

The progression of time as a cosmological process

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Abstract

A new dynamic process, the Dynamic Incremental Scale Transition (DIST), is proposed that could explain the progression of time and resolve long standing issues in physics and cosmology.

Key words: Dynamic Incremental Scale Transition, New Cosmology, Progression of Time, Scale Equivalence, Dark Energy, Quantum Theory from General Relativity, Origin of Inertia

1. Introduction

Presently there are several unresolved issues in physics and cosmology, which occasionally attract attention, but which largely are ignored. Yet, these issues, which stubbornly resist explanation, indicate that something important is missing in our understanding. They are:

- The progression of time. (There is no scientific explanation to this most keenly perceived aspect of our existence.)
- The origin of the universe.
- Dark Matter, Dark Energy and accelerating cosmological expansion.
- General Relativity (GR) is incompatible with Quantum Theory (QT).
- The nature of the QT wave functions. (Are they merely probabilistic entities or are they real physical waves of some kind?)
- The particle-wave duality (Is it a wave or a particle?)
- Non-locality in QT. (Action at a distance is faster than the speed of light.)
- The origin of Inertia

This article proposes a new type of dynamic process, which might shed some light on these issues. A generalization of GR that allows four-dimensional (4D) Dynamic Incremental Scale Transition (DIST) will be introduced. Although we do not know if this novel DIST process is valid, this paper will show that it warrants further investigation, since it might resolve several of the problems listed above.

The DIST idea is new, but proposing or postulating new ideas to be subjected to scrutiny is a time-tested approach in science, as evidenced by Einstein's two SR postulates and by Bohr's assumption that angular momentum of electrons in atoms is quantized.

The new process to be investigated is based on a fundamental cosmological symmetry – *4D scale-equivalence*.

2. Symmetry and Scale-Equivalence

'Symmetry' is a very important concept in modern science. Fundamental laws of physics that express conservation are often related to symmetry, for example the conservation of linear and angular momentum (spatial directional and rotational symmetry) or of energy (temporal symmetry). The concept of symmetry extends not only to obvious geometrical symmetries in space and time, but also to mathematical symmetries of sometimes considerable complexity, for example group theory.

However, in spite of the fundamental importance of symmetry, it appears that hitherto an important global (cosmological) symmetry has been overlooked.

This is 4D scale-equivalence.

The universe shows no preference for any particular 4D scale. If the scale of the three spatial metrics *and of time* were to change by the same scale-factor (from galaxies to atomic particles) the universe would remain the same relative to an observer, whose scale would also change. This conclusion is also supported by GR, since Einstein's equations are identical with a constant scale factor multiplying all metrical coefficients (metrics) of the GR line element.

The hidden symmetry implied by scale equivalence could be an over-riding cosmological symmetry; it could be 'the mother of all symmetries' that preserves *everything*. It is possible that the cosmos makes use of this fundamental symmetry.

In fact, this might be the way by which the universe expands; the cosmological expansion could be 4D scale-expansion, which could be the essence of the progression of time.

The author has investigated this possibility in a series of papers that introduce and explore the Scale Expanding Cosmos (SEC) model and has found that it describes our universe as observed [Masreliez 1999, 2004a, 2004b, 2004c, 2005a, 2006c]. The SEC model better agrees with observational data than the Standard Cosmological Model (SCM) based on the Big Bang theory. For example, there is no need for mysterious Dark Matter or Dark Energy. Also, there is no accelerating expansion and cosmological Inflation is not needed to explain the universe. Evolutionary speculation is not required, since the SEC model's predictions agree with observations. Furthermore, since the universe expands by the same tiny *fraction* (in the order of 10^{-17}) each second, a scale expanding cosmos has no beginning or end; it allows eternal existence, thus eliminating the enigmatic creation event. The author is not aware of any other work exploring the implications of cosmological 4D scale equivalence; it appears that 4D scale-expansion might be a new idea. Readers interested in further exploring this new cosmos model may consult the listed references.

3. Dynamic Incremental Scale Transition

Recognizing scale equivalence as being a fundamental feature of the universe, and the possibility that the 4D scale might change with time, the question becomes how to model this new process using known physics. This is not a trivial problem, since it is not clear how to describe a process that allows the duration of a second to change with time. It would be simple to model this using some fixed reference 'time' that does not expand, but how can such a process be modeled if the reference time-scale also were to expand? At first it might seem that this would be impossible, since the duration of the expanding second is to be compared relative to itself, which suggests that the scale-expansion would be undetectable. However, this might not be the case.

