Information Relativity Theory and its Application to Cosmology

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Abstract

In a recent paper [1] I proposed a novel relativity theory termed *Information Relativity* (*IR*). Unlike Einstein's relativity which dictates as *force majeure* that relativity is a true state of nature, Information Relativity assumes that relativity results from *difference in information about nature* between observers who are in motion relative to each other. The theory is based on two axioms: 1. the laws of physics are the same in all inertial frames of reference (Special relativity's first axiom); 2. All translations of information from one frame of reference to another are carried by light or by another carrier with equal velocity (information-carrier axiom). For the case of constant relative velocities, I showed in the aforementioned paper that IR accounts successfully for the results of a class of relativistic time results, including the Michelson-Morley's "null" result, the Sagnac effect, and the neutrino velocities reported by OPERA and other collaborations. Here I apply the theory, with no alteration, to cosmology. I show that the theory is successful in accounting for several cosmological findings, including the pattern of recession velocity predicted by inflationary theories, the GZK energy suppression phenomenon at redshift $z \sim 1.6$, and the amounts of matter and dark energy reported in recent ΛCDM cosmologies.

Keywords: Relativity, Information, Expanding universe, GZK cutoff, Dark energy, ΛCDM, Ontic, Epistemic.

1. Overview

In the present paper I describe a relativistic cosmology based on a recently proposed theory termed *Information Relativity* theory (or *IR*). The theory, detailed elsewhere [1], is shown to be successful in accounting for several classical and recent findings concerning the dynamics of small particles, including the famous Michelson-Morley experiment, the Sagnac Effect, and the findings of recent quasi-luminal neutrino experiments, conducted by OPERA and other collaborations (e.g., [2],[3]). Here I show that the theory is also successful in making significant predictions regarding the expansion of the universe, the GZK [4, 5] discontinuity (cutoff) at redshift z ~ 1.6 [6], and of the amounts of matter and dark energy reported by recent observationally based ΛCDM cosmologies (e.g., [7], [8]). The reader is cautioned that the approach taken here is fundamentally different from the current cosmological model based on Einstein's General Relativity theory. To set the grounds for the proposed cosmology, in the following section I give a brief account of the underlying Information Relativity theory. Section 3 applies the theory to cosmology and infers about the pattern of the universe's expansion. Section 4 discusses the theory's kinetic energy term and compares its predictions with tests of the well-known GZK energy suppression, reported by several experiments, including the High Resolution Fly's Eye (HiRes) experiment [6]. Section 5 proposes a relativistic definition of dark energy and utilizes it to provide estimates of the relative amounts of kinetic and dark energy in various redshift ranges, while comparing the resulting predictions with well confirmed ΛCDM cosmologies. Section 6 concludes.

2. Information Relativity theory (*IR*) – A brief account

Einstein's theories of relativity dictate, as a *force majeure*, an ontic view, according to which relativity is a *true state of nature*. For example, the solution to the famous clocks' paradox, whether in the framework of special or general relativity, predicts that the "traveling" twin returns truly and verifiably younger than the "staying" twin, thereby implying that the "traveling" twin returns to the future. Information Relativity theory takes a completely different view of relativity, according to which relativity is not a true state of nature, but is a result of *difference in information* about nature between observers who are in motion relative to each other. The proposed theory is based on two axioms: 1. the laws of physics are the same in all inertial frames of reference (*SR*'s first axiom); 2. All translations of information from one frame of reference to another are carried by light or by another carrier with equal velocity (information-carrier axiom). For the case of constant relative velocities, the theory's resulting transformations are depicted in Table 1. A detailed derivation of the time and distance transformation is detailed in [1], and the derivations of the mass and energy transformations are detailed in [9].

