the general science journal

Non Velocity Interpretation of the Cosmic Redshift – Cosmological Implications

Laszlo A. Marosi
67061 Ludwigshafen am Rhein
E-Mail: LaszloMarosi@aol.com

Abstract

In this paper, I reconsider the interpretation of Hubble's Law as recession velocity of distant galaxies, in association with novel theories of the physical properties of the quantum vacuum, by assuming thermalization of starlight into a homogeneous black-body energy distribution. I present scientific theories and experimental results supporting the assumption that the proposed equilibration process might take place without any material mediator. The equilibration follows from the interaction between quantum states of the excited spacetime entity, and therefore, energy equilibration has to be looked at as a natural quantum physical process, instead of as a physically unlikely one. Cosmological implications of the presented theory are discussed.

Keywords: Cosmic redshift, Hubble constant, energy equilibration, quantum vacuum, cosmic microwave background, diffuse background radiation, energy conservation.

1. Introduction

According to speculation about the emergence of the universe, the infant universe was an extremely hot dense cauldron of rapidly expanding radiation, and it began with zero baryon number. Baryons were formed later by grand unifying reactions. Tryon [1] proposed the extraordinary idea that the first light in the universe could originate as a vacuum fluctuation, starting from absolutely nothing. Hence, the question about the physical nature of light plays a central role, not only in conventional physics, but in particular, in cosmology.

1.1. What is Light?

'Having spoken of the rays of the sun, which are the focus of the heat and the light what we enjoy, you will undoubtedly ask, "What are these rays?" This is beyond question one of the most important inquiries in physics' [2].
Since Euler's time great progress has been made in exploring the physical properties of light, but, the question 'What is light?' is still unanswered and represents a big mystery of nature.
Common explanations describes light as "a field that, however, in contrast to other known fields like temperature distribution, sound waves or bow waves, light owes its physical reality only to itself. Light cannot be understood as oscillation of something substantial that exists also in the dark. Light is even nothing else as light ... oscillation of abstract quantities, numbers, assigned to discrete points of the empty space. [...] Light is the excitation of the empty space" [3]. Following this vague definition in [3], I take the view that the energy of the photons contained in the universe, the cosmic microwave background (CMB), starlight, and other electromagnetic waves such as diffuse background radiation (DBR), represents the excitation energy of the quantum vacuum above the ground state, and that this energy exists in discrete energy wave packets called photons. The term "light" (photons), in the context of

the above definition, differs from the conventional idea of light in the following way. The sum of the radiation energy $\sum E_{Ph}$, represents a global spacetime property with pressure $p = \rho_{Ph}$, and connotes a synonym for, and measure of, the excitation energy of the quantum vacuum whose numerical value is equal to the energy of the homogeneous photon radiation field. (This pressure p, must not be confused with the mechanical nature of radiation pressure, where individual photons are pushing outward on something substantial.) I will now discuss the physical properties of the energetically excited quantum vacuum and its possible role in cosmology.

2. Physical Properties of Energetically Excited Baryonic Quantum Systems

According to fundamental laws of physics, energetically excited quantum systems, atoms and molecules for example, are characterized by the following two spontaneously occurring processes:

2.1. The Energy Equilibration Process: For any given quantity of energy contained in the system, the most probable distribution of energy among the different quantum states is the Planckian-type energy distribution which represents the largest entropy state. Every non equilibrium energy distribution will spontaneously settle down into a Planckian-type one.

2.2. Decay of the Excitation Energy: Energetically excited systems tend to relax into a state of lower energy, such as a less excited state or the ground energy state. Atoms and molecules represent intimately interacting quantum entities, and these two processes (2.1. and 2.2.) will inevitably take place, separately or simultaneously, if no energy barrier (such as an activation energy for example) exists to cause the system to wind up in a local minimum of energy.

3. Physical Properties of the Excited Quantum Vacuum

Similar to baryonic systems, there are convincing physical reasons to assume that the energy associated with the excited quantum vacuum will show a similar behavior to the energy associated with atoms, subatomic particles, or molecules. The two processes described above, energy equilibration and relaxation of the quantum system into a less excited state or the ground state will also occur for the case of the quantum vacuum.