Consider a space traveler confined to the interior of a spaceship, which slowly accelerates, and assume that the concept of 'acceleration' is unknown to this traveler. No spatial or temporal measurements inside the ship would reveal the acceleration, but it would make its presence felt via the inertial force, which to the space the traveler might seem as mysterious as, for example, Dark Energy does to us. Spatial acceleration implies inertial effects and it is perhaps not surprising that exponential 4D scale-expansion, whereby the scale expands by the same tiny fraction each second and therefore accelerates, also implies 'inertial' effects. In fact, this would explain several mysterious features of the universe.

Since the universe is physically identical at different scales, and since GR is 'blind' to discrete scale changes, the cosmological expansion might be *partly incremental*. This could preserve the validity of GR by making the spacetime manifold continuous 'almost everywhere' and this would perhaps also explain why this novel semi-continuous expansion mode has not previously been considered.

This suggests that in trying to model the 4D scale-expansion we might generalize GR to allow discrete scale changes whereby all metrical coefficients in the line element change incrementally by the same scale-factor. As participants in the cosmological expansion we would then also incrementally 'jump into' the new and larger scales. In GR this could be taken into account by incrementally adjusting the pace of 'proper time' as expressed by the reference increment ds .

This implies that GR is generalized to allow discrete adjustment to the pace of proper time.

4. The Scale Expanding Cosmos theory

Consider for example the cosmological line element of the SEC theory as expressed by GR, assuming a fixed pace of proper time as given by the increments ds setting $c=1$ [Masreliez, 1999, 2005a]:

$$ds^2 = e^{2t/T} (dt^2 - dx^2 - dy^2 - dz^2) \quad (4.1)$$

Here t is atomic time and T is the Hubble time. Define a new temporal parameter t' by the translation:

$$t' = t + \Delta t \quad (4.2)$$

The discrete increment Δt is assumed to be constant. The resulting line element is a scaled version of the original one and, since the corresponding GR equations are identical, the scaled spacetime is physically identical to the original. In fact, a co-expanding observer would experience a slowing progression of proper time expressed by ds' :

$$ds = e^{\Delta t/T} \cdot ds' \quad (4.3)$$

Substituting this into (4.1) we recover the original line element; *the universe remains the same relative to the 'co-expanding' observer.*

This expansion mode suggests the iterative loop shown in Figure 1.

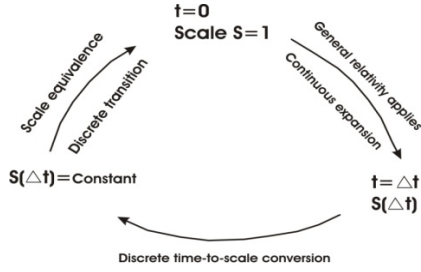


Figure 1: The DIST cycle

Figure 1 depicts the Dynamic Incremental Scale Transition process proposed in this paper. If this process models the cosmological expansion and the progression of time it could generate high frequency oscillation of the spacetime metrics, which might provide an ontological explanation to QT, see further below. In acknowledging the DIST process we must accept the possibility that the pace of proper time as modeled by GR may change in discrete increments. Although this is a new and unexpected feature of the cosmos, known physics does not rule out this possibility. In fact, strict continuity of dynamic processes has never been proven.

Note the interesting and unusual property that the DIST is a dynamic process that does not change the spacetime geometry at all. If this process were to model the progression of time it would allow perpetual existence in a universe that evolves but never changes! This would resolve an ancient mystery originally recognized by Parmenides and his followers, for example Zeno, who wondered how it is possible for time to progress in a cosmos that never changes.

The iteration loop of Figure 1 merely illustrates the basic idea; how the DIST process actually might be implemented in the cosmos is not known at this time. For example, the iteration might take place at different frequencies and might perhaps also differ slightly with spatial location.

5. Evidence in support of the DIST process

There is considerable evidence in support of the DIST. First, there is direct observational confirmation from astronomical observations and measurements. Second, there is indirect, circumstantial, evidence in the form of simple explanations to previously unresolved puzzles and phenomena. The DIST process emerges as a real possibility that might reveal previously unsuspected but important aspects of our existence. Some of the observational and conceptual evidence is outlined below.

