A Simple Relativistic Cosmology of the Universe

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Abstract

The paper presents a relativistic extension of Newton's mechanics, termed *Newtonian Relativity*, and utilizes it to infer the state of the observable universe. The theory is successful in making significant predictions regarding the accelerating nature of the universe, its composition of matter, dark matter and dark energy, and regarding the time-line of the evolution of chemical elements. The theory yields simple expressions for the dynamics of normal matter, dark matter, kinetic energy and dark energy, in their dependence on redshift. It also yields simple expressions for the prediction of Ω_{matter} and Ω_{Λ} for any given redshift range. Predictions from these expressions are compared with observations based ΛCDM cosmologies. Strikingly, the theoretical distribution of the kinetic energy density in the universe is bell shaped and symmetrical around the famous Golden Ratio. With regard to the evolutionary time-line of chemical elements, the theory predicts that the chemical elements may have been formed *twice*: first, in massive galaxy structures at the early universe, and second, in young galaxies in the recent history of the universe.

Keywords: Relativity, Accelerating Universe, Dark energy, Dark matter, Ionization.

1. Introduction

The discovery of cosmic acceleration is arguably one of the most important developments in modern cosmology. Conclusive evidence from supernovas and other observations show that despite gravitation, the universe is expanding with acceleration [1–3]. Nonetheless, the physical origin of cosmic acceleration remains a deep mystery, which ranks among the most compelling of all outstanding problems in physical science. Other big challenges modern cosmology faces are the nature of dark matter and dark energy, the constraints that could be placed on the evolution of the universe and its galaxy constituents, and how to map the cosmic particles and atoms re-ionization. No existing theory is capable of explaining what dark energy is, but it is widely believed that it is some unknown substance with an enormous anti-gravitational force, which drives the galaxies of our universe apart. It is also well established that at our time, the universe is composed of about 4.6% atoms, 72% dark energy, and 23% dark matter (see, e.g., [4]). Although current cosmological Λ models refer to Einstein's cosmological constant (λ), adherence to general relativity requires that for $\lambda \neq 0$, its magnitude should be $\approx 10^{120}$ (!) times the measured ratio of pressure to energy density [4]. An alternative explanation argues that dark energy is an unknown dynamical fluid, namely, one with a state equation that is dynamic in time. This type of explanation is represented by theories and models that differ in their assumptions regarding the nature of the state equation dynamics [5–7]. This explanation is no less problematic, because it entails the prediction of new particles with masses 35 orders of magnitude smaller than the electron mass, which might imply the existence of new forces in addition to gravity and electromagnetism [4]. At present, no persuasive theoretical explanation accounts for the existence, dynamics, and magnitude of dark energy and its resulting acceleration of the universe.

Dark matter is more of an enigma than dark energy. Scientists are more certain about what dark matter is not than about what it is. Some contend it could be baryonic matter tied up in brown dwarfs or in chunks of massive compact halo objects “or MACHOs” [8-10], but the common prejudice is that dark matter is not baryonic, and that it is comprises particles that are not part of the “standard model” of particle physics. Candidates that were considered include very light axions and weakly interacting massive particles (WIMPs) that are believed to constitute a major fraction of the universe’s dark matter [4, 11–13]. Given the frustrating lack of knowledge about the nature of dark energy and dark matter, most experts contend that understanding the content of the universe and its cosmic acceleration requires nothing less than “discovering a new physics” [13]. For example, the Dark Energy Task Force (DETF) summarized its 2006 comprehensive report on dark energy by stating that the consensus among most physicists is that “nothing short of a revolution in our understanding of fundamental physics will be required to achieve a full understanding of the cosmic acceleration” [4, see p. 6]. This statement includes the possibility of reconsidering Einstein’s Special and General relativity altogether.

An important issue in current cosmology pertains to the time-line of ionization of chemical elements, starting from the recombination epochs (at $z \sim 1100$ to $z \sim 6$) and the formation of the first cosmological structures and first stars, until the emergence of the cosmic web as we know it today [14]. Although this field is still poorly understood, results of major technological developments of observational facilities, including the *Wilkinson Microwave Anisotropy Probe* (*WMAP*), has enabled the detection of GRBs at $z \sim 6$ [e.g., 15-17] to $z \sim 20$ [18]. Data collected in various observations support a re-ionization epoch in the redshift range $z \sim 10$–25, depending on the details of re-ionization [19], and analytical calculations [e.g., 20, 21], which rely on ΛCDM, predict various rates of evolution of the global signal, depending on the details of the evolution of the Lyα and x-ray backgrounds [14].

In the present paper, I propose a simple cosmology based on a relativistic extension of Newton’s mechanics. The remainder of the paper is organized as follows: section 2 gives a brief account of the theory. Section 3 applies the theory to infer the universe recession velocity and acceleration.

In section 4, I propose a relativistic definition of dark matter and dark energy and utilize them to provide estimates of the relative amounts in the universe of matter, dark matter, kinetic energy, and dark energy. Section 5 gives a glimpse of how the theory could be implemented to infer the time-line of evolution of chemical elements. Section 6 concludes.

2. Theory

The theory, detailed elsewhere [22], is termed Newtonian Relativity simply because it is an extension of Galileo-Newton mechanics to the domain of relativistic velocities. The theory has no postulates, except the well accepted principle that sufficiently low (non-relativistic) velocities, the laws of physics in all internal frames reduce to the classical Galileo-Newton mechanics. For cosmological applications I also assume that information regarding physical entities is translated from one frame of reference to another via light and electromagnetic waves of equal velocity.

The requirement that at low velocities the laws of physics are classical Galileo-Newton laws has a profound implication on the strategy used in the proposed theory. Not only must we expect that all laws should converge at low velocities to the laws of classical mechanics; we must also require that any relativistic effect should be *uniquely* a function of relative velocities. A major advantage of Newtonian relativity lies in the fact that it maintains a smooth and natural continuity between relativistic and classical (non-relativistic) physics.

Note that the assumption that information from one frame of reference to another is translated by light or other electromagnetic waves is motivated by practical considerations, not by theoretical necessity. In fact, the proposed theory could be applied to any information carrier. The only theoretical requirement is that the velocity of the carrier is isotropic with regard to the observer's frame. Nonetheless, for a theory of cosmology, light and other electromagnetic waves are the only practical choice. An immediate consequence of the above assumption is that the proposed theory is limited to the observable universe. Like in General Relativity, Newtonian Relativity does not require that the recession velocities of cosmological objects, relative to an observer on Earth, do not exceed the velocity of light. The theory allows superluminal velocities, but information emitted from them will never reach Earth.