3.1. Energy Equilibration Process

In quantum field theory, the vacuum is described as a quantized, fine grained, dynamical medium; waves propagating in this medium can be described as excitation of specific quantum states. Because all constituents of the excited vacuum (photons, real and virtual particles, and possibly also space and time) are quantum mechanical, it is safe to assume that energy exchanges will take place between these constituent components, as they do in baryonic quantum systems, and that the equilibrium state of these energetically interacting fields is the probability, i.e., the black-body energy distribution. Energy equilibration also follows from the principle of maximum entropy, which states that the probability distribution has the largest entropy, and is the thermodynamically favored energy distribution. For photons (the excited quantum vacuum), the equilibrium state is the well-known Planckian type black-body energy distribution [4].
The following experimental results support of the proposed energy equilibration process:

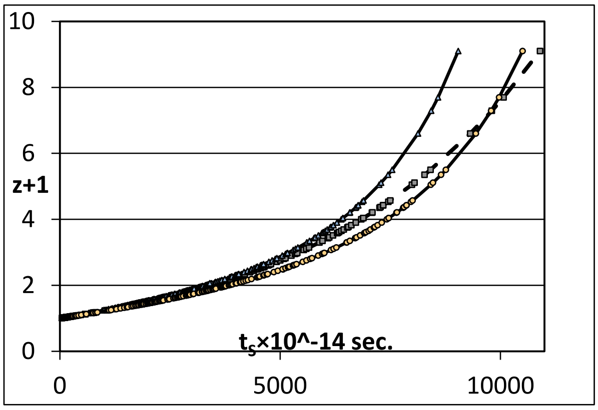
3.2. The Exponential Hubble Law

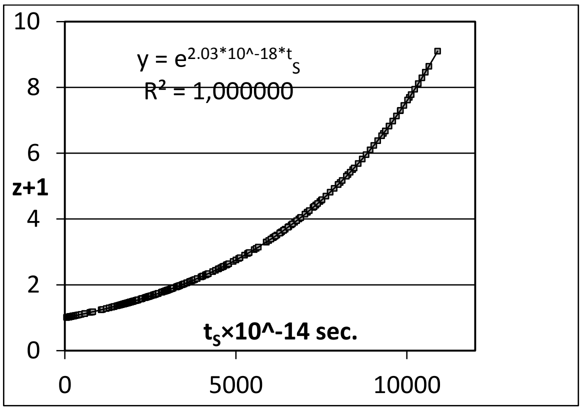
A Hubble diagram test of 280 supernovae, and gamma ray burst redshift (RS) data (z), has shown that the distance/RS relation obtained from the analytical function [5–7]

$$z = 25 + 5\log(\frac{c}{H_0}) + 5\log((z+1)\ln(z+1)), \quad (1)$$

precisely fits the measured distance/RS data points. It can be exactly expressed by the exponential function $z = e^{2.024*10\text{-}18*t_s} - 1$ [8, 9], where t_s is the time of flight of the photons between emission and detection; $t_s = D_c/c$ (c is the velocity of light), which is proportional to the D_c (give definition of Dc here) that is entered in the linear Hubble law.

In spite of numerous correction factors and unknown constituents such as dark matter (DM) and dark energy (DE), Lambda cold dark matter (ΛCDM) models show poor agreement with the observed data. In Figure 1a the ΛCDM model with H_0 = 62.5 km s $^{-1}$ Mpc^{-1} departs from the best-fit curve for z + 1 < 6.5 under the trend-line, and for z + 1 > 6.5 on the upper side of the trend-line. The deviations are of a systematic (nonstatistical) nature and, therefore, the model cannot reflect the observational exponential slope. For z > 3 the ΛCDM model with H_0 = 72.6 km s $^{-1}$ Mpc^{-1} shows a sharp increase in slope and departs considerably from the observed exponential function. The exponential slope of the Hubble diagram strongly supports energy decrease of starlight with a constant rate, which is characteristic of the tired light model.





