A new world-view

Explaining the Progression of Time

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There is no subject so old that something new cannot be said about it.

Fyodor Dostoevsky

Preface

This Technical Monograph summarizes work on a new cosmos model. However, the development below is somewhat atypical in that it addresses questions, and discusses ideas, not commonly brought up in scientific publications or in daily communications. Some of these ideas are ancient and seem to be more fundamental than many of the issues addressed at length in modern scientific treaties.

Arguably most fundamental of all is the question: “What causes time to progress?” We all keenly experience the passage of time, but what is causing it? Obviously the progression of time is of immense importance to all of us, yet there is no explanation for it. Nobody knows what is causing time to pass, but strangely science has largely ignored this unresolved issue.

How can we expect to be able understand and model the world scientifically if we do not know what is causing the progression of time? The General Relativity (GR) theory cannot explain it, nor can any other of our scientific theories. It seems that this should rule out attempts to use the GR theory for modeling the cosmos, yet the currently accepted cosmos model is based on GR. And, since science in the past has not found a valid explanation for what causes time to progress one may wonder if our foundation of science is sound. Are Newton’s laws of motion and gravitation really valid?

These questions may seem inappropriate since they challenge the very foundation of science, but if we cannot explain such a fundamental phenomenon as the progression of time, can we really rely on the scientific epistemology taught in our schools?

This monograph addresses this question and concludes that there are issues beyond current understanding that may revolutionize not just science but our world-view in general.

However, these new ideas are difficult to introduce because they do not fit into current epistemology. They break new ground; past knowledge sometimes becomes a detriment rather than an asset. Yet, as we shall see, a veil that in the past has hidden the true nature of the world and our existence is lifted and we enter into a new world of breathtakingly simple beauty.

According to the ancient Greek philosopher Parmenides of Elea (500 BC) existence cannot have been created out of non-existence. Therefore he argued that all speculation regarding the creation of the world should be abandoned, at least from a scientific point of view. Granted, this will disagree with the common idea that God created to world. However, if we want to adhere to a physical explanation to our world, we should simply give up on the idea of creation. Some may speculate that our cosmos might have been "spun off" from a "mother universe" but this does not solve the problem of the origin of existence either. As long as we are thinking in terms of a creation of the world we are facing the same impossible enigma; we simply have to accept that the world always has existed and always will exist!

This simple conclusion will in one stroke rule out the currently popular cosmos model based on the Big Bang creation (out of nothingness), which here will be referred to as the Standard Cosmological Model (SCM). In the past this model has been revised several times when new observations have become available that disagree with its predictions, and recently new observations have all but disqualified the SCM.

As we shall see the idea of perpetual existence carries with it several important consequences that lead to a new appreciation of the nature of our existence. This monograph explores these consequences and introduces a new cosmos model of perpetual existence that agrees with all observational findings and explains mysteries like the Dark Energy and Dark Matter.

However, it implies major revisions both to science and to our world-view.

Chapter I: Introduction

This monograph summarizes the reasoning and considerations that motivated a new cosmos model, which resolves several cosmological puzzles and observational discordances that hitherto have been unexplainable.

This new cosmos model, which will be denoted the "Scale Expanding Cosmos" (SEC) model challenges our current view of the world as being created in the so called Big Bang event some 14 billion years ago. The SEC model introduces a new idea, which to my knowledge has not previously been investigated or developed. I will show that the SEC model agrees with astronomical observations and that it resolves a number of previously unexplainable cosmological mysteries. The SEC model has so far been ignored although published in a number of papers [Masreliez, 1999, 2004a, 2004b, 2004c, 2005a, 2006c, 2007b]. There also is a book [Masreliez, "The Progression of Time, How expanding space and time forms our world and powers the universe", Amazon, 2013].

In a presentation like this it is customary to refer to earlier work in order to clarify how the new contribution fits into the framework of current epistemology and ideas. However, the SEC model has to my knowledge no known precursor in science or in philosophy; it may represent a new direction of physics that, if it turns out to be correct, will force revision of current physics reaching all the way back to Galileo and Newton. This claim may seem preposterous, but it will be justified.

To get the reader in the right frame of mind from the outset a few fundamental questions will be posed.

Question 1:

Was the world created?

Although it seems obvious to us that the world must have had a beginning in some kind of creation, this idea was logically refuted by the ancient Greek philosopher Parmenides of Elea (500BC), who was held in high esteem by Plato.