To derive the term for the Newtonian relativistic time, consider two observers who synchronize their watches just before one of them starts to move in +x direction with constant velocity v. Assume that a certain event started exactly at the time of departure ($t = t'$ = 0). Suppose the event ended when the moving frame was at distance x = d (in the rest frame of the "staying" observer. If the "moving" observer sends a signal to indicate the termination of the event, the signal will arrive at the "staying" observer after time dilation of $\Delta t = \frac{d}{c}$, where c is the velocity of the wave signal relative to "staying." Thus we can write the following:

$$t = t' + \Delta t = t' + \frac{d}{c} \qquad \text{...... (1)}$$

But $d = v\ t$, where v is the velocity of the "moving" frame relative to the "stationary" frame. Substitution in Eq. 1 yields the following:

$$t = t' + \frac{v\ t}{c} = t' + \beta t\ , \qquad \text{...... (2)}$$

where $\beta = \frac{v}{c}$.

Or

$$\frac{t}{t'} = \frac{1}{1-\beta} \quad . \qquad \text{...... (3)}$$

Note that eq. (3) is similar to the Doppler formula, except that the Doppler Effect describes frequency shifts of waves propagating from a departing or approaching wave source, whereas the result above describes the time "shifts" of moving bodies. For two frames that depart from each other, $\beta > 0$, and thus $\frac{1}{1-\beta}$ is larger than one, implying a *time dilation*, whereas for two frames which approach each other, $\beta < 0$, and thus $\frac{1}{1-\beta}$ is smaller than one, implying a *time contraction.* In a cosmology of the evolution of the universe, generally only positive β values are encountered, because for any observer on earth or close to it, the cosmos are in recession.

The relationship between the Doppler formula and eq. 3 is not metaphoric. In [23], I show that the velocity β could be expressed in terms of the redshift z as

$$\beta = \frac{z}{1+z} \qquad \text{…..} (4)$$

Derivations of the distance, mass density, and energy transformations are detailed in [22] and [23]. Table 1 summarizes these transformations in terms of velocity β (first column) and redshift (second column).

In [23], I utilized the above transformations to investigate the dynamics of a typical galaxy with a super massive black hole at its center. Ignoring intergalactic effects, for an observer looking at an entire galaxy, the main analytic results show that for a gravitational, spherical black hole, the radius of the event horizon is equal to the Schwarzschild radius (R= $\frac{2\,G\,M}{c^2}$), with *no singularity at the interior*, and with a *naked singularity* at redshift z = $2^{-\frac{1}{2}} \approx 0.7071$, suspected to be a quasar with extreme velocity offsets or an active galactic nucleus.

Table 1

Transformations

Physical Term	**Relativistic Expression** In Velocity	In Redshift	
Time (sec)	$\frac{t}{t'} = \frac{1}{1-\beta}$	z +1	(5)
Time (round trip)	$\frac{t}{t'} = \frac{2}{1-\beta^2}$	$\frac{2(z+1)^2}{2z+1}$	(6)
Distance (m)	$\frac{x}{x'} = \frac{1+\beta}{1-\beta}$	2z +1	(7)
Mass density (kg/m^3)	$\frac{\rho}{\rho_0} = \frac{1-\beta}{1+\beta}$	$\frac{1}{2z+1}$	(8)
Kinetic energy density e_k	$\frac{1}{2}\rho_0\, c^2 \frac{1-\beta}{1+\beta}\beta^2$	$\frac{1}{2}\rho_0\, c^2 \frac{z^2}{(z+1)^2(2z+1)}$	(9)

3. Recession Velocity and Acceleration

To apply the theory to the entire universe, consider an observer on Earth (z=0). Eq. 4 and Figure 1 depict the universe's *recession velocity* with respect to such observer as a function of the redshift *z*. The qualitative resemblance between the present prediction and the prediction of Special Relativity and of observations based ΛCDM models is easily noticeable. Roughly speaking, deceleration is steeper at epochs between z~30 to z ~ 0.01. The rate of change in β as a function of z is obtained from deriving eq. 4 with respect to z and equating the derivative to zero, yielding the following:

$$\frac{\partial\beta}{\partial z} = \frac{1}{(1+z)^2} \qquad \text{….. (10)}$$

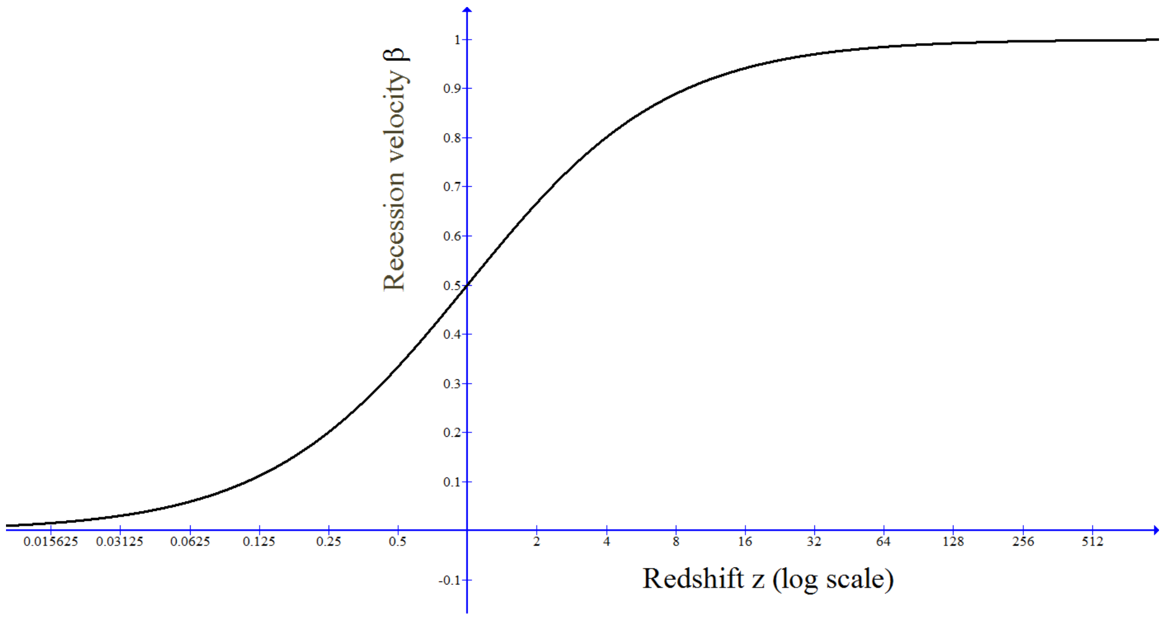

Figure 1. Predicted recession velocity as a function of redshift z

Figure 2 shows the rate of deceleration as a function of the redshift. Inspection of the figure reveals striking Golden Ratio symmetries. At z = $\frac{1}{\varphi}$ ≈ 0.618, we have β =$\frac{\partial\beta}{\partial z}$= $\frac{1}{\varphi^2}$ ≈ 0.382. Moreover, at z = φ ≈ 1,618, we have $\frac{\partial\beta}{\partial z}$ = $\frac{1}{\varphi^4}$ ≈ 0.1458. As the following section will show, the aforementioned symmetry, though fascinating, adds to other, equally striking symmetries in the distributions of kinetic and dark energies.

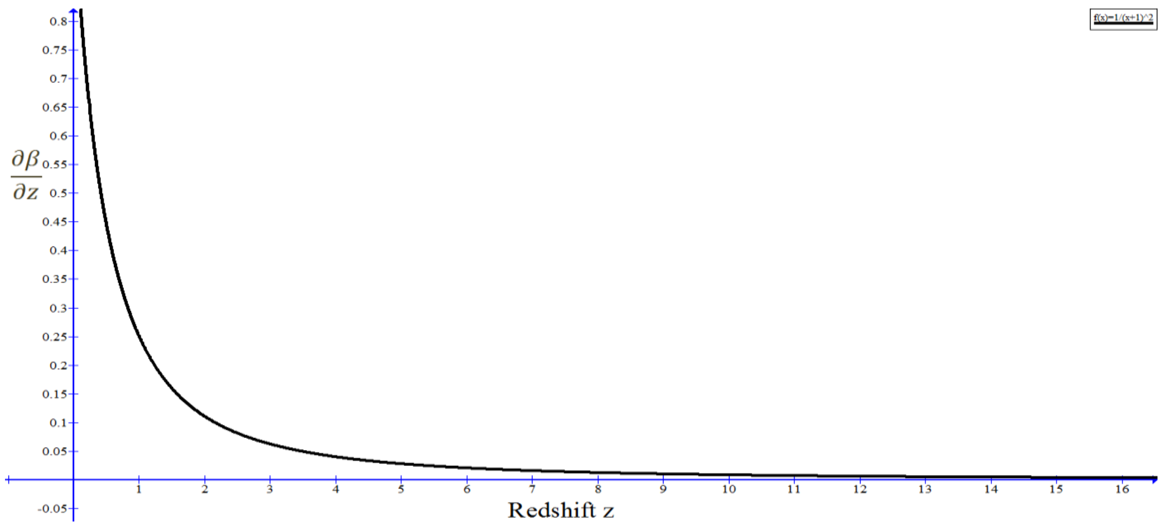

Figure 2 Deceleration as a function of the redshift **z**

Table 2 presents other interesting testable predictions based on the above analyses

Table 2

Symmetries in the dependence of the predicted velocity and deceleration on the redshift

Redshift z	Velocity β	Deceleration $\frac{\partial \beta}{\partial z}$
$\frac{1}{4}$	$\frac{1}{5}$	$\frac{16}{25}$
$\frac{1}{2}$	$\frac{1}{3}$	$\frac{4}{9}$
$\frac{1}{\varphi} \approx 0.618$	$(\frac{1}{\varphi})^2 \approx 0.382$	≈ 0.382
1	$\frac{1}{2}$	$\frac{1}{2}$
$\varphi \approx 1.618$	≈ 1.618	$(\frac{1}{\varphi})^4 \approx 0.1459$
3	$\frac{3}{4}$	$\frac{1}{16}$

4. Dark Matter and Dark Energy

In Newtonian Relativity, dark energy at a given velocity is defined as the difference between the classical kinetic energy measured at the internal frame and the relativistic kinetic energy, measured at the external frame. In other words, **dark energy is defined as the energy loss due to relativity**. Formally, using eq. 9, the dark energy density, $e_d(\beta)$, could be expressed as follows:

$$e_d(\beta) = \frac{1}{2}\rho_0{}^2 v^2 - \frac{1}{2}\rho_0{}^2 c^2 \frac{(1-\beta)}{(1+\beta)}\beta^2$$

$$= \frac{1}{2}\rho_0{}^2 c^2 \beta^2 \left(1 - \frac{(1-\beta)}{(1+\beta)}\right) = \rho_0{}^2 c^2 \frac{\beta^3}{(1+\beta)} \qquad \text{... (11)}$$

Where β is the **recession velocity** with respect to the observer. Similarly, **dark matter at a given velocity is defined as the relativistic loss of matter at that velocity.** In formal notation, $\rho_d(\beta) = \rho_0 - \rho(\beta)$. Using the density transformation (eq. 8), dark matter, $\rho_d(\beta)$, could be expressed as follows:

$$\rho_d(\beta) = \rho_0 - \rho(\beta) = \rho_0 \left(1 - \frac{(1-\beta)}{(1+\beta)}\right) = \rho_0 \left(\frac{2\beta}{(1+\beta)}\right) \qquad ...(12)$$

Or in terms of z:

$$\rho_d(z) = \rho_0 - \rho(z) = 1 - \frac{1}{(2z+1)} = \frac{2z}{(2z+1)}\rho_0 \qquad ...... (13)$$

$$e_d\ (z) = \frac{1}{2}{\rho_0}^2 c^2 \frac{2\left(\frac{z}{1+z}\right)^3}{\left(1+\frac{z}{1+z}\right)} = \frac{1}{2}{\rho_0}^2 c^2 \frac{2z^3}{(z+1)^2(2z+1)} \qquad .....(14)$$

Note that Newtonian Relativity makes no prediction about the nature of dark matter and dark energy. In terms of the theory, "dark" is interpreted to mean they exist in the dark, unobservable range of redshifts.