5.1 Observational evidence

In a series of papers the author has shown that the SEC theory, which is based on the DIST process, models a universe that in all aspects agrees with what we observe. As already mentioned, it eliminates several complications and observational discrepancies of the SCM theory beginning with the creation event. Here these will not be discussed in detail, since they are presented in the published papers listed in the references. However, they are mentioned in passing in order to provide justification for DIST.

There are several so-called cosmological tests, which are observational programs and protocols, designed with the objective of testing various cosmology theory candidates. Here four of these programs will be mentioned. All four are well-established and widely recognized programs that have been used in numerous independent studies by different groups.

- The number-count test
- The angular size test
- The surface brightness test
- The supernovae Ia measurements

The number count test

By counting the number of galaxies, and ordering these in terms of apparent luminosity we find that the number of galaxies (number-count) within a certain spatial angle increases with decreasing luminosity. We get a plot of number of galaxies as a function of luminosity, and each candidate theory will provide a

specific prediction of the number-count that may be compared to the observed. The degree of agreement between observation and prediction is a measure of the validity of the tested theory.

It turns out that at low luminosities there is very poor agreement with the SCM theory's number-count prediction, while the SEC theory agrees excellently with the observations [Masreliez, 1999, 2005a]. Figure 2 shows a summary from sixteen different number count programs taken from a paper by Metcalf et. al [Metcalf et. al., 1995]. The SCM model clearly fails the test, while the SEC model agrees well with the observations.

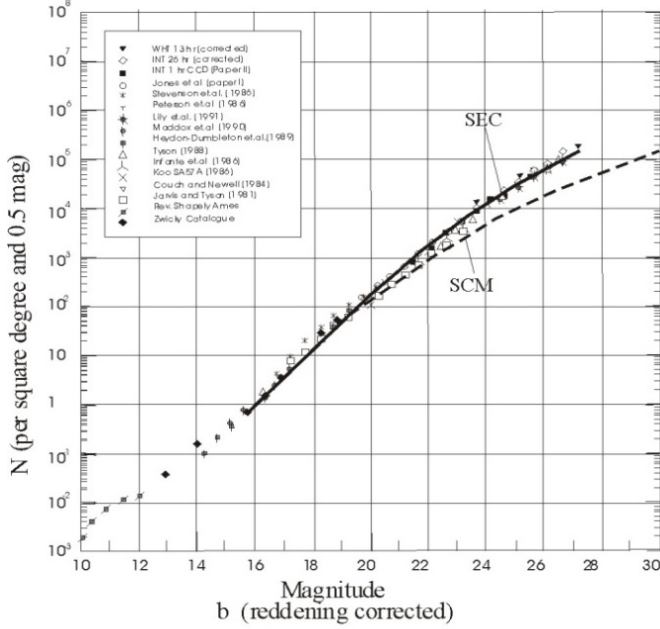


Figure 2: Number count as a function of magnitude.

The angular size test

The spatial angle occupied by an observed galaxy decreases roughly in inverse proportion to increasing redshift. However, since the universe expands, this inverse relationship is not perfect. Each cosmological model predicts a particular relationship, which allows comparison between each model's prediction and the observations. According to the SCM theory the angular size should decrease slower at higher redshifts, but the observations do not agree with this prediction. On the contrary, agreement between the SEC theory's predictions and the observations is excellent [Masreliez, 1999, 2005a]. Figure 3 is from a paper by Djorgovski and Spinrad, [Djorgovski and Spinrad, 1981]. The SEC prediction has been added. Clearly, the SEC model's agreement with the observations is superior as may be seen in figure 3.

The surface brightness test

The observed luminosity of a source divided by its angular size (squared) is denoted 'surface brightness', which may be predicted by the model and compared to measurements. This is a powerful test which combines luminosity and angular size. The SCM model fails this test miserably, while the SEC is in good agreement with measurements [Masreliez, 1999, 2005a]. Observational results [Sandage and Lubin, 2001] and [Lubin and Sandage I-III, 2001] show that the SEC theory agrees with observed galaxy surface brightnesses while the SCM does not. The solid line in Figure 4 is the calibrated surface brightness baseline estimated from nearby galaxies. The SEC theory's predictions agree well with the local surface brightness (filled symbols). However, there is disagreement with the SCM as shown by the heavier outlined open symbols.

