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The Principle of Energy Conservation and the Light Emitted by the Nearby or Distant Galaxies

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Abstract. By postulating that the Principle of energy conservation is not valid for the energy of photons emitted by the nearby and distant galaxies we find that the speed of light and the fine structure constant are invariant throughout the age of the Universe, but the rest energy of the Universe's atomic hydrogens follows the above principle. In contrast to the standard cosmology, we find in this case that time flows at a lower rate in the current Universe than in the past Universe. However, if the energy of these photons follows the above principle then the speed of light and the rest energy of the Universe's atomic hydrogens decrease throughout the age of the Universe but the fine structure constant and time flow are invariable.

Keywords: Principle of energy conservation, galaxy, speed of light, scale factor,
time flow, fine structure constant, rest energy.

Introduction. Cosmological redshift z is characterized by the relative difference between the observed and emitted wavelengths of light which is sourced by a nearby or a distant galaxy[1] (hereinafter galaxy). This shift is a direct consequence of the cosmological expansion. It can be defined as

$$1 + z = \lambda/\lambda_t \quad \ldots (1)$$

where λ_t is the wavelength at which the light (in the cosmological past) has been emitted by the source of the galaxy and λ is the wavelength of this light measured by an observer after its arrival to the Earth. If $z > 0$ then the galaxy's light redshifted; if $z < 0$ the galaxy then its light blueshifted. Often, a blueshift is referred to as a negative redshift.

Results/Discussion/Conclusions. Knowing that the product of the speed of light c ($\approx 3 \times 10^8$ m sec^{-1}) and frequency a photon equals to its wavelength, eqn. (1) can be expressed in the following form

$$1 + z = c\nu_t/c\nu = \nu_t/\nu$$

where ν_t/ν are the corresponding photon frequencies.

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[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 and galaxies with $z > 0.1$ [1, 2]. Of course, there is no sharp line between nearby and distant galaxies.

Multiplying/dividing the central part of this expression with Planck's constant h (= 6.34×10^{-34} J sec) and after a bit of algebra and canceling c, we get

$$1+z = h\nu_t/h\nu$$

where $h\nu_t$ is the energy E_t of a photon (or light) emitted by a galaxy and $h\nu$ is the energy E of this photon (or light) measured by Earth's observer. As $\lambda > \lambda_t$ or $\nu_t > \nu$ then $E_t > E$ or the photon energy is non-conserved. This apparent violation of the Principle of energy conservation by the cosmological expansion is one of the major sources of concern in cosmology. This principle, as one of the basic laws of physics, is not violated by any known process. Several approaches have been offered to solve this problem but none of them is completely satisfactory.[2]

The redshift of galaxy's light z is directly linked to the scale factor values at the time when this light is emitted, a_t, and the time when it is examined, a, by an Earth's observer or mathematically

$$1 + z = a/a_t.$$

At present time the scale factor a is considered to be 1 and we write

$$1 + z = 1/a_t = \lambda/\lambda_t = \nu_t/\nu.$$

So, the expansion of the Universe decreases the frequency of the light coming from a galaxy. Since the frequency is inversely proportional to the period, it increases In other words, by the expansion of the Universe time dilated. According to the standard cosmology[3], time in cosmological past is dilated or it is inversely proportional to the age of the Universe.

The fine-structure constant, α (dimensionless number, $\alpha = 1/137.03599$) can be expressed by

$$\alpha = k/c \ \ldots \ (2)$$

where k is a constant.[4] Since the speed of light c has been constant throughout the age of the Universe so has the fine structure constant α.

Most astronomers and cosmologists believe the Universe's formation started with the Bing Bang about 13.8 Gy ago. Atomic hydrogen comprises about 90 % of the current Universe by number density or about 75 % of the Universe by mass. It was created in the early Universe after the Big Bang event. We call it the Universe's atomic hydrogen.

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[2] As Hands [3] simply pointed out: "The only reasonable conclusion is that we do not know whether or how the Principle of conservation of energy can be applied to the Universe".

[3] According to this cosmology, time appears to pass slower in the distant Universe compared to the present. This is cosmological time dilation (predicted by the General relativity) and it is very recently confirmed by Lewis and Brewer [4] by the identification of this dilation in a sample of 190 quasars monitored for over two decades. However, **the** appearance of time dilation in other less distant sources is less conclusive.

[4] $k = e^2/4\pi\varepsilon_0 h = 1/137.03599$) where e is the charge of an electron, ε_0 is the permittivity of free space and h is Planck's constant.