The redshift at which the densities of baryonic and dark matter are predicted to be equal is obtained from solving the equation $\rho(z) = \rho_d(z)$, or

$$\frac{1}{(2z+1)} = \frac{2z}{(2z+1)} \qquad .... (15)$$

Yielding

$$z = \frac{1}{2}\ \left(\beta = \frac{1}{3}\right) \qquad ..... (16)$$

Figure 3 depicts the distributions of normal and dark matter densities as functions of the redshift z. As the figure illustrates, the two distributions mirror image each other. Normal matter is predicted to dominate the universe up to redshift z = $\frac{1}{2}$, before which dark matter is predicted to have dominated the universe. For small redshifts, the rate of decrease in baryons and the comparable increase in dark matter is relatively slow. It speeds up steeply for intermediate z values, ranging roughly between z and z, and then slows again at about z > 8. In addition to the domination of normal matter at redshifts z < $\frac{1}{2}$ and the domination of dark matter at redshifts z > 0, inspection of the terms in equations 8 and 11 reveal the following symmetries:

At z = $\frac{1}{4}$ $\rho = \frac{2}{3}$ and $\rho_d = \frac{1}{3}$ …… (17)

At z =1 $\rho = \frac{1}{3}$ and $\rho_d = \frac{2}{3}$ ……. (18)

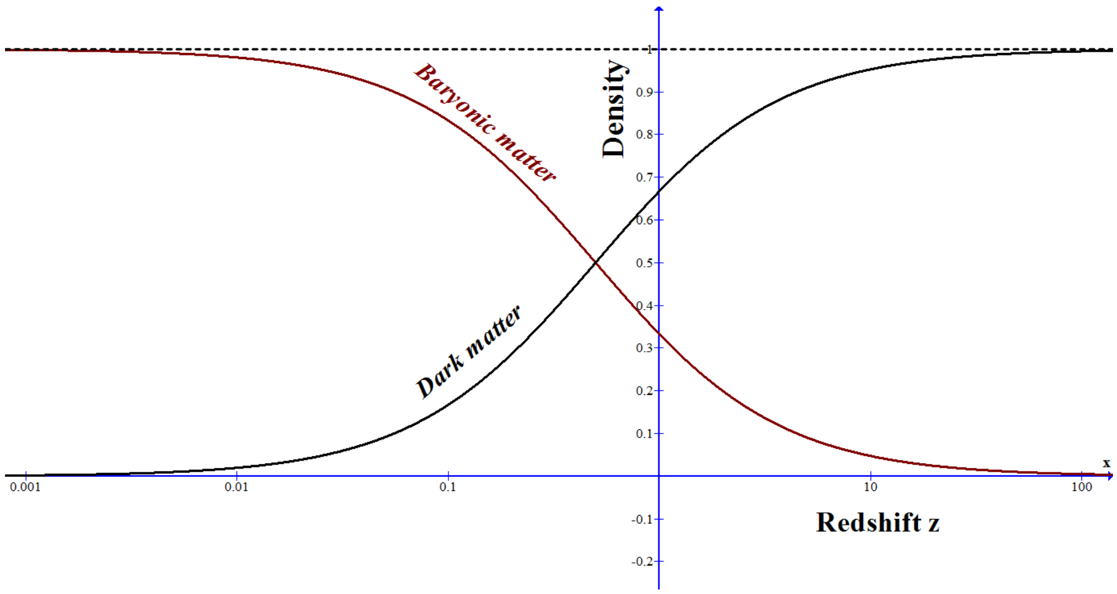

Figure 3. Densities of normal and dark matter as functions of redshift z

Figure 4 depicts the dark and normal *energy* densities as functions of z. The figure reveals a striking symmetry in the distribution of normal energy. As the figure illustrates, the distribution of the kinetic energy density is normal like, centered at the Golden Ratio ($z \approx 1.618$). This result could be verified by deriving the term in eq. 9 with respect to z and equating the result to zero:

$$\frac{d}{dz}\left(\frac{z^2}{(z+1)^2(2z+1)}\right) = \frac{2z\,(-z^2+z+1)}{(z+1)^3(2z+1)^2} = 0 \qquad \text{…. (19)}$$

For $z \neq 0$, we have

$$z^2 - z - 1 = 0 \qquad \text{….. (20)}$$

Or

$$z_{max} = \frac{\sqrt[2]{5}+1}{2} = \varphi \approx 1.618 \qquad \text{…. (21)}$$

Where φ is the Golden Ratio.

With a corresponding recession velocity of

$$\beta = \frac{\varphi}{\varphi+1} = \varphi - 1 \approx 0.618 \qquad \text{…. (22)}$$

The corresponding max value of $\frac{E}{\frac{1}{2}\rho_0\, c^2}$ is given by

$$\frac{e_{max}}{\frac{1}{2}\rho_0\, c^2} = \frac{1-(\varphi-1)}{1+(\varphi-1)}\,(\varphi-1)^2 = \frac{1-(\varphi-1)}{\varphi}\,(\varphi-1)^2 \qquad \text{….(23)}$$

Using the relationship $\varphi - 1 = \frac{1}{\varphi}$, we get

$$e_k(z=\varphi) = e_{knax} = \left(\frac{1}{\varphi}\right)^5 \left(\frac{1}{2}\rho_0\, c^2\right) \approx 0.09016994\,\left(\frac{1}{2}\rho_0\, c^2\right) \qquad \text{….. (24)}$$

The density of dark energy $e_d(z=\varphi)$ is given by:

$$e_d(z = \varphi) = \frac{1}{2}\rho_0{}^2 c^2 \frac{2\varphi^3}{(\varphi+1)^2(2\varphi+1)} \approx 0.29179607(\frac{1}{2}\rho_0{}^2 c^2) \quad \text{..... (25)}$$

And the predicted ratios of kinetic energy and dark energy at z ≈ 1.618 are ≈ 0.24 and 0.76, respectively.

Note that the result in eq. 21 is in agreement with astronomical findings concerning the luminosity of QSOs and AGNs, which indicate a break in luminosity densities at about z=1.6 [24, 25], as well as with the abundance of galaxy clusters at redshifts z ≈ 1.5 - 1.7 [e.g., 26- 31], including a recent discovery of galaxies at redshift equaling exactly 1.618 [32].