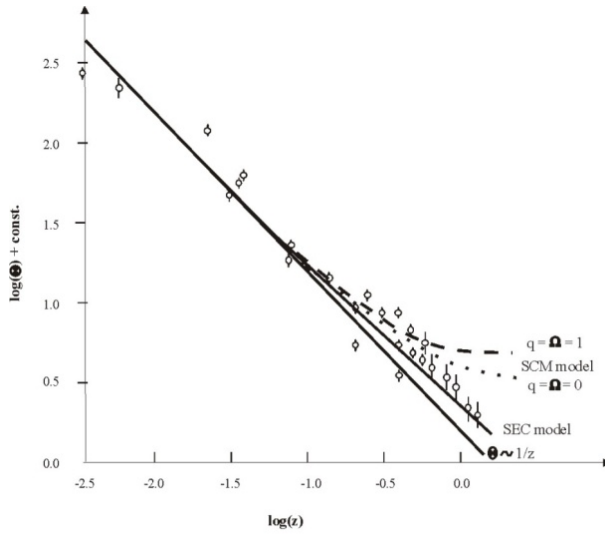


Figure 3: Angular sizes vs. redshift

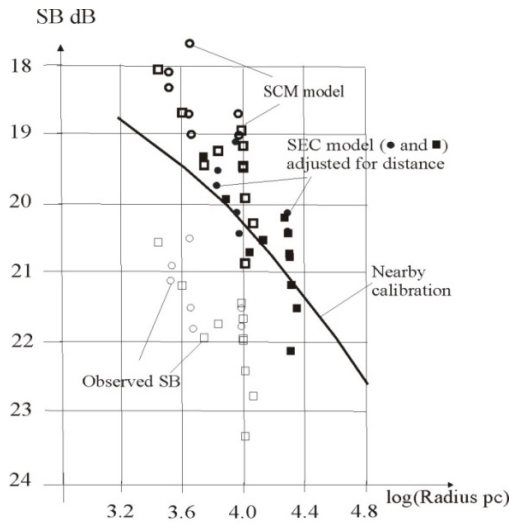


Figure 4: Surface brightness comparison

Circles: I band data for cluster C11604+4304 at $z=0.90$
Squares: I band data for cluster CL1324+3011 at $z=0.76$

The supernova Ia measurements

Recently another test of the SCM theory has received much attention – it is the supernovae Ia (SNe Ia) observations, which at first seemed to indicate that the cosmological expansion for some unknown reason currently is accelerating. However, recently this conclusion has been put into question by additional measurements suggesting that the cosmological expansion initially decelerated before it began accelerating. This has led to much speculation. There seem to be a cosmological Dark Energy and perhaps also a Cosmological Constant as initially proposed by Einstein [Einstein, 1917]. Considerable work is currently expended in trying to find some explanation to the supernova Ia measurements. However, SEC theory is in excellent agreement with the SNe Ia data; there is no indication of cosmological acceleration or deceleration [Masreliez, 1999, 2005a].

The recently reported supernovae Ia (SNe Ia) observations by the Supernova Cosmology Project [Perlmutter et. al. 1995, 1997, 1999, 2003] and by the High-Z Supernova Search Team [Schmidt et al., 1998] confirm that these observations do not agree with the SCM unless the cosmological expansion accelerates. However, as shown in Figure 5 the SNe Ia observations agree well with the theoretical predictions of the SEC model. This good agreement with the SEC model is obtained without any adjustable parameters.