Table 1

Information Relativity Transformations

Physical Term	Relativistic Expression
Time	$\frac{t}{t_0} = \frac{1}{1-\beta}$ .. (1)
Distance	$\frac{x}{x_0} = \frac{1+\beta}{1-\beta}$ …. (2)
Mass density	$\frac{\rho}{\rho_0} = \frac{1-\beta}{1+\beta}$ .... (3)
Kinetic energy density	$\frac{e_k}{e_0} = \frac{1-\beta}{1+\beta}\beta^2$ .. (4)

The variables $t_0, x_0,$ and ρ_0 in the table denote measurements of time, distance and mass density at the rest frame, respectively, $\beta = \frac{v}{c}$, and $e_0 = \frac{1}{2}\rho_0 c^2$.

As seen in Eq. 1, IR disobeys the Lorentz Invariance principle. In similarity with Doppler's blue- and red-shift of waves, it predicts time dilation with respect to departing bodies, and time *contraction* with respect to approaching bodies. As will be shown hereafter, this similarity is far more than metaphoric. The relativistic distance term prescribes distance contraction for approaching bodies, and distance *stretching* for departing bodies, causing the mass density along the travel axis to increase or decrease respectively. Investigation of the energy term as a function of velocity is more complicated and is detailed elsewhere [9, 10].

Noteworthy, IR has some nice properties: (1) it is very simple. (2) It satisfies the EPR necessary condition for theories *completeness*, in the sense that every element of the physical reality must have a counter part in the physical theory [11]. In fact, all the variables in the theory are observable by human senses or are measurable by human-made devices. (3) The theory applies, without alterations to describing the dynamics of very small and very large bodies.

3. Applications to intergalactic cosmology

In applying the theory for investigating the intergalactic universe, several simplifications assumptions are made: 1. that the universe is isotropic, 2. that each galaxy could be represented by a lumpy point mass, and 3. That intergalactic interactions are weak and thus negligible. The isotropy assumption concurs with the "cosmological principle" and with abundant observations indicating that the universe looks the same in all directions. The second and third assumptions are justified by the gigantic number of galaxies in the observable universe, estimated to be ~100 billion galaxies and the enormous (and continually increasing) distances between galaxies. Obviously, the present simplified model fits better for describing the dynamics of more distant galaxies from an observer on Earth. We know for example that the Milky Way and the smaller galaxy Andromeda are continually attracted to each other, and that Andromeda will be eventually sucked by our home galaxy.

Given the above simplification, we consider an observer on Earth who conducts measurements of an event taking place on a distant galaxy which during the measurement recedes from the observer's reference frame with uniform velocity *v*. Assume that the event is associated with the emission of light or another wave with similar velocity *c*, and that the observer on earth measures the time duration of the event by means of the signals emitted from the galaxy in which the event has taken place. Using Eq. 1 together with the classical Doppler formula, it is shown in [10] that the arriving waves red-shift z, due to the body's recession at velocity $\beta = \frac{v}{c}$ is given by:

$$z = \frac{\beta}{1-\beta} \qquad \text{….. (5)}$$

And the transverse relationship is:

$$\beta = \frac{z}{1+z} \qquad \text{….. (6)}$$

The comparable expression of SR is:

$$\beta = \frac{(1+z)^2-1}{(1+z)^2+1} \qquad \text{….. (7)}$$

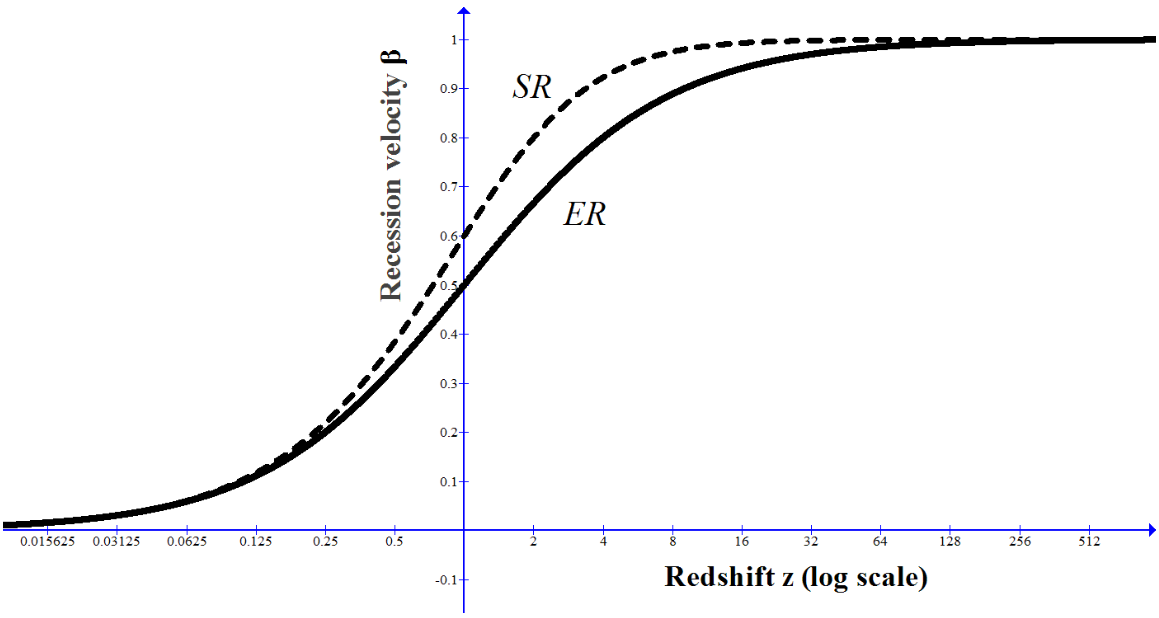

Figure 1. Predicted recession velocity as a function of redshift z

Figure 1 depicts IR's prediction of the universe's *recession velocity* with respect to an observer on earth as function of the redshift *z*. The dashed line depicts the comparable prediction of SR. The qualitative resemblance between the predictions of the two theories is easily noticeable. Roughly speaking, IR predicts that for very high redshifts (from z ~ 8 to z ~ 1089), the recession velocity is close to the velocity of light, and its deceleration rate is low and relatively steady. This prediction confirms with the well accepted inflation theory [12-14] predicting an early period of accelerated expansion of the universe. 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~ 1089 to z~ 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.

4. Kinetic Energy

To further investigate the cosmology constructed by Information Relativity theory, I use the relationship between recession velocity and redshift (Eq. 6) to express the transformation depicted in Table 1 in terms of redshift. Simple calculations yield the results depicted in Table 2. As the table shows IR prescribes that relativistic time and distance stretch linearly with redshift, while the "dilution" in mass density is hyperbolic with z. Far more interesting is the dependence of relativistic kinetic energy density on redshift depicted by the continuous line in Figure 2. The dotted line in the figure depicts the relativistic "loss" in the observed kinetic energy density, defined as $\frac{e_N - e_k}{e_0}$, where e_0

$= \frac{1}{2}\rho_0 c^2$, and e_N is the classical Newtonian term of kinetic energy per mass density of ρ_0. For reasons to be detailed hereafter, I call this term "unobservable" or "dark" energy.

Table 2

Information Relativity Transformations in terms of Redshift z

Physical Term	Relativistic Expression	
Time	$\frac{t}{t_0} = z + 1$	(8)
Distance	$\frac{x}{x_0} = 2z + 1$	(9)
Mass density	$\frac{\rho}{\rho_0} = \frac{1}{2z+1}$	(10)
Kinetic energy density	$\frac{e_k}{e_0} = \frac{z^2}{(z+1)^2(2z+1)}$	(11)