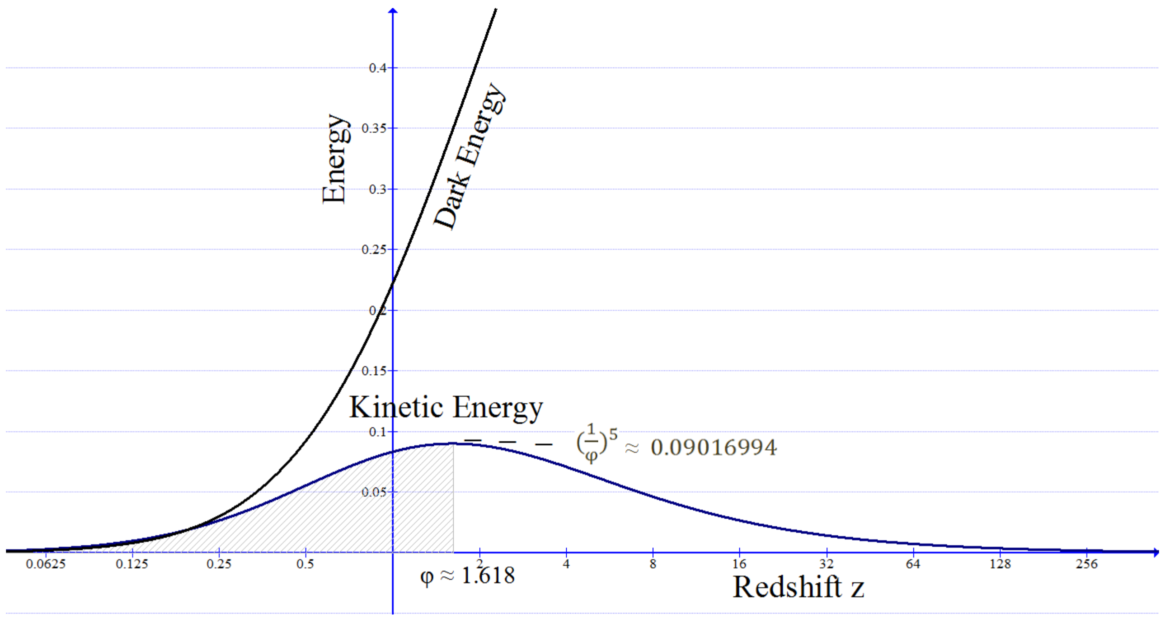

Figure 4. Densities of kinetic and dark energies as functions of redshift z

Figure 5 depicts the ratios of the two energy densities as a function of z. As expected, the dynamic patterns of the relative kinetic and dark energies are identical to the dynamics of normal and dark matter, respectively, with kinetic energy dominating the universe up to redshift z = $\frac{1}{2}$, and dark energy dominating the rest of the history of the universe.

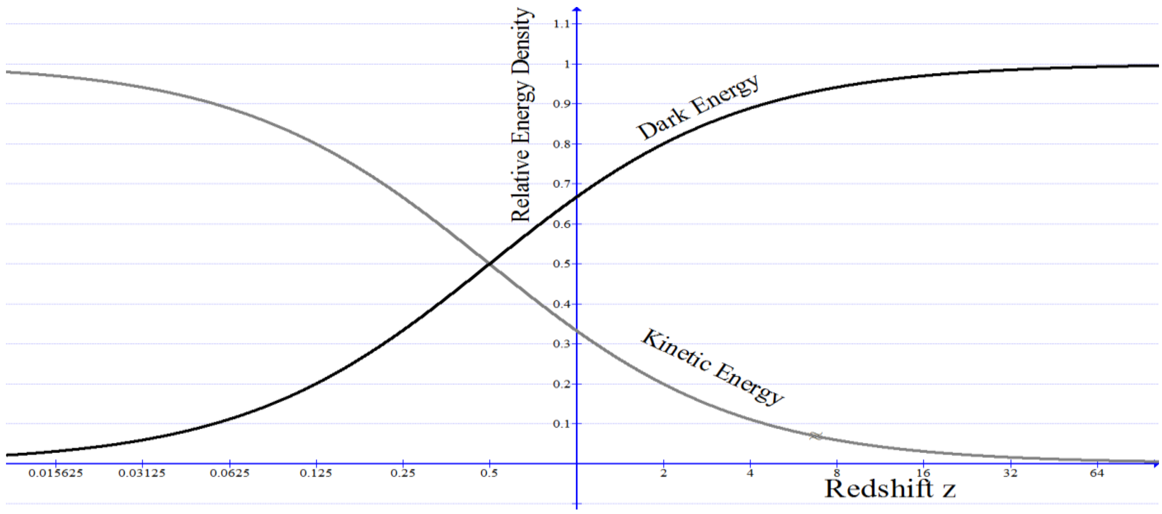

Figure 5. The ratios of the kinetic and dark energy densities as a function of redshift

Content of the Universe

The total normal and dark energy densities in any segment (z_1, z_2), $z_2 > z_1$, are given, respectively, by the following:

$$e_k(z_1 - z_2) = \int_{z_1}^{z_2} e_k(z)\, dz = \frac{1}{2}\, \rho_0\, c^2 \int_{z_1}^{z_2} \frac{z^2}{(z+1)^2(2z+1)} dz = \frac{1}{2}\, \rho_0\, c^2 \left[\frac{1}{2} \ln(2z+1) + \frac{1}{z+1}\right]_{z_1}^{z_2}$$

$$= \frac{1}{2}\, \rho_0\, c^2 \left[\frac{1}{2} \ln\left(\frac{2z_2+1}{2z_1+1}\right) - \frac{z_2-z_1}{(z_2+1)(z_1+1)}\right] \qquad \text{...... (26)}$$

and

$$e_d(z_1 - z_2) = \frac{1}{2}\, \rho_0\, c^2 \int_{z_1}^{z_2} e_d(z)\, dz = \frac{1}{2}\, \rho_0\, c^2 \int_{z_1}^{z_2} \frac{2z^3}{(z+1)^2(2z+1)} dz$$

$$= \left(\frac{1}{2}\, \rho_0\, c^2\right) \left[(z_2 - z_1) + 2\frac{(z_2-z_1)}{(z_2+1)(z_1+1)} - 2\ln\left(\frac{(z_2+1)}{(z_1+1)}\right) - \frac{1}{2} \ln\left(\frac{(2z_2+1)}{(2z_1+1)}\right)\right] \qquad \text{.....(27)}$$

I tested the above results using data from Wittman et al. (2000) [33] who reported the detection of cosmic shear using 145,000 galaxies, at redshift ranging between 1 to 0.6, and along three separate lines of sight. The analysis was based on weak lensing data from COBE and on galaxy clusters. The study concluded the dark matter is distributed in a manner consistent with either an open universe, with $\Omega_b = 0.045$, Ω_{matter} - Ω_b = 0.405, $\Omega_\Lambda = 0$, or with a ΛCDM with $\Omega_b = 0.039$, Ω_{matter} - Ω_b = 0.291, $\Omega_\Lambda = 0.67$, where Ω_b is the fraction of critical density in ordinary (baryonic) matter, Ω_{matter} is the fraction of all matter, and Ω_Λ is the fraction of dark energy.