a) **b)**

Figure 1. (a) Redshift of type Ia supernovae as a function of $t_S = D_C/c$. Squares (dashed line): t_S/z data inferred from the potential best-fit curve of the observed z/μ diagram. Triangles: (upper line) t_S/z relationship derived from the ΛCDM model with H_0 = 72.6 km s^{-1} Mpc^{-1}. Circles: (bottom line) t_S/z relationship derived from the ΛCDM model with H_0 = 62.5 km s $^{-1}$ Mpc^{-1}. (b) Squares: t_S/z data inferred from the potential best-fit curve of the observed z/μ diagram; solid line: exponential trend-line (Excel). Data are taken from [9].

3.2.1. The Missing Diffuse Background Radiation

Besides the CMB, the universe also contains a considerable amount of radiation not belonging to the blackbody spectrum, which is called diffuse background radiation (DBR). DBR is expected to arise from cumulative emissions of pregalactic, protogalactic, and evolved galactic systems over the history of the universe, assuming that star formation is the major source of the observed background [10]. It is to be expected that DBR would establish a certain radiation temperature of the interstellar space, in the same way that the CMB does. There are numerous estimates of this temperature. A compilation of these results is shown in Table 1.

Table 1: Estimates of the temperature of the interstellar space. Data are taken from [11, 12].

Measured by	Temperature (K)
Guillaume	5 – 6
Eddington	3.18
Regener	2.8
Herzberg	2.3
Nernst	2.8
Finlay-Freundlich	1.9 - 6

It is a surprising fact that all of these similar estimates deviate considerably from the experimental data. Sky brightness measurements by COBE, DIRBE, and FIRAS have permitted the first quantitative results of the diffuse cosmic background (or DBR) at all wavelengths. They show that infrared radiation in the range from 0.3 to – 200 μm is the major contributor to the total DBR energy. It amounts to only 10 % of the expected value [13–15]. Thus, it is legitimate to question if all of these careful estimates carried out by notable physicists are really so much in error? Is it more likely that the lack of DBR energy can be seen as evidence in favor of the presented theory, namely as a steady flow of energy from starlight into the CMB by the proposed energy equilibration process.

3.2.2. Tests on the Expansion of the Universe

Big Bang cosmologies are based on the assumption that the universe is expanding according to the Hubble law with a velocity of H_0 = 72.6 km s^{-1} Mpc^{-1}. Since one cannot measure the expansion experimentally, different tests based on observational data have been proposed to provide evidence for the expansion hypothesis. These include (i) the Tolman surface brightness test, (ii) the time dilation test, (iii) the CMB temperature as a function of the RS test, (iv) the apparent magnitude versus distance test, (v) the angular size versus RS test, (vi) the UV surface brightness test, and (vii) the Alcock–Paczynski test. All of these have been proposed as possible observational evidence for the expanding space paradigm. Recently, Lopez-Corredoira [16, 17] and Crawford [18] critically reviewed the results of these tests and concluded that convincing evidence for the cosmic expansion hypothesis is still lacking. The static or slowly expanding [19] universe models fit the observational data better than expansion models. The exponential slope of the Hubble diagram, the missing DBR, and the results of the expansion tests are strong indicators in favor of the proposed equilibration process. With this, the interpretation of H_0 as an expansion velocity appears disputable.

3.3. Interpretation of the Hubble Constant as Recession Velocity — The Root of the Greatest Problems in Current Cosmology

The interpretation of the RS of atomic spectral lines emitted by distant galaxies as recession velocity was probably the most important contribution leading to the conception of the Big Bang theory. This is a highly successful theory for explaining the origin and expansion of the universe, the abundance of light elements, and the existence of the 2.7 K cosmic microwave background, demonstrating that its basic assumption, i.e., the expansion of the universe, is a legitimate global concept.