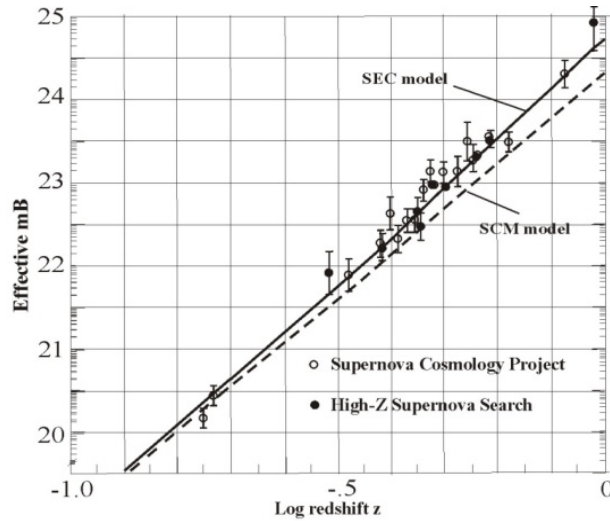


Figure 5: SNe Ia Magnitudes vs. redshift

An even more recent paper [Riess et. al., 2004] presents data for 16 newly discovered SNe Ia, six of them observed in the redshift range $z > 1.25$ using the Hubble space telescope. These new observations suggest that the universe initially went through a phase with *decelerating* expansion rate, which later was followed by *accelerating* expansion. Riess et. al. models the evolution of the luminosity distance by assuming an initial phase with a linearly decreasing positive deceleration 'constant', later followed by an accelerating phase with a linearly decreasing negative deceleration constant. The parameters of this model, as well as the transition redshift at which the deceleration constant is zero, may be estimated from observational data and used to model the evolution of the luminosity distance. The transition from decelerating to accelerating expansion is by Riess et. al. estimated to occur at $z=0.46$. Figure 6 (Figure 4 in Riess et. al.) shows the fit to the observations assuming flat SCM cosmology and the SEC fit.

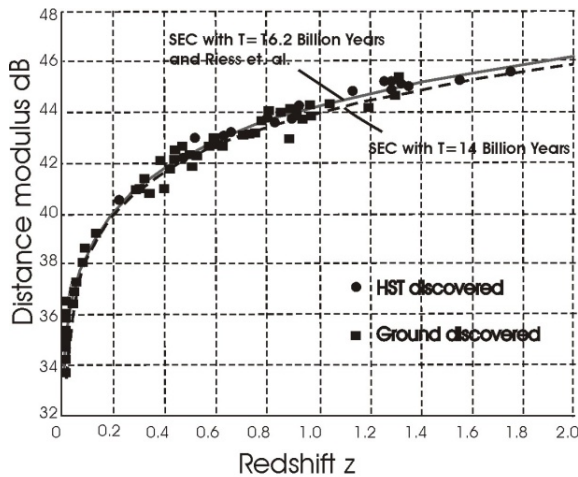


Figure 6: SNe Ia match to the SEC relation compared to the fit by Riess et.al.

Although these four observational programs all were designed to check the accuracy of the SCM theory, the repeated failure of this model has not caused the scientific community to abandon it. Rather than accepting these discrepancies as clear indications that the SCM theory might be flawed, attempts are being made to explain away the discrepancy by arguing that the universe of today is different from what it was in the past, and that the observed disagreements are based on 'cosmological evolution'. Of course, since such speculation cannot be confirmed, it defeats the purpose of the test.

Time and again the SCM theory has been saved by various adjustments to the model and by the speculative introduction of sometimes strange new cosmological properties, for example Dark Energy, Cosmological Constant, Inflation, and accelerating (and decelerating) expansion.

In contrast, the SEC theory's predictions all agree with observations without any adjustment. Thus, there is ample observational evidence in favor of the SEC model, which provide strong indirect support for the DIST process.

The reason for the continued support of the SCM theory could be that there is no plausible alternative to the SCM theory based on known physics. The use of GR to model the universe will naturally lead to some version of the SCM model. And, since GR is believed to be correct, the SCM theory is also believed to be correct. The shortcoming of GR is that it does not allow the pace of (proper) time to change; it does not allow the pace of time to slow down and therefore it rules out the SEC model. As we will see this might also explain why GR is incompatible with QT.

Quoting the late Carl Sagan from his book 'Cosmos':

'Science... has two rules.

First: There are no sacred truths; all assumptions must be critically examined; arguments from authority are worthless.

Second: Whatever is inconsistent with facts must be discarded or revised. We must understand cosmos as it is and not confuse how it is with how we wish it to be. The obvious is sometimes false; the unexpected is sometimes true.'

In other words, the universe does not necessarily comply with what we currently believe to be 'the laws of physics'.

5.2 Conceptual support for the SEC

The strongest, and perhaps logically most persuasive, argument in favor of the SEC might be that cosmological existence well could be eternal. The only alternative to eternal existence is Creation, either from nothingness, which cannot be scientifically justified, or from some nebulous 'pre-existence' ('mother universe'). Needless to say this is no longer science but pure speculation that can never be confirmed. However, logically as well as scientifically, nothing rules out eternal existence in a scale-expanding cosmos.