Because Newtonian Relativity treats the dark and the observed components of the universe alike, I consider only Ω_{matter} and Ω_Λ. In the open universe model, we have Ω_{matter} = 0.045 + 0.405 = 0.45, and $\Omega_\Lambda = 0$, whereas in the ΛCDM, we have Ω_{matter} = 0.039 + 0.291 = 0.33, and $\Omega_\Lambda = 0.67$.

To test the prediction of Newtonian Relativity, I calculated the kinetic energy and dark energy in the redshift range from z=0.6 to z=1. Substitution in equations 26 and 27 gives the following:

$$e_k(z = 0.6 \to 1)= \frac{1}{2}\ \rho_0\ c^2\ [\frac{1}{2}\ln(\frac{2+1}{2 \text{ x } 0.6+1})\ - \frac{1-0.6}{(1+1)(0.6+1)}]$$

$$= \frac{1}{2}\ \rho_0\ c^2\ [\frac{1}{2}\ln(\frac{3}{2.2})\ - \frac{0.4}{3.2}]\ \approx 0.0300775\ (\frac{1}{2}\ \rho_0\ c^2) \qquad \ldots\ldots (28)$$

and

$$e_d(z = 0.6 \to 1) = =(\frac{1}{2}\ \rho_0\ c^2)\ [\ (1-0.6)\ +2\ \frac{(1-0.6)}{(1+1)(0.6+1)} - 2\ \ln(\frac{1+1}{0.6+1}) - \frac{1}{2}\ln(\frac{2+1}{2\text{x } 0.6+1})\ )]$$

$$= [0.4 + \frac{0.8}{3.2} - 2\ \ln(\frac{2}{1.6}) - \frac{1}{2}\ln(\frac{3}{2.2})] \approx 0.0486354\ (\frac{1}{2}\ \rho_0\ c^2) \qquad \ldots.. (29)$$

Thus, the ratios of e_k *and* e_d in $z = 0.6 \to 1$ are

$$\frac{e_k}{e_{tot}} = \frac{e_k}{e_k+e_d} = \frac{0.0300775}{0.0300775 + 0.0486354} \approx 0.382\ (\approx 38.2\%) \qquad \ldots. (30)$$

and

$$\frac{e_d}{e_{tot}} = \frac{e_d}{e_k + e_d} = \frac{0.0486354}{0.0300775 + 0.0486354} \approx 0.618 \; (\approx 61.8\%) \qquad \text{.... (31)}$$

Which is in agreement with the observations based ΛCDM model with ($\Omega_m = \frac{1}{3}$, $\Omega_\Lambda = \frac{2}{3}$). It is also justifiable to calculate the relative densities of kinetic and dark energies from now (z=0) back to the critical redshift z = φ ≈ 1.618. Substitution in equations 26 and 27 yields:

$$e_k(0-\ \varphi\ ) \ = = \frac{1}{2}\ \rho_0\, c^2\ [\frac{1}{2} \ln(\ 2\varphi + 1\ ) - \frac{\varphi}{(\varphi+1))}\ ] \approx 0.1038\ (\frac{1}{2}\ \rho_0\ c^2) \qquad \text{.... (32)}$$

$$e_d(0-\ \varphi) = =(\frac{1}{2}\ \rho_0\, c^2)\ [\ (\varphi + 2\frac{\varphi}{\varphi+1} - 2\ln(\varphi+1) - \frac{1}{2}\ln(2\varphi)] \approx 0.3420\ (\frac{1}{2}\ \rho_0\ c^2) \qquad \text{....(33)}$$

Thus,

$$\frac{e_k}{e_k + e_d} \ = \frac{0.138}{0.138 + 0.3420} \approx 0.233 \text{ (or 23\%)} \qquad \text{.... (34)}$$

and

$$\frac{e_d}{e_k + e_d} \ = \frac{0.3420}{0.138 + 0.3420} \approx 0.767 \text{ (or 76.7\%)} \qquad \text{.... (35)}$$

The above results suggest that if we consider the range of z up to high redshift of ≈ 1.618, the theory prediction is in excellent agreement with the ΛCDM cosmology with Ω_{matter} = 0.23, Ω_Λ = 0.77 (see, e.g., 34-36), and quite close to the Ω_{matter} = 0.26, Ω_Λ = 0.74 cosmology (see, e.g., 37-39).

Equations 26 and 27 can be used to put constraints of future observations based cosmologies. For example, for a cosmology that best fits the entire range from z = 0 to z = 8, we have:

$$e_k(z = 0 - 8) = \frac{1}{2}\ln(17) - \frac{8}{9} \approx 0.5277 \quad \text{.... (36)}$$

And

$$e_d(z = 0 - 8) = 8 + \frac{16}{9} - 2\ln(9) - \frac{1}{2}\ln(17) \approx 3.9967 \quad \text{.... (37)}$$

The predicted ratios of kinetic energy and dark energy are, respectively,

$$\frac{e_k}{e_{tot}} = \frac{e_k}{e_k + e_d} = \frac{0.5277}{0.5277 + 3.9967} \approx 0.1074 \text{ (or 10.74\%)} \quad \text{.... (38)}$$

And

$$\frac{e_d}{e_{tot}} = \frac{e_d}{e_k + e_d} = \frac{3.9967}{0.5277 + 3.9967} \approx 0.8826 \text{ (or 88.26\%)} \quad \text{.... (39)}$$

5. On the Evolution of Chemical Elements

Currently, the details of the ionization history is not well understood [40], but it is believed to exist at as early as $z \sim 20$ [41]. It is well accepted that fusion reactions (starting with hydrogen into helium) inside stars synthesize the elements up to iron, and that elements heavier than iron cannot be formed by fusion, and that they are synthesized as a result of slow and fast neutron-capture reactions, known as n-capture [42].