The total energy E of the moving Universe's atomic hydrogen is $E = \gamma m_0 c^2$, where m_0 is its rest mass, c is the speed of light, $\gamma = 1\sqrt{(1 - \upsilon^2/c^2)}$ and υ is its speed to a laboratory frame. This atom is the non-relativistic particle with $\upsilon/c << 1$, so we have $\gamma \approx 1$, and the Universe's atomic hydrogen has the rest energy

$$E_0 = m_0 c^2 \quad \ldots (3).$$

We can extend this equation to the rest energy of all the Universe's atomic hydrogens. So, having in mind the mass conservation law and that the speed of light is constant we conclude that the rest energy of atomic hydrogen atoms is constant over cosmological time. This is in agreement with the Principle of energy conservation.

By adopting in advance, the Principle of energy conservation, Premović [5] recently proposed that the speed of light c_t emitted (in the cosmological past) by a galaxy with the cosmological redshift z is lower by the factor $(1 + z)$ than the (current) speed of this light c ($\approx 3 \times 10^8$ m sec^{-1}) after its arrival to the Earth. In the equation form

$$c_t = c/(1 + z) \quad \ldots (4).$$

For Earth's observer, the speed of light is not constant throughout the Universe but increases with cosmic time reaching its current speed c ($\approx 3 \times 10^8$ m sec^{-1}). This increase can be interpreted as a result of the Universe's expansion as implied by Premović [5]. **Moreover, from the moment the light is emitted from the galaxy, it is independent of the Universe and this galaxy.**

Elementary physics states that the frequency equals the speed of light divided by the wavelength or $\nu = c/\lambda$. If we denote with c_t and λ_t the speed and wavelength of light emitted by a galaxy (in its cosmological past) and with c and λ the speed and wavelength of this light reaching the Earth then we have

$$c_t/\lambda_t = c/\lambda\ (= \nu).$$

Combining this equation with eqn. (4) we have

$$\lambda_t = \lambda(1 + z).$$

Therefore, the wavelength of light emitted (in the cosmological past) by a galaxy with the cosmological redshift z is lower by the same factor $(1 + z)$, as the speed of this light, after its arrival to the Earth. The Principle of conservation, as one of the basic laws in the Universe, implies that the wavelength and speed of light emitted from a galaxy are higher by the same factor $(1 + z)$ when it reaches the Earth. Having in mind eqn. (1), we have

$$1 + z = 1/a_t = \lambda/\lambda_t = c/c_t \quad \ldots (5).$$

So, the expansion of the Universe does not affect the frequency and period of the light coming from the galaxy opposing the above standard cosmology formulation.

Since the speed of light has not been constant throughout the age of the Universe. At first sight, one can conclude that the fine structure constant α has not been constant during this age. However, according to Premović [5], the fine structure constant can be now expressed by the following expression

$$\alpha = c_{\min}/c$$

where $c_{\min}$ is the minimum speed of light is a constant characteristic of the Universe**.**

Taking into account the mass conservation law and that c_t is lower for $(1 + z)$ or a_t times than c ([see the expresion (5)] the rest energy of the Universe's atomic hydrogen E_0 is lower as many times [see eqn. (3)]. However, this is against the Principle of energy conservation.

Therefore, not accepting the Principle of conservation of energy, the energy of light emitted by a galaxy decreases throughout the Universe and the rest energy of the Universe's hydrogen is constant according to this principle. By accepting this principle, the energy of the galaxy's light is constant but the rest energy of the Universe's atomic hydrogen decreases throughout the Universe.

The question now is which of the two mentioned possibilities related to the Principle of conservation of energy can be accepted? Apparently, none.

The cosmological Hubble law is a consequence of an expanding Universe, as predicted by the Big Bang theory. Hubble measured the actual distance to the nearby galaxies (using the concepts of standard candles), and their recessional speed (using the redshift of their light emitted) to create his Hubble diagram and his law. This law is usually expressed by the following relationship

$$cz = H_0D_0.$$

where H_0 is the Hubble constant and D_0 is a distance between the Earth and galaxy. Without adopting the Principle of energy conservation $z = \lambda/\lambda_t - 1$, but adopting this law we have an additional equation $z = c/(c_t - 1)$. This law is valid for about $z \leq 0.1$. For the present-day Earth $z = 0$ and according to this last formula $c_t = c$.

In fact, H_0 is not constant and varies over cosmological time. It is more appropriate to call it Hubble parameter and mark as $H(t)$. Now, in general case, we express the Hubble law with this equation

$$c_tz = H_tD_t.$$

Combining this equation with $c_t = c/(1 + z)$ and $1 + z = 1/a_t$ we arrive to

$$a_t = H_tD_t/H_0D_0.$$

Finally, to explain the redshift of the galaxy's light in the infinite, Euclidean and static Universe, Premović [1] hypothesized that this light has a superluminal speed when it reaches the Earth. Now we can explain this redshift [$z = \lambda/\lambda_t - 1$], see above] by assuming that light emitted from a galaxy in such a universe has a subluminal speed c_t [$= c/(1 + z)$, see (5)].

References

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