At the same time, however, we have to bear in mind that, as a counterpart to its great success, this interpretation was the most compelling evidence for introducing the elusive dark components — DM and DE — into cosmology. Nearly all of the major problems of modern cosmology have their origins in this hypothesis. We mention only a few here. (i) The missing mass problem; the density of matter which has been observed so far amounts to only a few percent of the critical value. (ii) A further problem is related to the age of the universe, which almost corresponds to the age of its oldest stars. However, it is impossible for baryonic matter to form galaxies and large-scale structure in a time as short as 10 – 20 billion years. (iii) The cosmological constant problem; Λ is usually interpreted as the energy contained in empty space. However, the estimated energy of the vacuum exceeds the value required by the ΛCDM model by 120 orders of magnitude. The tiny value of the cosmological constant represents one of the greatest problems of present day cosmology.

Many cosmologists consider the postulation of DM and DE as the main finding of present day astrophysics. Speculations about the physical nature of these unknown particles and energy are numerous, but have not yet been successful. If the search for DM and DE turns out to be unsuccessful, the whole construction will break down, and we shall face the unavoidable question about what the real mechanism that produces the observed values of the RS is.

3.4. New Interpretation of the Hubble Constant

I provided arguments that Planck's formula probably continues to be valid in every quantum system, in atomic, solid state systems, and even also in the excited quantum vacuum itself. Thus, energy equilibration is an inevitable physical process rather than a theoretically unfounded physical assumption. In common with atomic and molecular quantum systems, energy equilibration is an inherent property of the excited quantum vacuum. It does not require any material mediator in order to occur. With this interpretation, the Hubble constant (H_0) represents the velocity constant (Hz s^{-1} Hz^{-1}) of thermalization of every non equilibrium photon (starlight, for example) into the Planckian type equilibrium energy distribution.

4. Cosmological Implications - Expansion of the Universe

According to speculation about the emergence of the universe, the infant universe was an extremely hot dense cauldron of rapidly expanding radiation, and it began with zero baryon number. After a short inflationary period, driven by the vast amount of the repulsive excitation energy, some of the radiation condensed into elementary particles and single atomic nuclei. The attractive force of gravitation comes into being during this short era of matter formation. The physical processes leading to the formation of baryons and photons, with a fixed ratio $\Omega = N_B/N_\lambda$, were governed by microphysics and have nothing to do with initial conditions [20–22]. The law of conservation of energy requires that the total energy in the universe, as measured by the space curvature $(GM/R) - (\kappa\psi/R)$, must have zero net value. The universe settled down to a quasi-steady-state with an exact balance between the attractive (gravitational) and repulsive (excitation energy pressure) forces. The major problem with any such stationary state equilibrium is how to start the present expansion process.

As a new approach to explain the physical nature of the cosmological constant, I postulated [23] that the repulsive force responsible for the expansion of the universe is associated with the excitation energy of the quantum vacuum; this energy is represented by the energy of the photons contained in the universe whilst zero-point energy (ZPE) has no cosmological effect [24]. We have

$$\left(\frac{\overset{\bullet}{R}}{R}\right)^2 = \frac{2}{R^2}\frac{GM}{R} - \frac{2}{R^2}\frac{\kappa\psi}{R} = 0\,, \tag{2}$$

where M = $\rho_M \times V$, $\Psi = \rho_\lambda \times V$, ρ_M and ρ_λ are the mass and radiation energy densities today, and κ is a constant to convert the present radiation energy density into energy g^{-1}. The numerical value of κ can be calculated as $\kappa = G\times\rho_M/\rho_\lambda = 10^{-25}$ cm g^{-1}.