The proposed theory can be used to make predictions about the cosmic ionization of light and of heavy elements. This highly important issue goes far beyond the scope of the present paper, and will hopefully be addressed in a subsequent paper. Here, I only give a glimpse of the topic by applying the theory for predicting the times of formation, after the Big Bang, of two light elements, Carbon ${}^{6}_{12}\mathrm{C}$ and Oxygen ${}^{6}_{12}\mathrm{C}$.

For this purpose, consider the generic nuclear fusion of the type

$$ {}_{k}\mathrm{X} + {}_{l}\mathrm{Y} = {}_{m}\mathrm{Z} + \omega + E_k \quad \text{... (40)}$$

Where *k*, *l*, and *m* are the atomic weights of the elements X, Y, and Z, respectively, ω is some elementary particle, and E_k is the emitted kinetic energy. Denote the difference in atomic mass between the interacting and the produced elements by Δm. Assuming that all the emitted kinetic energy is carried by the newly formed particle Z, from eq. 9, we have the following:

$$E_k = (\frac{1}{2} m\, c^2) \frac{z^2}{(z+1)^2(2z+1)} = \frac{1}{2} \Delta \mathrm{m}\, c^2 \; ^{(2)} \qquad \text{…. (41)}$$

Solving for $\frac{\Delta m}{m}$, we get

$$\frac{\Delta m}{m} = \frac{z^2}{(z+1)^2(2z+1)} \qquad \text{…. (42)}$$

The right-side term in eq. 42 is identical to the kinetic energy term (see eq. 9), implying that the dependence of $\frac{\Delta m}{m}$ on z mimics the dependence on z of the kinetic energy density depicted in Figure 4, with maximum obtained at z ≈ 1.618. Inspection of eq. 42 (see also Figure 4) reveals that for very high redshifts, the rate of increase in atomic mass, $\frac{\Delta m}{m}$, is very low, suggesting the differences between the atomic masses of very heavy elements are predicted to be small. A similar prediction applies to the differences between the atomic masses of very light elements. As we move from epochs of very low redshifts to epochs of larger redshifts (or from epochs of very high redshifts to earlier epochs), $\frac{\Delta m}{m}$ is predicted to increase, reaching a crest at z = φ ≈ 1.618.

To derive the term for the dynamical dependence of $\frac{\Delta m}{m}$ on time, denote the redshift corresponding to the Big Bang moment by z_T (≈ 1089), with corresponding time of T (≈ 13.789 BY). From eq. 5, we can write the following:

Footnote 2: For consistency, I use the relativistic Newtonian term for the conversion of mass to energy, rather than the conventional E = m c^2:

$$\frac{T}{t'} = z_T + 1 \qquad \text{…. (43)}$$

For any time t and redshift z, using equation 43 and 4 we can write:

$$\frac{t}{T} = \frac{z+1}{z_T + 1} \qquad \text{….. (44)}$$

Which yields:

$$z = (z_T + 1)\frac{t}{T} - 1 \qquad \text{….. (45)}$$

Substituting z from eq. 45 in eq. 42, we get:

$$\frac{\Delta m}{m} = \frac{((z_T + 1)\frac{t}{T} - 1\ )^2}{\left((z_T + 1)\frac{t}{T}\right)^2 (2(z_T + 1)\frac{t}{T} - 2 + 1)} \qquad \text{….. (46)}$$

For $z_T \approx 1089 >> 1$, solving eq. 47 for $\frac{t}{T}$ gives

$$\frac{t}{T} \approx \frac{1}{2z_T\frac{\Delta m}{m}} \approx \frac{1}{2178\frac{\Delta m}{m}} \qquad \text{... (47)}$$

For T ≈ 13.789 BY, we get

$$t \approx \frac{1}{2178\,\frac{\Delta m}{m}} \,.\, 13.789 \text{ BY} \qquad \text{….. (48)}$$

In principle, given any nucleuses reaction, eq. 42 could be used to explore the timeline for the formation of the various chemical elements. Solving eq. 42 for z gives:

$$2\, z^3 + (5 - \frac{1}{(\frac{\Delta m_i}{m_i})})\, z^2 + 4\, z + 1 = 0 \qquad \text{….. (49)}$$

Here I apply the model for estimating the redshifts and times for the cosmic formation of two important elements: Carbon ${}^{6}_{12}\mathrm{C}$ and Oxygen ${}^{8}_{16}\mathrm{O}$.

Carbon ${}^{6}_{12}\mathrm{C}$ is produced by the nuclear fusion:

$${}^{4}_{8}\mathrm{Be} + {}^{2}_{4}\mathrm{He} \rightarrow {}^{6}_{12}\mathrm{C} + E_k \qquad \text{….. (50)}$$

Thus,

$$\frac{\Delta m}{m} = \frac{(m_{b-8} + m_{He-4}) - m_{C-12}}{m_{C-12}} = \frac{(8.00530510 + 4.0026020) - 12}{12} \approx 0.000658925 \qquad \text{….. (51)}$$

Substituting $\frac{\Delta m}{m}$ = 0.000658925 in eq. 49 and solving for z yields:

$z_h \approx 756$, and $z_l \approx 0.027$

Using eq. 44, we have:

$$t_h = \frac{z_h + 1}{z_T + 1}\, \mathrm{T} = \frac{756 + 1}{1089 + 1} \text{ x } 13.789 \approx 9.6 \text{ BY.}$$

and

$t_l = \frac{z_l + 1}{z_T + 1}$ T = $\frac{0.027+1}{1089+1}$ x 13.789 ≈ 0.013 BY = 13 MY.

For Oxygen ${}_{16}^{8}\mathrm{O}$, the nuclear fusion reaction is:

$${}_{12}^{6}\mathrm{C} + {}_{4}^{2}\mathrm{He} \rightarrow {}_{16}^{8}\mathrm{O} + E_k \qquad \text{….. (52)}$$

Thus,

$$\frac{\Delta m}{m} = \frac{(m_{C-12} + m_{He-4}) - m_{O-16}}{m_{C-12}} = \frac{(12.0107 + 4.002602)\mathrm{u} - 15.9994\mathrm{u}}{15.9994\mathrm{u}} \approx 0.00086891 \qquad \text{…. (53)}$$

Substituting $\frac{\Delta m}{m}$ = 0.00086891 in eq. 49 yields

$z_h \approx 573$, and $z_l \approx 0.031$

Which correspond to:

$t_h = \frac{573+1}{1089+1}$ x 13.789 ≈ 7.26 BY, and

$t_l = \frac{z_l + 1}{z_T + 1}$ T = $\frac{0.031+1}{1089+1}$ x 13.789 ≈ 0.013 BY = 13 MY.

