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Minimum Quantum Energy of the Tired-Light Universe

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The tired-light theory argues that the light of nearby or distant galaxies[1] is redshifted because it loses energy as it passes through intergalactic space. In his recent communication, Premović [2] derived basic equations related to the tired-light hypothesis. According to it, the initial energy of photon E_0 emitted by a nearby or a distant galaxy (hereinafter galaxy) and its energy E after traveling a distance d in the intergalactic space are related by

$$E = E_0 e^{-\beta d}$$

where β is the energy attenuation or the rate of energy attenuation [3]. Premović [4] has also found that the value of β is 0.071 Gly and the above equation can be written as

$$E = E_0 e^{-0.071d} \quad ... (1).$$

Premović [5] estimated that the minimum quantum energy of the observable Universe, ε, is about 1.5×10^{-51} J. Eqn. (1) allow us to calculate a distance d_ε at which a photon emitted by a galaxy would have a final energy equal to the minimum quantum energy ε (= 1.5×10^{-51} J) or

$$\varepsilon = E_0 e^{-0.071d_\varepsilon} \quad ... (2).$$

Example 1:

A Lyman-alpha (-α) emitter is a type of distant galaxy that emits the Lyman-α line of the hydrogen atom. The relationship between the energy of this line E_α and its wavelength λ_α (= 121.6 nm) can be described by the following equation

$$E_\alpha = hc/\lambda_\alpha$$

where h (= 6.63 10^{-34} J sec) is called Planck's constant and c (≈ 3×10^{8} m sec^{-1}) is the speed of light. Putting the given values for h, c and λ_α we find that $E_\alpha = 1.6 \times 10^{-18}$ J.

In the tired-light terminology, E_α represents E_0 and eqn. (1) can be written as

$$E = E_\alpha e^{-0.071d}$$

[1] We 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 line between nearby and distant galaxies [1].

The Lyman-α photon would reach its minimum quantum energy of the observable Universe ε when $E = \varepsilon$ (= 1.5×10^{-51} J). So, we can write after a bit of algebra

$$E_\alpha/\varepsilon = e^{0.071 d_\varepsilon}$$

where d_ε is the distance from the galaxy emitter at which these energies would be equated. Logarithmizing this expression and after a bit of algebra, we get

$$d_\varepsilon = \ln(E_\alpha/\varepsilon)/0.071.$$

Introducing into this equation the above values for E_α and ε we have

$$d_\varepsilon = \ln(1.07 \times 10^{33})/0.071 = [\ln(1.070) + \ln(10^{33})]/0.071 = 1100 \text{ Gly}.$$

The time of flight of this photon up to this distance away from the galaxy emitter is about 1100 Gy.

Example 2:

GRB 190114C was an extreme gamma-ray burst explosion whose radiation detected is the highest energy ever observed for a GRB: 1TeV or E_{GRB} is about 1.6×10^{-7} J. In this case, employing eqn. (2) and similar mathematical procedure as in Example 1, one gets

$$d_\varepsilon = \ln(E_{GRB}/\varepsilon)/0.071.$$

If we plug the above values for ε and E_{GRB} we find that

$$d_\varepsilon = \ln(1.07 \times 10^{44})/0.071 = [\ln(1.07) + \ln(10^{44})]/0.071 = 1465 \text{ Gly}.$$

The time of flight of this photon up to this distance away from GRB 190114C is 1465 Gy.

As we have shown in our previous communication [3], for the Hubble law case of a linear relationship between the redshift z and the distance D between the Earth and a nearby galaxy there is the following relationship

$$\beta = H_0/c$$

where H_0 is the Hubble constant [= 72 km sec^{-1} (Mpc)$^{-1}$]. In Hubble terminology, H_0/c represents the inverse of Hubble's distance, $1/D_H$. Plugging $1/D_H$ instead of $\beta = 0.071$ (Gly)$^{-1}$ and D instead of d and into eqn. (1) we have

$$\varepsilon = E_0 e^{-D/D_H}.$$

References

[1] P. I. Premović**,** *Nearby and distant galaxies: a brief note*. The General Science Journal, August 2024.
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[3] P. A. LaViolete, *Is the Universe really expanding?* ApJ. 301, 544-553 (1986).
[4] P. I. Premović, *Expanding Universe vs. Tired-light Universe: the rate of energy attenuation and the cosmological distance*. The General Science Journal, December 2022.
[5] P. I. Premović, *Minimum quantum energy of the observable Universe.* The General Science Journal, January 2023.