He reasoned:

Only being ***is*** *- non-being* ***is not****. But, if only being* ***is****, there can be nothing outside this being that articulates it or could bring about change. Hence being must be conceived as eternal, uniform and unlimited in space and time.*

It seems obvious that something that exists cannot have had its origin in something that does not exist!

Parmenides further argued:

For never shall this be proved: that things that ***are not - are****.*

But do restrain your thought from this path of inquiry, and do not let habit born from much experience, compel you along this path. Judge by reason the highly contentious disproof that I have spoken.

Only one path is left for us to speak of: that ***it is****.*

In other words, we should simply accept that the world exists and may always have existed. Although this conclusion disagrees with traditional thinking, and with current physics, it has the advantage of avoiding the mysterious and illogical creation event. In the West there is the general belief that God created the world, and in the past questioning this creation myth amounted to heresy. However, if an almighty God really created the world, we may ask why he should have created a world of limited existence, doomed to suffer the eventual demise predicted by current physics? Wouldn't an almighty God rather have created a world of perpetual existence?

It will be shown that although the "laws of thermodynamics" currently rule out perpetual existence, a world of perpetual existence may actually be possible!

Question 2:

What determines the cosmological scale of material objects?

Let's consider the following thought experiment:

We are given the task of creating something out of nothingness. (For the moment let's ignore the unreasonableness of this request!)

Let's say that the first object to be created is an apple. At what size shall we create it? In nothingness the scale of the apple should not matter. It could be the size of a pea, and apple, a basket ball, or even the Earth, provided that its atoms and all its other attributes were scaled accordingly. *This suggests that worlds of different scales might exist.*

From what we currently know this should actually be true! GR does not show any preference for any particular scale of material objects. Its field equations remain identically the same regardless of the metrical scale because the "Christoffel Symbols" are identical for line-element differing only by a constant scale. This is also true in geometry; a sphere is a sphere regardless of its scale!

This conformal scale property of the universe will here by called *"scale-equivalence"*. Accordingly worlds of different scales would appear identical to their inhabitants. If this is true we may wonder why the scale of our world is what it actually is.

Or is it?

Perhaps the cosmological scale slowly changes with time? *Perhaps this is the nature of the cosmological expansion*; the expansion could be in the scale of both space and time (spacetime) and not only in space as in the Standard Cosmological Model (SCM). Since by scale-equivalence all epochs are geometrically identical the cosmos could keep expanding perpetually without ever changing!

Question 3:

What is causing the progression of time?

This is an age old question that still remains unanswered.

"What, then, is time? If no one asks me, I know; if I wish to explain to him who asks, I do not know."

Augustine of Hippo (From Confessiones lib xi, cap xiv, sec 17 (ca. 400 AD))

This situation has not changed in the sixteen centuries since then; we still don't know what is causing time to progress. But, strangely some of us seem to think that we may explain the universe without having an answer.

This cannot be done!

General Relativity (GR) does not help here, since it cannot explain the progression of time either. And, since most of our currently contemplated cosmos models are based on GR these models will all fall short. This should not be surprising; because the progression of time arguably is the most important and keenly felt aspect of our existence it has to be taken into account in any cosmos model.

Albert Einstein admitted that he did not know what is causing the progression of time either. Here is a quote from a letter he wrote after the death of his old friend from is school days, Angelo Besso:

"...for us physicists believe that the separation between past, present, and future is only an illusion, although a convincing one."

Furthermore, in discussing Minkowski's Space World interpretation of his theory of relativity, Einstein writes:

Since there exists in this four dimensional structure (spacetime) no longer any sections which represent "now" objectively, the concepts of happening and becoming are indeed not completely suspended, but yet complicated. It appears therefore more natural to think of physical reality as a four dimensional existence, instead of, as hitherto, the evolution of a three dimensional existence.

However, the four-dimensional existence modeled by GR might not suffice to describe the world. The cosmos is all about motion; and motion is impossible without the progression of time. However, since current physics cannot explain the progression of time it cannot properly explain motion either. In fact, by current physics time may run both in the forward and backward direction. However, since time always progresses forwards, which is known as "the arrow of time", current physics cannot explain the world.

We simply have to accept this fact.

By the SEC model cosmos expands without ever changing it four-dimensional (4D) geometry as perceived by co-expanding inhabitants. This is illustrated in the figure.