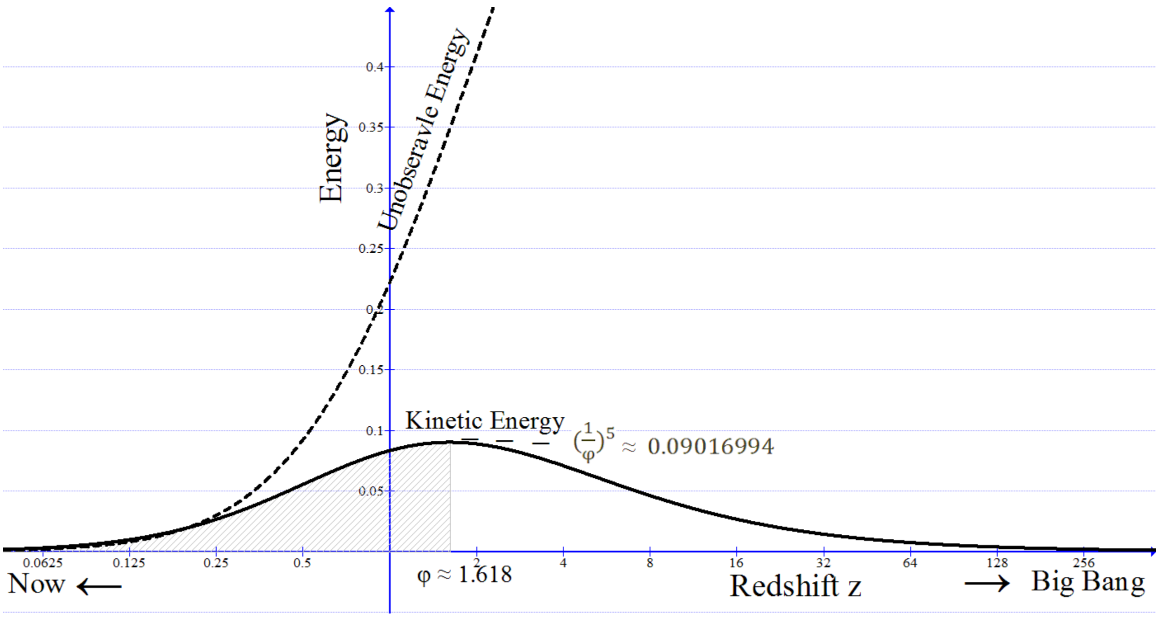

Figure 2: Densities of kinetic and unobservable energies as functions of redshift z

Strikingly, the distribution of the kinetic energy in the universe is predicted to be bell shaped, with quite unexpected, yet fascinating symmetries: It is centered at redshift equaling the Golden Ration, z =

$\frac{\sqrt[2]{5}+1}{2} = \varphi \approx 1.618$ [15, 16], with maximum equaling $(\frac{1}{\varphi})^5 \approx 0.09016994$. These results could be verified by deriving the term in Eq. 11 with respect to z and equating the result to zero:

$$\frac{d}{dz}\left(\frac{z^2}{(z+1)^2(2z+1)}\right) = \frac{2z\,(-z^2+z+1)}{(z+1)^3(2z+1)^2} = 0 \qquad \text{.... (12)}$$

For $z \neq 0$, we have

$$z^2 - z - 1 = 0 \qquad \text{..... (13)}$$

Or

$$z_{max} = \frac{\sqrt[2]{5}+1}{2} = \varphi \approx 1.618 \qquad \text{.... (14)}$$

Where φ is the Golden Ratio.

The corresponding max value of $\frac{e_k}{e_0}$ is equal to:

$$\frac{e_k}{e_0} = \frac{1-(\varphi-1)}{1+(\varphi-1)}(\varphi-1)^2 = \frac{1-(\varphi-1)}{\varphi}(\varphi-1)^2 \qquad \text{....(15)}$$

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

$$\frac{e_k}{e_0} = (\frac{1}{\varphi})^5 \approx 0.09016994 \qquad \text{.... (16)}$$

The corresponding recession velocity at z = φ is:

$$\beta = \frac{\varphi}{\varphi+1} = \varphi - 1 \approx 1.618 - 1 = 0.618 \qquad \text{.... (17)}$$