The above results are consistent with observations. The low redshift predictions are in agreement with the findings of several survey studies using highly ionized metal absorption lines in ultraviolet, and X-ray spectra (e.g., 43-44). These findings revealed an abundance of Carbon and Oxygen in the Milky Way, at redshift z = 0.027 [43], and of Oxygen at z = 0.031 [44]. Precision tests for the predicted high redshifts are (still) unfeasible, but several survey findings were successful in tracing the formation of Carbon and Oxygen to early epochs, of z ≥ 5 [45-46].

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The above mentioned predictions are quite interesting, because they imply that Carbon ${}^{6}_{12}\mathrm{C}$ and Oxygen ${}^{8}_{16}\mathrm{O}$, and most probably all chemical elements, were created twice: once in massive galaxy structures in the early universe epochs, at redshifts $z > 1.618$ (golden ratio), and a second time in the more recent history of the universe, at redshifts $z \leq 1.618$. Coupled with the confirmed prediction (see, e.g., [25-33]) of intense galactic activity at $z \approx 1.618$, it is not unrealistic to conjecture that the ionization of elements at low redshifts is indeed a second-round, or "re-ionization," probably in the internal galaxy of the observer (the Milky Way). Because the analysis applies to an observer in any galaxy, the theory predicts that the process of ionization that took place closer to the Big Bang repeats itself in all galaxies, with their massive black holes playing the role of the Big bang.

6. Summary and Concluding Remarks

Based on the well accepted assumption that the laws of physics at non-relativistic velocities are described by classical Newtonian mechanics, I derived a novel set of parameter-free transformations for time, distance, the densities of matter and dark matter, and the densities of kinetic and dark energies. I used the derived transformations to investigate the dynamics of the universe, as perceived by an observer on Earth. The emerging model of the universe has the following main properties:

1. *Recession Velocity and Acceleration*: For very high redshifts (roughly from $z \sim 8$ to $z \approx 1089$), the recession velocity is close to the velocity of light, and its deceleration rate is low and relatively steady. For very low redshifts ($z \leq 0.1$), the recession velocity is very low, and its deceleration rate is low and relatively steady. The epoch spanning from $z \sim 1089$ to $z \sim 8$ likely corresponds to the time of massive galaxy formation in the early universe, whereas the epoch of very low redshifts ($z < 0.1$) corresponds to the time of young stars and galaxy formations. In the

midrange of redshifts, between z~ 8 and z~ 0.1, the universe underwent a period of rapid deceleration.

2. *Matter and Energy Dynamics*:

The kinetic energy density in the universe is bell shaped and symmetrical around a redshift equaling the famous Golden Ratio (≈ 1.618). This result is consistent with numerous discoveries of quasars, galaxies, and AGNs, at redshifts in the range z = 1.618 ± 0.1 (e.g., 29-37). The dark energy is monotonically increasing with redshift. The dynamics of baryonic matter and dark matter densities display perfect mirror-image symmetry (see Figure 3). From the Big Bang epoch to redshift z = $\frac{1}{2}$, dark matter dominated the universe, and from z = $\frac{1}{2}$ to now, normal matter has dominated it. The same result applies to the relative densities of kinetic energy and dark energy (see Figure 4).

The dynamics of kinetic energy reveal that different ΛCDM models may apply to different redshift ranges (see equations 26 and 27). As examples, for a redshift range of (0.6, 1), investigated in [33], the calculations yield the parameters $\Omega_{\text{matter}} \approx 0.38$, and $\Omega_\Lambda \approx 0.62$, which fits nicely with a ($\Omega_{\text{matter}} \approx \frac{1}{3}$, $\Omega_\Lambda \approx \frac{2}{3}$) cosmology. If we consider the entire redshift range (0, 1.618), after which matter ceases to obey the classical Newtonian mechanics, the calculation reveals that the favorable cosmology is one with $\Omega_{\text{matter}} \approx 0.23$, $\Omega_\Lambda \approx 0.77$.

3. *Evolution of Chemical Elements*

The theory predicts that the chemical elements were formed *twice*: first in massive galaxy structures at the early universe, at redshifts z >1.618 (golden ratio), and second in younger galaxies in the recent history of the universe, at redshifts z <1.618. In other words, the ionization of elements at very low redshifts are a second-round, or "re-ionization", of chemical elements that were ionized much earlier in massive galaxies' formations in the early universe.

4. *A Possible Duality between Cosmology and Quantum Mechanics*

The redshift at which the kinetic energy density reaches its maximum is equal to the Golden Ratio (z ≈ 1.618). For higher redshifts, the dynamics of baryonic matter completely disobey classical Newtonian mechanics. Strikingly, this result resonates with a recent finding in quantum mechanics, indicating that applying a magnetic field to an aligned chain of cobalt niobate atoms, makes the cobalt enter a quantum critical state in which the ratio between the frequencies of the first two notes of the resonance equals the Golden Ratio [47]. No less interestingly, the maximal value of the kinetic energy density, equals the classical Newtonian energy density ($\frac{1}{2}\ \rho_0\ c^2$), multiplied by ≈ $0.09016994,$ a number that is equal (up to 8 decimal digits) to L. Hardy's probability of entanglement [48–49]. Clearly, one should not rush to draw far-reaching conclusions about a possible duality between quantum mechanics and cosmology based on two pieces of "circumstantial evidence." Nonetheless, the probability that the above two numbers coincide with comparable key quantum numbers and the similarity of their physical meanings encourages us to further pursue such a possibility, simply because the benefit, if such a possibility is verified, is too precious to be overlooked.

Obviously, the proposed theory requires a paradigmatic shift of tremendous magnitude. Thus, a reflexive reluctance to accept it, and even a refusal to discuss it, are comprehensible human reactions. Nonetheless, such reactions contradict the essence of scientific inquiry. If we agree that chivalry should stay where it belongs - in human, and other life forms relations, and not in science - we should be able to challenge any theory, including Einstein's relativity.

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