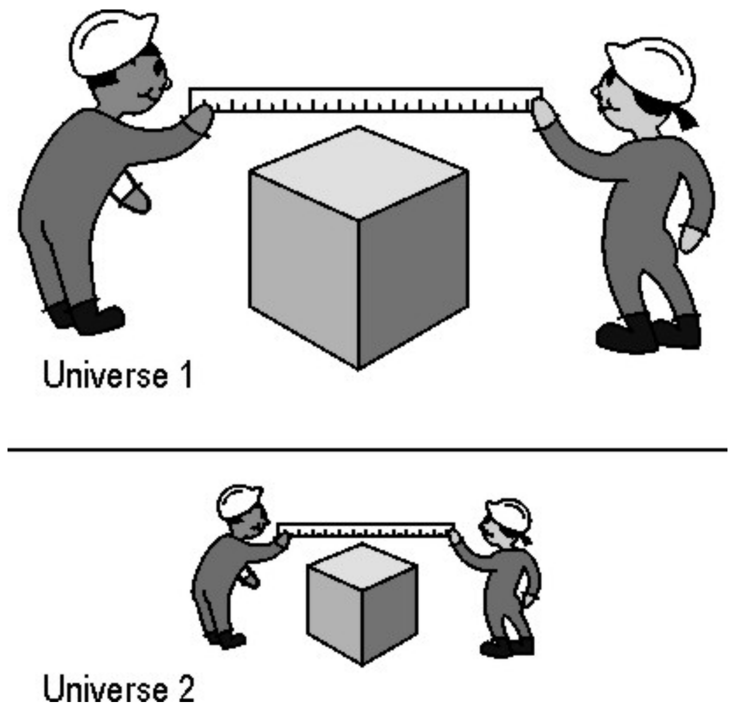

Figure 1: Scale-equivalent worlds

Changing the metrical scales of space and time four-dimensionally means that the cosmos remains the same for its inhabitants, which makes perpetual existence possible.

By the SEC model the progression of time mirrors the cosmological scale expansion.

The cosmos expands by incrementally increasing the four-dimensional scale of spacetime at each step reproducing the 4D geometry modeled By GR. (This may be compared to a movie which models motion as a sequence of picture frames.) Furthermore, as we shall see, this process is involved in all kinds of motion, whether in time or in space.

The scale of spacetime acts as an additional dynamic degree of freedom beyond the four spacetime dimensions of GR.

It will be shown that this new thinking will explain the world we see and experience.

The content of this monograph addresses three different subjects:

- The SEC model
- The link between General Relativity and Quantum Mechanics

- Motion and the origin of the inertial force

The latter two subjects became unexpected consequences of the SEC model that in their own right deserve independent attention.

This monograph will show that there is a line-element of GR, the SEC line-element, which agrees with several cosmological tests. It also explains observational discordances in the solar system, for example the drifts in planetary positions relative to their computed ephemerides, which have been confirmed by optical observations.

It will be shown that the difference between Universal Time and Ephemeris Time primarily may be a consequence of the cosmological scale-expansion rather than a slowing rotation of the Earth due to tidal action. It also suggests and explanation for the Pioneer Anomaly [Anderson et. al, 2003] and it implies that the Moon is not receding from the Earth as fast as currently estimated; the Moon could have been formed at the same time as the Earth.

Furthermore, the components of the energy-momentum tensor for the SEC line-element do not disappear; its positive T_{00} component equals Einstein's Critical Density of his paper on cosmology [Einstein, 1917].

This may explain the origin of Dark Energy.

The three negative components correspond to a Cosmological Constant, which explains the recently discovered "accelerating cosmological expansion". However, the net energy of the energy-momentum tensor disappears; the net vacuum energy of the SEC model is zero.

These excellent agreements with observations, and the resolution of several cosmological puzzles, suggests that *the metrical scale* of 4D spacetime could act as an additional dynamic, cosmological, degree of freedom beyond the four spacetime dimensions. The progression of time may directly mirror the cosmological scale expansion, which acts everywhere across the cosmos from huge mass accumulations in the form of galaxies down to subatomic particles. This would also explain why all of us intimately experience the progression of time as being perhaps the primary aspect of our existence.

Furthermore, as we shall see, the scale expansion may be a perpetual power source for the cosmos.