The physical meaning of the above results could be described as following: For an observer on Earth, the relativistic kinetic energy density is predicted to increase with redshift up to redshift z ~ 1.618, at which its reaches its maximum value equaling ≈ 0.09016994. This value is quall, to the eighth decimal digit, to L. Hardy's probability of entanglement [17, 18]! From z = 0 to z ≈ 1.618 (recession velocity β between zero and ≈ 0.618) galactic bodies are predicted to exhibit a quasi-classical behavior. That is, despite continuous depreciation in kinetic energy density relative to the classical Newtonian value, more recession velocity is still associated with higher energy density. Starting from the critical kink point at z ≈ 1.618, galactic bodies are predicted to undergo a relativistic phase transitions, after which the classical monotonous increase in kinetic energy with velocity (and redshift) is converted, such that higher recession velocities (higher redshift) are associated with lower, rather than higher kinetic energy density. The apparent energy "loss" is contained in an unobservable or "dark" form (see figure 2), such that the total energy is conserved.

The resemblance between the predicted non-monotonicity of normal energy density with redshift, and the well-known GZK cutoff limit could not be overlooked. In their well-known papers, Greisen [4], and Zatsepin and Kuzmin [5], proposed an upper limit to the cosmic-ray energy spectrum. A first observation of the Greisen-Zatsepin-Kuzmin suppression was reported in the High Resolution Fly's Eye (HiRes) experiment [6]. HiRes measurement of the flux of ultrahigh energy (UHE) cosmic rays showed a sharp suppression at an energy of 6×10^{19} eV, consistent with the expected cutoff energy. Interestingly, in the HiRes experiment the evolution of QSO's and AGN's has been measured and both types of source show a break in their luminosity densities at about z=1.6, quite consistent with the Golden Ratio prediction of $z \approx 1.618$. Strong support to the maximal energy density at $z \approx 1.618$ has been reported by numerous discoveries of quasars, galaxies, and AGNs, indicating a break in luminosity densities at about z=1.6 (e.g., [19], [20]), including a recent discovery of galaxies at redshift equaling exactly 1.618 [21].

However, it is also known that several experiments (e.g., [22], [23]) have reported the detection of one event each above 10^{20} eV, and a continuing, unbroken energy spectrum beyond the predicted GZK threshold was later reported by a larger experiment, the Akeno Giant Air Shower Array (AGASA) [24, 25]. These seemingly contradicting results are reconciled by the cosmology of IR, as could be directly verified from the relativistic kinetic energy density depicted in Figure 2.

5. Dark Energy

5.1 *A brief introduction*:

One of the big challenges facing modern cosmology pertains to the nature of dark energy. 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 (negative energy), which drives the galaxies of our universe apart. Despite efforts to ascribe the theoretical discovery of dark energy to Einstein's cosmological constant λ, the reference to λ in current ΛCDM cosmologies is no more than metaphoric. In fact, 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 [26]. 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 [27–29]. 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 [26]. At present, no persuasive theoretical explanation accounts for the existence, dynamics, and magnitude of dark energy and its resulting acceleration of the universe.

5.2 *IR's definition of unobservable* (*dark*) *energy*

In IR theory, the cosmic unobservable (or dark) energy density at a given recession velocity (redshift) is defined here as the *energy "loss" due to relativity*, or:

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

$$= \frac{1}{2}{\rho_0}^2 c^2\, \beta^2 \left(1- \frac{(1-\beta)}{(1+\beta)}\right) = \frac{1}{2}{\rho_0}^2 c^2 \frac{2\,\beta^3}{(1+\beta)} \qquad \text{... (18)}$$

And:

$$\frac{e_d(\beta)}{e_0} = \frac{2\,\beta^3}{(1+\beta)} \qquad \text{.... (19)}$$

Where β is the recession velocity with respect to an observer on Earth. In terms of redshift, the above equation becomes:

$$\frac{e_d(z)}{e_0} = \frac{2z^3}{(z+1)^2(2z+1)} \qquad \text{.....(20)}$$

It is important to stress that IR's interpretation of unobservable (dark) energy has nothing to do with the current belief holding that dark energy is some sort of unknown *negative* energy that is responsible to the accelerating recession of the universe.

