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The Tired-Light Hypothesis: Derivations of Basic Relations

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The Big Bang model is the generally accepted theory for the origin and evolution of the Universe although it faces many challenges. There are other alternative theories about the origin of the Universe and its evolution. One of them is the "tired-light" theory.

This theory was originally proposed by Zwicky [1] in 1929 immediately after Hubble [2] discovered the linear distance-redshift relationship of some galaxies (outside local group) through observations. This theory explains the cosmological redshift z as a result of energy loss of photons of the light emitted by a nearby or distant galaxy.[1] This loss is due to the interactions of photons with material particles as they travel through intergalactic space. According to the tired-light theory, space is Euclidean, static, slowly evolving [4] and probably infinite.

In this communication, we will derive the basic equations of the tired-light theory using a derivation similar to that for radioactive decay.

We denote with E_0 the initial energy of a photon emitted by a nearby or distant galaxy and with E_d its energy at a distance d away which remains after n light-years. Of course, n is an integer. Let us assume that after each unit of distance, in this case, a light year (ly), the same fraction of the photon energy is transferred to the intergalactic material particles; we will call it the energy fraction f. It can be easily shown that after n light-years the energy of a photon would be

$$E_d/E_0 = f^n \quad \ldots (1).$$

Applying the natural logarithm to both sides of this **equation**, we get

$$\ln (E_d/E_0) = n \times \ln f \quad \ldots (2)$$

The photon distance d away from the galaxy is related to the number of light-years as follows

$$d = n \times (\mathrm{ly}) \quad \ldots (3).$$

Combining eqns. (2) and (3) and rearranging we get

[1] We will define nearby galaxies as those whose redshift z is from 0.001 to 0.1 (or $0.001 \leq z \leq 0.1$) and distant galaxies with $z > 0.1$. Of course, there is no sharp boundary between nearby and distant galaxies [3].

$$\ln (E_d/E_0) = [\ln f/(ly)] \times d \quad \dots (4).$$

The term in square brackets on the right side of this equation is constant and LaViolette [5] defined it as "the energy attenuation coefficient" (or "the rate of energy attenuation") and denoted with β. The term lnf is negative because f is a fraction then

$$\beta = - [\ln f/(ly)] \quad \dots (5).$$

This coefficient is a positive number and has the unit of $(ly)^{-1}$. Introducing β instead the term of lnf/(ly) of eqn. (4) we obtain

$$\ln (E_d/E_0) = - \beta d$$

or

$$E_d = E_0 e^{- \beta d}.$$

The distance d can be expressed as ct where c (= 299792 km sec^{-1}) is the speed of light and t is the time taken for the photons to cover this distance. We now write

$$E_d = E_0 e^{- (\beta c)t}.$$

The term $\beta c(Gy)^{-1}$ is a constant characteristic of the tired-light hypothesis. We will call it the attenuation time constant and we will mark it with $\tau = \beta c$. The above equation can be then written as follows

$$E_t = E_0 e^{-\tau t}$$

The constant τ is related to the attenuation half-time by

$$\theta_{1/2} = 0.692/\tau = 0.692/\beta c \quad \dots (6).$$

This formula, at first sight, is similar to the corresponding formula for more familiar radioactive decay: $t_{1/2} = 0.692\lambda$ where $t_{1/2}$ is the half-time of a radioactive atom and λ is its decay constant. There is, however, a fundamental distinction between them. In radioactive decay, the radioactive atom decays. In contrast, in the tired-light case, the photon emitted by the galaxy does not decay.

If D represents the distance between the galaxy and the Earth then $E_d = E_D$ where E_D is the energy of the photon when it reaches the Earth then eqn. (1)

$$E_0/E_D = 1/f^n.$$

We can easily find that

$$\lambda_D/\lambda_0 = f^n$$

where λ_0 and λ_D are the corresponding photon's wavelengths. We know that the greater distance between the galaxy and the Earth, the larger the wavelength of light of this photon reaching the Earth.

Subtracting 1 from both sides of the last equation and after a bit of algebra we have

$$(\lambda_D - \lambda_0)/\lambda_0 = 1/f^n - 1.$$

We know that the left side of this equation is a redshift z of a photon reaching the Earth. So

$$1 + z = 1/f^n$$

or

$$f = \text{nth root of } 1/(1 + z).$$

The cosmological redshift z is a universal physical constant and is independent of the wavelength of a photon emitted by a galaxy. This independence is regularly found in all galaxy spectra with a precision of about 10^{-4} [6]. So, according to the last equation, the energy fraction f is independent of a photon wavelength. Hence the energy attenuation coefficient β must be also independent of this wavelength [see eqn. (5)], as well as the attenuation time constant τ (= βc) and the attenuation half-time $\theta_{1/2}$ [see eqn. (6)].

References

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