Although the SEC model cannot be described by the continuous 4D manifold of GR, it may instead be modeled by a new process denoted Dynamic Incremental Scale Transition (DIST) whereby the 4D scale of spacetime is being adjusted in a stepwise manner. Another possibility would be to add the scale as a fifth dimension of GR. This suggests that incremental progression of time might cause the metrical scale of spacetime to oscillate. Modeling such oscillation in GR allows the derivation of Quantum Mechanics (QM) from GR! This suggests that the QM wave functions may be modulations of the metrical scale of spacetime, which could provide the missing link between GR and QM, and merge these two theories into a single five-dimensional theory. It would provide and ontological explanations to the QM wave functions as being oscillations in the scale of spacetime. Furthermore it would explain the Kaluza-Klein "miracle" by which Maxwell's equations are derived from a 5D version of GR, suggesting that the fifth dimension should be taken into account not only in cosmology but in all aspects of motion.

The origin of the inertial force has never been explained. Although Newton's celebrated second law, $F=am$, postulates the existence of such an inertial force F, an explanation to its origin has in the past been missing. Since there can be no motion unless time progresses, the dynamic scale of spacetime may participate in all motion, in space as well as in time. This idea is investigated with the objective of finding an explanation to the inertial force. By applying a dynamic scale-factor to the Minkowskian line-element a certain scale-factor is found for which all accelerating trajectories will take place on GR geodesics. If the metrical scale for all accelerating objects were to contract in a relative sense by this scale-factor it would explain the inertial force as being a phenomenon akin to gravitation, being caused by spacetime curvature.

Such dynamic scale contraction would also explain the length-contraction and time-dilation of Special Relativity. Furthermore, it would unambiguously resolve the Twin Paradox by allowing the *observed* time in moving frames to differ from the local time, while allowing clocks in inertial frames to run at the same pace. This admits the existence of an absolute cosmological temporal reference. However, this would mean that inertial frames are in different 4D manifolds of GR separated by different relative scales in a five-dimensional cosmos. If this is true it would mean that Special Relativity is in need of conceptual revision.

Some of the detailed derivations in support of this development may be found in the text, while the more elaborate technicalities may be found in the appendices.

Dynamic Incremental Scale Transition (DIST)

Key to appreciating the SEC model is to become comfortable with the idea of being an inhabitant who participates in the cosmological scale-expansion. You might perhaps wonder if this new scale-expansion process really is "allowed" since it probably never has been considered before. However, the world is what it is, and might not be what we think it is.

And, as we shall see, there is a good reason for this scale-expansion since it generates energy that makes perpetual existence possible.

Science is a game played with certain rules, and the scale expansion process does not yet belong among these rules. But we must remember that all our rules of science were laid down based on previous knowledge. We are continually expanding our knowledge base and revising these rules. The scale expansion might be such a revision that adds another dimension to our existence, but does not invalidate GR.

If the scale of four-dimensional spacetime were to change incrementally it would not alter its 4D geometry since the field equations of GR would remain unchanged. Generally, the process may be described by the loop depicted in Figure 2.