The redshift at which the densities of kinetic and "dark" energy densities are predicted to be equal is obtained from solving the equation $e_k(z) = e_d(z)$, or:

$$\frac{z^2}{(z+1)^2(2z+1)} = \frac{2z^3}{(z+1)^2(2z+1)} \qquad \text{.... (21)}$$

Yielding

$z = \frac{1}{2}$ (or $\beta = \frac{1}{3}$) ….. (22)

Figure 3 depicts the ratios of the two energy densities $\frac{e_k(z)}{e_0}$ and $\frac{e_d(z)}{e_0}$ as functions of redshift. As shown in the figure IR predicts that kinetic and "dark" energies mirror image each other around an axis of symmetry $\frac{e_k(z)}{e_0} = \frac{e_d(z)}{e_0} = 0.5$, such that kinetic energy dominates the universe only from now up to redshift $z = \frac{1}{2}$, while dark energy dominating the rest of the universe from $z > 0.5$ the Big Bang era.

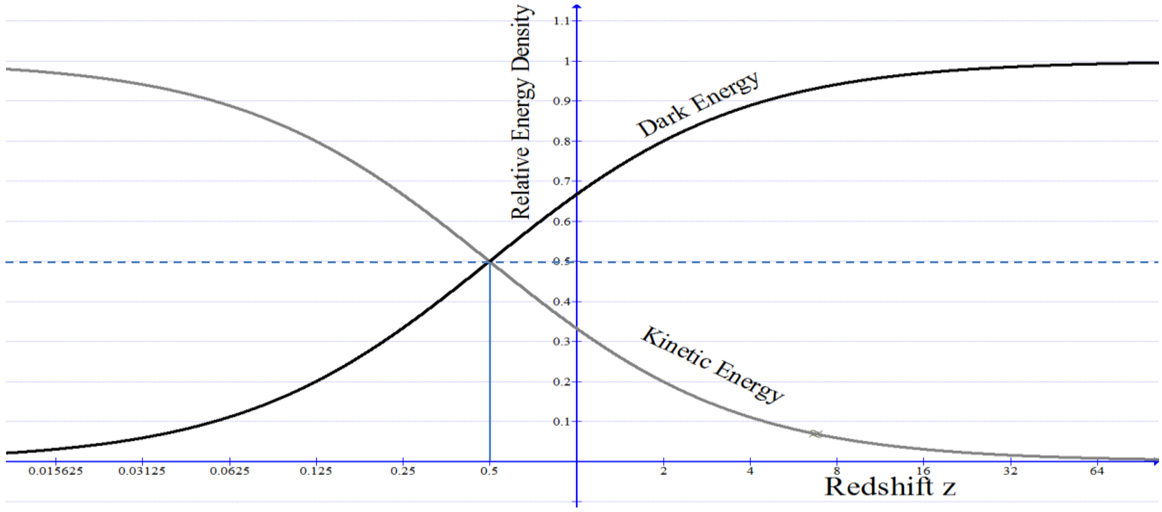

Figure 3. The ratios of the kinetic and dark energy densities as a function of redshift

5.3 *Comparison with ΛCDM cosmologies*:

To compare the theory's predictions with observationally based ΛCDM cosmologies, I calculated the total normal and dark energy densities for any redshift range (z_1, z_2), $z_2 > z_1$. The results are respectively:

$$\frac{e_k(z_1 - z_2)}{e_0} = \int_{z_1}^{z_2} \frac{e_k(z)}{e_0}\, dz = \int_{z_1}^{z_2} \frac{z^2}{(z+1)^2(2z+1)} dz = \frac{1}{2}\ln\left(\frac{2z_2+1}{2z_1+1}\right) - \frac{z_2 - z_1}{(z_2+1)(z_1+1)} \quad \dots (23a)$$

and

$$\frac{e_d(z_1 - z_2)}{e_0} = \int_{z_1}^{z_2} \frac{e_d(z)}{e_0}\, dz = \int_{z_1}^{z_2} \frac{2z^3}{(z+1)^2(2z+1)} dz$$

$$= (z_2 - z_1) + 2\,\frac{(z_2 - z_1)}{(z_2+1)\,(z_1+1)} - 2\ln\left(\frac{(z_2+1)}{(z_1+1)}\right) - \frac{1}{2}\ln\left(\frac{(2z_2+1)}{(2z_1+1)}\right) \quad \text{.....(23b)}$$

I tested the above results using data from Wittman et al. (2000) [7] 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. 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 *IR*, I calculated the ratios of kinetic and dark energies in redshift range from z_1=0.6 to z_2=1, by substitution in equations 23 and 24, respectively, yielding:

$$\frac{e_k(0.6-1)}{e_0} = \frac{1}{2}\ln\left(\frac{2+1}{2 \text{ x } 0.6+1}\right) - \frac{1-0.6}{(1+1)(0.6+1)} = \frac{1}{2}\ln\left(\frac{3}{2.2}\right) - \frac{0.4}{3.2} \approx 0.0301 \quad \text{...... (24a)}$$

and

$$\frac{e_d(0.6-1)}{e_0} = (1-0.6) + 2\,\frac{(1-0.6)}{(1+1)(0.6+1)} - 2\ln\left(\frac{1+1}{0.6+1}\right) - \frac{1}{2}\ln\left(\frac{2+1}{2\text{x } 0.6+1}\right)$$

$$= 0.4 + \frac{0.8}{3.2} - 2\ln\left(\frac{2}{1.6}\right) - \frac{1}{2}\ln\left(\frac{3}{2.2}\right) \approx 0.0486 \quad \text{..... (24b)}$$

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

$$\frac{e_k}{e_{tot}} = \frac{e_k}{e_k + e_d} = \frac{0.0300775}{0.0300775 + 0.0486354} \approx 0.382\ (\approx 38.2\%) \quad \text{.... (25a)}$$

And:

$$\frac{e_d}{e_{tot}} = \frac{e_d}{e_k + e_d} = \frac{0.0486354}{0.0300775 + 0.0486354} \approx 0.618\ (\approx 61.8\%) \quad \text{.... (25b)}$$

Which is in agreement with the observations based ΛCDM model with ($\Omega_m = \frac{1}{3}$, $\Omega_\Lambda = \frac{2}{3}$).

Calculation of the ratios of normal and dark energy in the range spanning from now (z_1=0) to the critical redshift $z_2 = \varphi \approx 1.618$ yields:

$$\frac{e_k(0-\varphi)}{e_0} = \frac{1}{2}\ln(\,2\varphi+1\,) - \frac{\varphi}{(\varphi+1))} \approx 0.1038 \qquad \text{…. (26a)}$$

And:

$$\frac{e_k(0-\varphi)}{e_0} = \varphi+2\,\frac{\varphi}{\varphi+1} - 2\,\ln(\varphi+1) - \frac{1}{2}\ln(2\varphi) \approx 0.3420 \qquad \text{….(26b)}$$

Thus we have,

$$\frac{e_k}{e_k+e_d} = \frac{0.138}{0.138+0.3420} \approx 0.233 \text{ (or 23\%)} \qquad \text{…. (27a)}$$

And

$$\frac{e_d}{e_k+e_d} = \frac{0.3420}{0.138+0.3420} \approx 0.767 \text{ (or 76.7\%)} \qquad \text{…. (27b)}$$

Notably, the above prediction is in excellent agreement with the ΛCDM cosmology with Ω_{matter} = 0.23, Ω_Λ = 0.77 (see, e.g., [30-32]), and quite close to the Ω_{matter} = 0.26, Ω_Λ = 0.74 cosmology (see, e.g., [33-35]).