The progression of time

The DIST process could also provide an explanation to the progression of time, the essence of which might be incremental cosmological scale-expansion allowing eternal existence without cosmological aging, see further section 8.

Quantum Theory from General Relativity

In a letter to Max Born in 1926 Einstein wrote [Born, 1971]:

'Quantum mechanics is certainly imposing but an inner voice tells me it is not yet the real thing'.

The DIST process could induce oscillation of the spacetime metrics, which suggests an ontological explanation to our quantum world; it proposes that the QT waveforms are modulations of very high frequency, very low amplitude, oscillations in the metrics of spacetime, possibly sustained by the cosmological scale-expansion. In modeling oscillating metrics in GR using the Minkowskian line element we find that a moving region (particle) oscillating at the Compton frequency always will be accompanied by the de Broglie 'matter-wave' in the form of modulation of the metrical Compton oscillation. This resolves the puzzling 'particle-wave duality'; the Compton 'carrier wave', which always is associated with a particle, is in motion modulated by the deBroglie matter-wave. The particle and wave aspects are inseparable. Furthermore, with oscillating metrics the deBroglie/Bohm 'pilot function' may be derived from the GR geodesic, and setting the Ricci scalar equal to zero results in a metrical wave equation from which the Schrödinger equation may be derived. This suggests that the QT wave functions are real physical entities that do not operate *in* spacetime but as projections *on* spacetime via the metrics. This could also explain non-local influences.

The assumption that the four spacetime metrics oscillate allows QT to be derived directly from GR [Masreliez, 2005a].

It might be possible to merge these two previously incompatible theories into one single theory.

Vacuum Energy

The net vacuum energy disappears in the SEC, but the Cosmological Energy-momentum Tensor (CET) evaluated from the line element (4.1) does not disappear:

$$CET = \begin{vmatrix} \frac{3c^2}{8\pi GT^2} & 0 & 0 & 0 \\ 0 & -\frac{c^2}{8\pi GT^2} & 0 & 0 \\ 0 & 0 & -\frac{c^2}{8\pi GT^2} & 0 \\ 0 & 0 & 0 & -\frac{c^2}{8\pi GT^2} \end{vmatrix}$$

G is the gravitational constant. The T_{00} component, which commonly is associated matter density, exactly equals Einstein's Critical Density. However, since by GR the net energy density is the sum of the four components, this 'matter-energy' is balanced by corresponding negative cosmological 'pressure-energy', which in the SCM model would correspond to a Cosmological Constant, as in Einstein's static cosmology model of 1917 [Einstein, 1917]. *Thus, the net cosmological energy density disappears.*

Should it turn out that the SEC model is correct, it is intriguing to note that Einstein's first attempt to model an eternal universe in equilibrium [Einstein, 1917] using GR actually came quite close to the right answer. In this model Einstein found that the cosmological mass density ought to equal a so-called *Critical Density* and that a *Cosmological Constant* would be needed counteract the gravitational pull at cosmological distances. Here in the SEC model the same Critical Density and cancelling Cosmological Constant reappears, however they are both induced by the cosmological scale-expansion, in other words, *they are implicit with the 4D scale-expansion*. They do not have to be artificially added to the model in order to explain the observations and they do not imply the existence of some mysterious Dark Energy. But, what about the 'real' mass density found in for example galaxies? Preliminary investigation suggests that in the SEC a gravitational field has negative energy that perfectly balances the matter-energy; therefore matter might not contribute to the net cosmological energy density [Masreliez, 2004c].

Cosmological Inflation

As a final example, consider the cosmological Inflation scenario conceived in support of the SCM theory [Guth, 1981]. From the perspective of the SEC theory, cosmological Inflation might be explained as being an artifact of the selection of cosmological coordinates in the SCM. In particular, it may be explained by the use of different time-scales. The SCM theory models the world using a fixed pace of time, while by the SEC theory the pace of time decreases with the expansion. The relationship between elapsed time in the SCM model (t_{SCM}) and the time-scale in the SEC model is given by:

$$t_{SCM} = T \cdot \exp(t_{SEC} / T) \quad (6)$$

Here the SEC model's time-scale, t_{SEC} , equals zero at the present and runs negative into the past (without limit), while the SCM time-scale starts at zero and presently equals the Hubble time, T . Since by the SEC model time was running faster in the past, an infinite past in the SEC may be compressed into an arbitrary short time interval close to zero in the SCM model, which in this model is believed to be the 'beginning of the world'. By the SCM model's time-scale the expansion seemed to be extremely rapid after the big bang, just as envisioned by Inflation, but in the SEC the cosmological expansion has always progressed at the same pace. Note that GR does not tell us which choice of coordinates is 'right'; they are both equally valid according to GR.