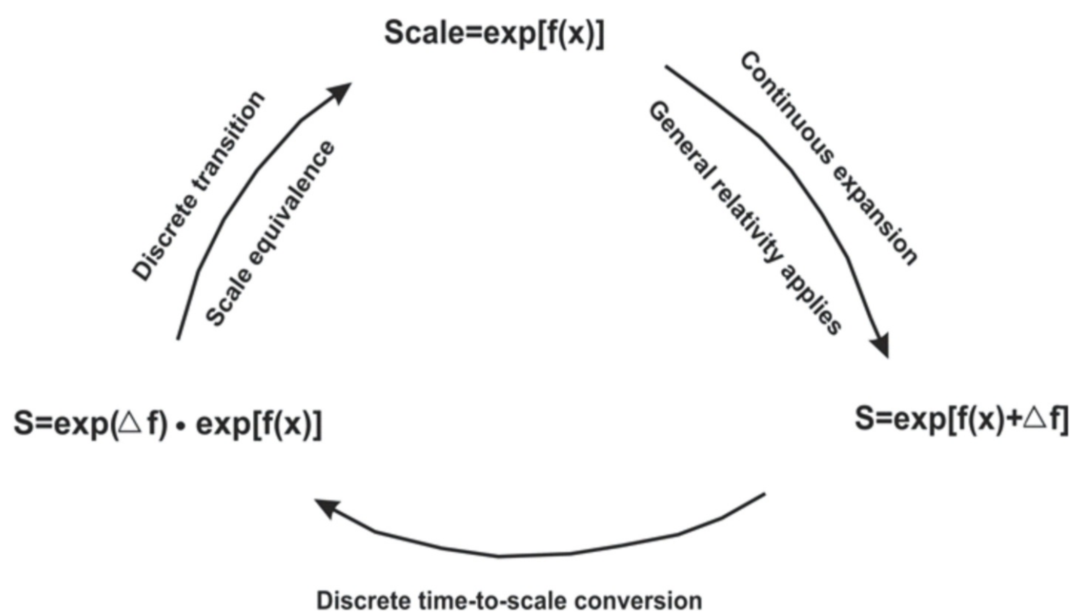

Figure 2: The DIST cycle

This semi-continuous loop will be denoted Discrete Incremental Scale Expansion (DIST). Here, $f(\boldsymbol{x})$ signifies a function of possibly all four coordinates of spacetime. By the DIST process the scale of spacetime may change continuously in intervals where GR applies, while the scale adjusts incrementally to compensate for the changing scale.

This allows the 4D geometry to remain unchanged while the scale of spacetime changes.

Because of this incremental step the four-dimensional geometry always remains the same. Therefore, the DIST represents a new kind of motion that takes place "beyond" the 4D manifold of space and time.

It makes use of scale-equivalence, which might be the most fundamental of all symmetries. It is a process that does not change the energy-momentum tensor of GR; it does not "cost" anything, so it can take place without energy loss. It is therefore not surprising that the universe takes advantage of this process in its cosmological expansion mode. Note that relative to a co-expanding observer the DIST process becomes *cyclic* in nature since the four-dimensional geometry of the SEC returns to its starting point by the end of each cycle. This explains the eternal aspect of the progression of time that takes place in a "fifth dimension" beyond the four spacetime dimensions. This also explains why the passage of time always has been enigmatic in the past; it cannot be explained as motion in space or time.

However, we must keep in mind that we are trying to model the dynamic scale process by extending the applicability of known physics. At first this might appear to be questionable, but it is possible that the DIST process is more fundamental than the traditional continuous processes we are used to. We must acknowledge that continuous processes are achieved by visualizing increments in time and space as becoming arbitrarily small, which we now know is impossible due to quantum theory and the wave aspect of particles. Therefore, we should not expect that all aspects of the world might be modelled by continuous processes. Continuity may not apply for motion in scale, at least not in four dimensions. In other words, our extensive use of differential methods, which have served us so well in the past, may have outlasted their applicability.

Chapter II: The SEC model

Initially I thought that cosmological four-dimensional (4D) scale expansion may be modeled by using a line-element in GR:

$$ds^2 = e^{2t/T}\left((c \cdot dt)^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(II.1)}$$

Here *t* is atomic time and *T* the Hubble Time (about 14 billion years), which currently is associated with the age of the SCM. I will call this line-element "the SEC line-element". In the following the speed of light c will be set equal to one, c=1, to simplify the writing. Thus time will be measured in light-seconds rather than seconds.

The reader familiar with GR and the SCM might here immediately object to this form since this line-element easily may be changed into a standard Friedman-Robertson-Walker (FRW)-type line-element by the transformation *t'=T·exp(t/T)*.

$$ds^2 = dt'^2 - \left(\frac{t'}{T}\right)^2 \left(dx^2 + dy^2 + dz^2\right) \qquad \text{(II.2)}$$

According to GR these two forms of the line-element are physically equivalent. It therefore seems that the SEC model does not introduce anything new. In the SCM the time t' is usually referred to as "proper time", which is the temporal coordinate in the absence of gravitational fields or acceleration.

However, the main idea behind the SEC model is cosmological scale-equivalence that makes all epochs physically identical. This also means that the cosmological scale expansion is an inherent feature of the cosmos that does not alter its 4D geometry. Therefore atomic time *t* is not what we call proper time but is subject to perpetual change with the accelerating scale metric.

Translation in time $t \Rightarrow t + \Delta t$ gives line-element:

$$ds^2 = e^{2\Delta t/T} \cdot e^{2t/T}\left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(II.3)}$$

Since this line-element is scale-equivalent with the SEC line-element the constant scale factor $exp(2\Delta t/T)$ may be ignored. Inhabitants in the SEC always experience the cosmos geometry as being flat with a Minkowskian line-element, but also experience the effects of the dynamic scale-expansion modeled by the SEC line-element.