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:

$$\frac{e_k(0-8)}{e_0} = \frac{1}{2}\ln(17) - \frac{8}{9} \approx 0.5277 \qquad \text{…. (28a)}$$

And

$$\frac{e_k(0-8)}{e_0} = 8 + \frac{16}{9} - 2\ln(9) - \frac{1}{2}\ln(17) \approx 3.9967 \qquad \text{…. (28b)}$$

And the predicted ratios of kinetic and dark energies are, respectively,

$$\frac{e_k}{e_{tot}} = \frac{e_k}{e_k+e_d} = \frac{0.5277}{0.5277+3.9967} \approx 0.12 \text{ (12\%)} \qquad \text{…. (29a)}$$

And

$$\frac{e_d}{e_{tot}} = \frac{e_d}{e_k+e_d} = \frac{3.9967}{0.5277+3.9967} \approx 0.88 \text{ (88\%)} \qquad \text{…. (29b)}$$

6. Summary and concluding remarks

The present paper described a simple cosmology based on a fundamentally different view of relativity. Whereas Einstein's special and general relativity are based on the assumption that relativity is a true state of nature, the proposed Information Relativity theory (IR) takes an *epistemic* view by assuming that relativity is an aftermath of *difference in information* (knowledge) about nature between observers who are in relative motion between each other. Under simplifying assumptions the theory's transformations we applied to investigate the dynamics of the galactic universe as perceived by an observer on Earth. The emerging model, although extremely simples, proves successful in providing theoretical explanations for key cosmological phenomena, including the expansion of the universe and its initial inflationary epoch, the GZK knee cosmic rays phenomenon at z ≈ 1.6. The amounts of normal and dark energies predicted by the theory are consistent with ΛCDM observationally based cosmologies. In a related paper [36], application of IR to the gravitational, spherical black hole, yielded a radius equal to the Schwarzschild radius (R= $\frac{2\,G\,M}{c^2}$), but with *no singularity at the interior*.

The present cosmological model differs in fundamental ways from current general relativity cosmology. In all GR's Friedman models, the cosmological redshift is interpreted as a consequence of the general-relativistic phenomenon. In the cosmology described here, the relativistic expansion of the universe is explained with no gravitation and the redshifts corresponding to different recession velocities are simple Doppler redshifts (see [10]).

It is argued that IR's cosmology described here is superior in many aspects to the cosmological model of GR: (1) it is much simpler; (2) it rests on two undebated axioms, (3) it is parameter-free; (4) It yields several important predictions, for which GR is mute. No less important, IR transformations without alteration, apply successfully to describing the dynamics of small particle physics (see [1, 37] for details). Furthermore, analysis of the mass-energy transformations, detailed in [12], reveals intriguing deterministic explanations for cardinal quantum phenomena, including the mass-wave duality, quantum criticality and quantum entanglement.

Another obvious advantage of IR is that it satisfies EPR's [9] necessary condition for theories *completeness*, in the sense that every element in the theory is in one-to-one correspondence with the physical reality. All variables in the theory have a counter part in the physical theory. Time and space are treated independently without the need to introduce the hypothetical constructs of spacetime as done in GR. The introduction of gravity or other force to the theory could be carried on in a straightforward way, simple by using the equivalence principle, and modifying the theory's transformation to account for acceleration. A simple example of such modification is presented elsewhere for the case of gravitational, spherical black holes [36].

It is argued that given the remarkable success of the proposed theory in accounting for many physical phenomena at both the micro and macro levels, and its potential in unifying relativity with quantum mechanics, it deserves to be considered as a "legitimate" contender of Einstein's relativity. Reluctance to do so would be anything but scientific. The required paradigmatic shift which the theory calls for is probably of tremendous magnitude, but even so, ignoring it remains unjustified.

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