In summary, it appears that the strong observational and conceptual evidence presented above cannot merely be a coincidence; rather, it provides ample support for the DIST idea.

6. The progression of time as a dynamic physical progress

The nature of the progression of time has been a mystery since the beginning of human thought. Before the introduction of special and general relativity and the subsequent discovery of the cosmological redshift,

cosmological existence was believed to be perpetual. However, with the discovery of the cosmological redshift, and attempts to model this aspect of the cosmos by GR, the idea of creation of the world gained scientific support.

In retrospect this might have been a mistake, because it is likely the cosmological expansion cannot be modeled by GR's continuous manifold. Different cosmological epochs might belong to different manifolds that cannot be related by covariant coordinate transformation in GR.

*The dynamic cosmological progression that models the universe might take place in the metrics of spacetime without altering its four-dimensional spacetime geometry. **It might be the essence of the progression of time.***

This new DIST process takes place beyond the 4D world of both classical and modern physics; it is process 'beyond space and time' that cannot be modeled by a continuous 4D manifold.

With this new insight dynamic spacetime metrics enter physical epistemology as a new formidable 'player' that actively might be involved in all motion, in time as well as in space. Motion in time, which models the progression of time, preserves the 4D energy-momentum tensor by balancing the directly perceived cosmological energy, for example radiation, with spacetime energy induced by the ever slowing pace of cosmological time. Although energy-momentum is preserved four-dimensionally, it appears to us inhabitants of the universe as if energy is being generated perpetually 'out of nothing', since we do not directly perceive the very slowly changing pace of time (with a time constant $1/T$).

The expanding cosmological scale makes its presence felt everywhere in the cosmos at all levels. It is the essence of all existence. At the atomic level it takes the form of metrical vibrations modeled by the quantum mechanical wave functions, and at cosmological distances its existence appears as mysterious Dark Energy.

Dynamic metrics in the DIST process could also explain Inertia as a curved spacetime phenomenon [Masreliez, 2007]. A 4D scale factor exists for the Minkowskian line-element by which all accelerating trajectories become geodesics of GR. This inertial scale factor is $1-(v/c)^2$, which we recognize from Special Relativity. It implies revision of Special Relativity and the elimination of the Twin Paradox; traveling twins always agree on the elapsed time [Masreliez, 2008]. Since by the SEC theory all free relative motion diminishes with time, a spatial cosmological reference frame exists, and is defined as the frame toward which all motion converge.

Newton's absolute reference frame returns in a modern form induced by the cosmological expansion!

7. Concluding comments

The main objective of this article is to propose and stimulate interest in a new type of dynamic process, which may explain several mysterious features of the cosmos. Admittedly, at this time the DIST process is merely a proposition to be either confirmed or refuted by further investigation.

When modeling the universe based on known physics as represented by GR, we might naturally assume that the pace of (proper) time for a co-expanding observer (like all of us) always has remained the same, which leads to the SCM model. However, the pace of time for a co-expanding observer might change with the cosmological expansion, which leads to the SEC model.

Although both cosmological line elements are equally 'right' according to GR, it appears that the SEC model provides a simpler and more consistent explanation for our observations. However, it implies that GR should be generalized to model 4D scale-expansion *as experienced by a co-expanding observer*. One possibility would be to allow discrete scale transition that adjusts the pace of proper time in GR. This is the proposed DIST process.

General Relativity was of course a development of fundamental importance without which the DIST model would not have been possible. However GR does not give any clue to what might be causing the progression of time. This shortcoming should have raised a red flag; it should have made us question GR's applicability for modeling the cosmos.

A theory that cannot explain the progression of time, which is the most keenly felt aspect of all existence, obviously cannot model the universe.

However, with the DIST process the progression of time assumes its rightful role as the dominant feature of all existence, which resolves many puzzling aspects of our world. It could explain several hitherto

unresolved enigmas including the origin of the universe, the progression of time, the missing link between General Relativity and Quantum Theory, Dark Matter and Dark Energy, and the origin of Inertia.

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