesis of its uniform expansion. The properties of such a model must be well defined, which is not the case since the application of astronomical methods is restricted to comparatively small s and at great distances s can be determined only by 'cosmological' relation of the type of (1). Therefore, the problem of evaluation of H_0 becomes somewhat indefinite and cannot be solved now with a sufficient degree of accuracy. We are certain that additional investigations of the nature of propagation of light will be useful for cosmology.

In Krat and Gerlovin (1974a, b) the authors have shown that the universal gravitational constant can be evaluated with a high degree of accuracy in the framework of the fundamental field theory (FFT). Here we would make an application of FFT to the red-shift problem. As it was shown in Gerlovin (1973) the FFT can be considered as a generalization of the general theory of relativity (GTR) with an introduction of physical vacuum. It is well known that formerly the role of vacuum in the formation of gravitational field was totally ignored. Now we see that the properties of vacuum must be necessarily taken into account because it is filling the space with particle (vacuum particles) density of the order of 10^{39} cm^{-3} (the proton–antiproton vacuum). In Gerlovin (1973) the propagation of light is considered as the process of propagation of vacuum particle excitation (evp) and the birth of every photon as an elementary act of excitation of the evp. In this process a small loss of energy is inevitable since it is

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caused by the resistance of gravitational force to the excitation of evp. During this process the distance between the virtual antiparticles of the evp increases from 0 to x_0 at the act of formation of a photon. It may be emphasized that before the excitation any changes inside the 'black-hole' sphere of radius R (the radius of a Schwarzschild sphere) due to the properties of the evp geometry must be unobservable. Thus we take into account only the loss of energy produced by the expansion from R to x_0 and not from 0 to x_0. The loss of energy cannot be restored by the transfer of excitation to the neighbouring evp and is totally controlled by the electromagnetic field. In this electromagnetic energy can be transferred unchanged through evp.

Thus the propagation of light conserving the number of photons in the free vacuum at each act of the evp excitation leads to irreversible loss of very small amount of energy due to the resistance of gravitational forces.

The gravitational 'friction' of light in vacuum can be computed using some results of FFT. If the initial energy of a photon is $h\nu_0$ and the loss of energy per one sec is u, then during the time interval t the photon energy will change from $h\nu_0$ to $h\nu$

$$h\nu_0 - h\nu = \int_0^t u \,\mathrm{d}t; \tag{2}$$

and, hence,

$$\frac{\lambda}{\lambda_0} = 1 + \frac{\int_0^t u \,\mathrm{d}t}{h\nu}. \tag{3}$$

Let us introduce the value u_1 in (3) being the loss of energy at one act of the evp excitation, and write (3) in the form

$$\frac{\lambda}{\lambda_0} = 1 + \frac{\int_0^s u_1 \,\mathrm{d}s}{hc}, \qquad u_1 = \frac{u}{\nu}. \tag{4}$$

Comparing (1) and (4) we see that the gravitational 'friction' leads to a red-shift of the same form as the Doppler effect. In order to determine the part of the observed red-shift which can be attributed to the Doppler effect we must evaluate H_0 from

$$H_0 = \frac{\int_0^s u_1 \,\mathrm{d}s}{sh}. \tag{5}$$

The virtual particle and antiparticle in the process of moving apart during the act of excitation from R to x_0, loss energy u_1 working against the force of gravitational friction (Gerlovin, 1973) f_u

$$f_u = m \operatorname{grad} \frac{gm}{2\pi r e^{R/r}(1 - \beta^2)}, \tag{6}$$

where m is the mass of one of the virtual particles of evp, $\beta = v/c$ – the relative dimensionless velocity of oscillation of the evp structure elements, given only in the proper system of coordinates in evp (under the Schwarzschild sphere). It is clear that

$$u_1 = -\frac{gm}{2\pi(1 - \beta^2)} \int_R^{x_0} \operatorname{grad} \frac{m}{r e^{R/r}} \, dr. \tag{7}$$

The process of evp excitation can be observable in the macro events only when $x_0 > R$. Thus we have

$$u_1 = -\frac{gm^2}{2\pi e R(1 - \beta^2)} \left(1 - \frac{R}{x_0 e^{R/x_0 - 1}}\right). \tag{8}$$

The physical meaning of the fact that the ratio of energy of a photon to its frequency is the Planck constant consists of the statement that, for every photon, $x_0 = \lambda$.

Then (8) can be written in the form

$$u_1 = \frac{gm^2}{2\pi e R(1 - \beta^2)} \left(1 - \frac{R}{\lambda e^{R/\lambda - 1}}\right). \tag{9}$$

The constants R and β in the FFT can be expressed with an accuracy to the factor about 1.04 by the 'outer' particle constants determined from the experiment (Gerlovin, 1973) and, hence,

$$H_0 = \frac{9 g m_e^3 c}{2 e h^2 \alpha^4 s} \int_0^s \left(1 - \frac{R}{\lambda e^{R/\lambda - 1}}\right) ds, \tag{10}$$

where m_e is the mass of an electron and α, the fine-structure constant. Inserting the numerical values of constants in (10) we obtain

$$H_0 = \frac{2.01 \times 10^{-17}}{s} \int_0^s \left(1 - \frac{R}{\lambda e^{R/\lambda - 1}}\right) ds. \tag{11}$$

Since $R \ll \lambda$, the dependence of H_0 on λ varying with s is insignificant. The numerical value of H_0 is the same for vacuum with various sizes of Schwarzschild spheres. For the optical range of spectrum, including the low-frequency ultraviolet ($\lambda > 10^{-5}$),

$$H_0 = 2.01 \times 10^{-17} \, s^{-1}. \tag{12}$$

The dependence of H_0 on frequency can be detected only in the far ultraviolet and X-ray part of the spectrum. The theoretically estimated value of H_0 does not contradict its experimental values. Hubble's previous value of H_0 is greater than (12) and the more recent one given in Allen's compilation is smaller (Allen, 1955). We must also take into account the well-known uncertainty in the determination of the scale of the intermetagalactic distances. We can now only conclude that the theoretical value of H_0 being exclusively a sample of the world (universal) constants is near to the observed one.

The more precise determination in the future will show that a part of H_0 can be explained as the effect of gravitational vacuum friction. If it definitely transpires that the observed H_0 is smaller than its theoretical value, this would mean that the Universe at the present time is not expanding, but contracting. In any case we can expect that the 'friction' effect, being taken into account, can influence essentially the choice of the cosmological models.

References

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