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The Cosmic Energy-Time Uncertainty

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The energy-time relation of Heisenberg's uncertainty principle describes the relationship between the uncertainty in energy ΔE and the relevant uncertainty in time Δt for a physical process. In expression,

$$\Delta E \Delta t \geq h$$ [1]

where h (= 6.63×10^{-34} J sec) is Planck's constant. This uncertainty is noticeable, for instance for physical processes involving subatomic particles, but not for the physical processes of macroscopic objects such as tennis balls, planets of the Solar System, stars and galaxies.

According to the standard cosmology, the redshifts of the light emitted by nearby and distant galaxies[2] is the result of the Universe's expansion during the flight of the light from these galaxies to the Earth. The corresponding change in wavelength is:

$$\Delta\lambda = \lambda_G - \lambda$$

where λ_G is the wavelength of light emitted by nearby or distant galaxies and measured by the Earthlings, and λ is the wavelength of light supposedly generated by the corresponding source on the Earth.

The best estimate of the age of the Earth 4.55 ± 0.05 Gyr. Premović [2] concluded that the time of Earth's formation is a more reliable zero-time standard for the Universe. All distant galaxies were formed before the Earth. Premović used for this type of galaxies the term before the Earth and labeled it as BE. For galaxies created after the Earth, he applied AE. Of note, all "megamaser" galaxies are nearby and formed in AE [2, 3]. We will first consider the galaxies born in BE.

In earlier communication [2] the author derived the following relationship between the distance from a distant galaxy and the Earth D_G and Earth's age A_E:

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[1] Strictly speaking, more common values are: ħ (= h/2π = 1.05×10^{-34} J sec) or ħ/2. For simplicity, the author prefers h.

[2] In what follows, we will define nearby galaxies as those whose redshift z_G is from 0.001 to 0.1 (or $0.001 \leq z_G \leq 0.1$) and distant galaxies with $z_G > 0.1$. Of course, there is no sharp line between nearby and distant galaxies [1].

$$D_G = cA_E \quad \ldots (1).$$

Premović [4] proposed that this distance can be expressed by the following formula:

$$D_G = \mathcal{N}\lambda$$

where $\mathcal{N}$ is an extremely large natural number.[3] Using eqn. (1), we find the variation of D_G

$$\Delta D_G = c\Delta A_E \ldots (2).$$

Obviously,

$$\Delta D_G = \boldsymbol{n}\lambda \quad \ldots (3)$$

where $\boldsymbol{n}$ is a natural number that would be extremely less than $\mathcal{N}$ but greater or equal to 1. Combining the equations (2) and (3) and after a bit of algebra, we get

$$\boldsymbol{n}\lambda/c = \Delta A_E.$$

We know that $\lambda/c = 1/\nu$, where ν is the frequency of light emitted by a nearby or distant galaxy. Substituting λ/c of the above equation with $1/\nu$ and after dividing it with the Planck constant, we obtain

$$\boldsymbol{n}(1/h\nu) = \Delta A_E/h.$$

Of course, $h\nu$ represents the accompanying change in energy ΔE. Substituting $h\nu$ in this equation with ΔE and rearranging, we arrive at

$$\Delta E\Delta A_E = \boldsymbol{n}h.$$

Since $\boldsymbol{n}$ is a small natural number greater or equal 1, than

$$\Delta E\Delta A_E \geq h \quad \ldots (4).$$

Let us now consider the galaxies born in AE. Premović [3] also derived the relationship between the distance D_G of an AE galaxy and its age A_G

$$D_G = cA_G.$$

By applying a similar mathematical procedure as above for the BE case, we find

$$\Delta E\Delta A_G \geq h \quad \ldots (5)$$

[3] For example, nearby "megamaser" galaxy NGC 1052 (with a negligible peculiar motion) is at a distance 65 Mly [4, and references therein]. Suppose that this galaxy emits a spectral line at about 650 nm (or 6.5×10^{-7} m). Then, using the eqn. (2), we calculate $\mathcal{N} \approx 10^{30}$.

where ΔE is the accompanying change in energy ΔE.

Therefore, eqns. (4) and (5) can be interpreted as the "cosmic" energy-time uncertainty relations for the BE and AE galaxies, respectively.

References

[1] P. I. Premović**,** *Nearby and distant galaxies: a brief note*. The General Science Journal, August 2024.
[2] P. I. Premović, *The age of the "megamaser" galaxies in the Big Bang Universe*. The General Science Journal, December 2021.
[3] P. I. Premović, *A simple way to show space-time expansion*. The General Science Journal, December 2021.
[4] P. I. Premović, *The Big Bang Universe and the Principle of energy conservation.* The General Science Journal, December 2021.