The presented model provides a plausible mechanism for the expansion which started from an apparently steady-state origin; primordial underdensities generated during the early stage of evolution represent centers of expansion, and are the seeds for formation of the cosmic large-scale structure. Because mass underdensities are regions of suppressed gravitational attraction, the repulsive force exerted by the still-homogeneous photon field overwhelms the gravitational attraction, causing such regions to expand. The observed large-scale structure of the universe is in support of this expansion mechanism. Measuring the clustering of bright galaxies has shown that the three-dimensional distribution of luminous matter has a soap bubble like appearance, with the visible galaxies on the surfaces of the soap bubbles [25]. The galaxies are situated in walls, filaments, and dense nodes, and form a network which surrounds huge voids. The voids occur on scales of 100 Mpc and are free of matter. The excess of radiation energy inside empty spaces causes a true instability, which can drive the cosmic expansion due to the postulated repulsive force of that radiation.

According to the presented hypothesis, the energy loss of the excitation (expressed by the energy of the photons) takes place by doing work against the gravitational attraction of the baryons. The energy decrease of the CMB is equal to the work done by the repulsive excitation energy in the expansion of the universe versus the gravitational attraction of the baryons. We have

$$\Lambda E\lambda = \int_{R_1}^{R_2} G\frac{M^2}{R^2}\,dR = -\left(\frac{GM^2}{R_1} - \frac{GM^2}{R_2}\right) \tag{3}$$

And

$$Z = \frac{\lambda_2 - \lambda_1}{\lambda_1} = \frac{E_1}{E_2} - 1 = \frac{GM^2/R_1}{GM^2/R_2} - 1 = \frac{R_2}{R_1} - 1\,. \tag{4}$$

5. Conclusions

In this paper I reconsider the interpretation of the Hubble constant by introducing the principle of energy equilibration between starlight and the CMB. I present quantum theoretical arguments and cosmological observations which support the hypothesis that the proposed equilibration process follows from the interaction between quantum states of the excited spacetime entity. Therefore, energy equilibration has to be looked at as a natural quantum physical process rather than something which is physically unlikely.

This new approach — that the excitation energy of the quantum vacuum, expressed by the energy of a homogeneous photon field, could act as a repulsive scalar field — differs from previous discussions about the physical nature of the decaying cosmological constant. Instead of presupposing repulsive scalar fields of an unknown physical nature, we introduce a homogeneous density of radiation sources. An advantage of this approach is that expansion works with forms of matter and radiation that are known to be present in the universe today, and provides a natural explanation for the flatness or fine-tuning problem without the need for dark matter and dark energy.

Accurate observations of the CMB anisotropy show that the universe is flat [26]. Following the paradigm of the Big Bang theory (kinetic energy = ½ gravitational energy), the critical mass for a flat universe $\rho_{CR} = \frac{3H^2}{8\pi G}$ (H_0=72.6 km s^{-1} Mpc^{-1}) corresponds to a mass density of $\approx 10^{-29}$ g cm^{-3}. In contrast, the density of matter which has been observed so far amounts to a few percent of this critical value. In contrast, inferring the Hubble constant from the observable mass and photon densities [23] leads to $H_{Exp.}$ ~ 5 - 6 km s^{-1} Mpc^{-1} and the missing mass problem does not arise on the cosmic scale.

A further problem is related to the age of the universe, which almost corresponds to the age of its oldest stars. The problem is that galaxy formation in a purely baryonic universe does not work. It is impossible for baryonic matter to form galaxies and large-scale structure in a time as short as 10 – 20 billion years. Estimates show that the time necessary for the formation of galaxy clusters amounts to roughly 200 billion years [27]. For comparison, inferring the age of the universe from $1/H_0$ with H_0~5 - 6 km s^{-1} Mpc^{-1}, yields ~200 billion years. Therefore, galaxies may have evolved over time in some regular way without the need for DM or DE.

Another problem with the cosmological expansion relates to the loss of energy associated with the RS. Attempts to explain this loss of energy include some physically questionable arguments; the universe is an open system to which, on the cosmic scale, energy conservation does not apply, or simply use of the statement that the redshifted energy disappears in the quantum vacuum. In the equilibration model there is no real loss of energy associated with the cosmic RS. The energy of the redshifted photons is merely converted into CMB energy and the total energy ($E_{Starlight}$ + E_{CMB}) has not changed.

References

[1] Tryon, E. P. (1973) Is the Universe a Vacuum Fluctuation? Nature, **246**, December 14.

[2] Euler, L. (1835) Letters of Euler on Different Subjects in Natural Philosophy, Vol. 1.

[3] Genz, H. (1994) Die Entdeckung des Nichts, (Nothingness – The Science of the Empty Space) p. 224, Carl Hansen Verlag München Wien 1994.

[4] Santillán, M., de Parga, G. A., and Angula-Brown, F. (1998) Black-body radiation and the maximum entropy production regime, Eur. J. Phys., **19**, 361.

[5] Sorrell, W.H. (2009), Misconceptions about the Hubble Law, Astrophysics and Space Science, **323**, 205

[6] Vigoureux, J.M., Vigoureux, B., and Langlois, M. (2014) An Analytical Expression for the Hubble Diagram of Supernovae and Gamma-Ray Bursts. arXiv:1411.3648v1.

[7] Traunmüller, H. (2014) From Magnitudes and Redshifts of Supernovae, Their Light-Curves, and Angular Sizes of Galaxies to a Tenable Cosmology. Astrophysics and Space Science, **350**, 755, http://dx.doi.org/10.1007/s10509-013-1764-z.

[8] Marosi, L.A. (2014) Hubble Diagram Test of 280 Supernovae Redshift Data. Journal of Modern Physics, **5**, 29, http://dx.doi.org/10.4236/jmp.2014.51005

[9] Marosi, L. A. (2016) Modeling and Analysis of the Hubble Diagram of 280 Type SNIa Supernovae and Gamma Ray Bursts Redshifts with Analytical and Empirical Redshift/Magnitude Functions, International Journal of Astronomy and Astrophysics, **6**, 272, doi: 10.4236/ijaa.2016.63022.

[10] Fixsen, D. J., Dwek, E., Mather, J. C., Bennett, C. L., and Shafer, R. A. (1998) ApJ, **508**, 123.

[11] Assis, A. K. T., and Neves, M. C. D. (1995) Astrophysics and Space Science, **227**, 13

[12] Assis, A. K. T., and Neves, M. C. D. (1995) Apeiron, Vol. 2, Nr. 3, 79

[13] Henry, R. C. (1999) ApJ, **516**, L49–L52.
[14] Biller, S.D., Akerlof, C. W., Buckley, J. et al. (1995) ApJ, **445**, 227
[15] Hauser, M. G., Arendt, R., Kelsall, G. T., et al. (1998) ApJ, **508**, 25.
[16] López-Corredoira, M. Observational cosmology caveats and open questions in the standard model, http://arxiv org/abs/astro-ph/0310214.
[17] López-Corredoira, M. Tests for the Expansion of the Universe, [astro-ph.CO] [astro-ph.CO].
[18] Crawford, D. (2011), Observational Evidence Favors a Static Universe Part I J. Grav. Cosmol., **13**, 3875
[19] Marosi, L.A. (2013) Hubble Diagram Test on Expanding and Static Cosmological Models: The Case for a slowly Expanding Flat Universe, Advances in Astronomy, Article ID 917104, http://dx.doi.org/10.1155/2013/917104
[20] Yoshimura, M. (1978) Physical Reviews Letters, **41**, 281.
[21] Weinberg, S. (1979) Physical Reviews Letters, **42**, 850.
[22] Zee, A. (1980) Physical Reviews Letters, **44**, 703.
[23] Marosi, L.A. (2012) The Photon-Baryon Governed Universe, Physics Research International, Article ID 640605, doi: 10.1155/2012/640605.
[24] Guang-jiong Ni, Zero-point energy of vacuum fluctuation as a candidate for dark energy versus a new conjecture of antigravity based on the modified Einstein field equation in general relativity, https://arxiv.org/pdf/physics/0506017.
[25] Landy, S. D. (1999) Scientific American, June, 38.
[26] deBernardies, P. et al. (2000) Nature, **404**, 955.
[27] Korbmann, R. (1990) Bild der Wissenschaft, **7**, 3.