Furthermore, since the SEC is scale-equivalent for translations in time, we may always set t=0 at the present time.

The time NOW becomes a perpetual temporal reference with time *t* running negative into the past with diminishing scales. This is true for all epochs, and is consistent with perpetual existence. Therefore, the most natural temporal reference in a perpetual scale-expanding cosmos is the present time NOW.

Another way of seeing this is be to make the substitution $ds \Rightarrow ds \cdot exp(\Delta t/T)$ in (II.3), which restores the SEC line-element (II.1). Repeatedly implementing this dynamic scale transition process would suggests a new dynamic scale-dimension beyond the four dimensions of spacetime, which cannot be modeled by GR.

This process may be modeled by the DIST loop:

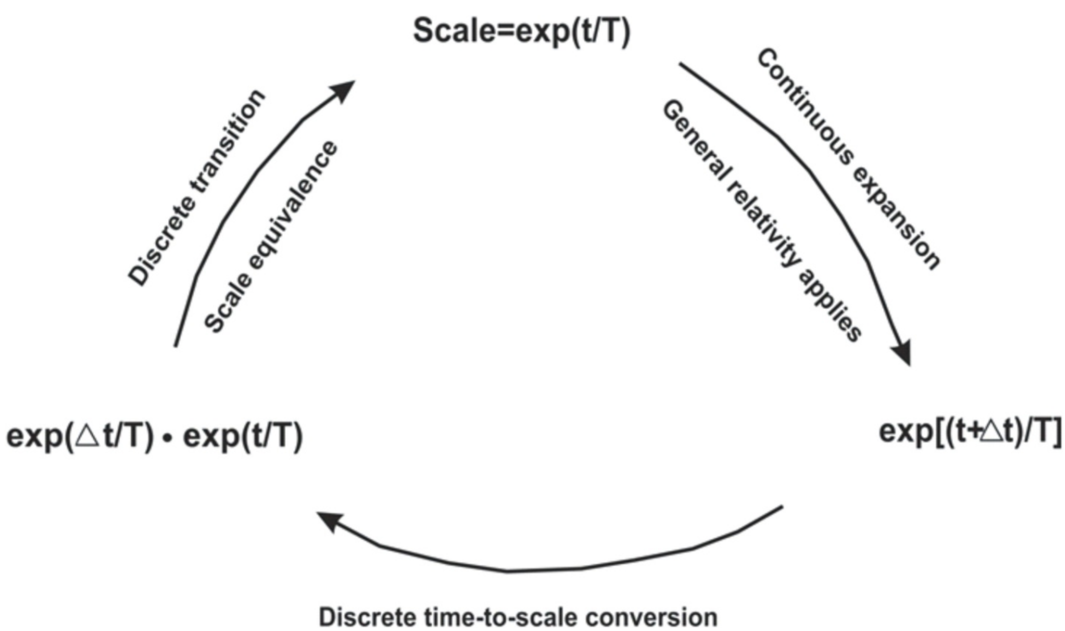

Figure 3: The DIST loop of the SEC

Therefore the SEC model implies new physics.

However, note that at all times we may still investigate the consequences of cosmological scale expansion using GR, because the SEC is scale-equivalent for translations in time.

The SEC line-element deserves serious consideration because as we shall see its observational predictions excellently agree with measurements, and it also explains previously unresolved mysteries, for example Dark Energy and Dark Matter.

A few useful relationships derived from the SEC line-element

The age of the cosmos

We first note that if the scale increases with time so that the duration of time intervals always "keep up" with this increasing scale, the duration of a "proper" second increases exponentially with time. Although the SEC line-element may at each instant equal the Minkowskian line-element, the seconds of the past were shorter by the factor exp(t/T) (remember that t<0 in the past).

The "age" of the cosmos may therefore be found by integration:

$$"Age" = \int_{-\infty}^{0} e^{t/T} dt = T \quad \text{(II.4)}$$

The "age" of the SEC *as expressed in the current duration of the year* is always the same, and equal to the Hubble Time, *T,* about 14 billion years. This may always have been true; 14 billion years ago the cosmos was also 14 billion years "old"!

The Hubble Time T is a cosmological constant that has nothing to do with the age of the universe!

In the figure the upper graph illustrates the SEC time-scale and the lower the SCM.

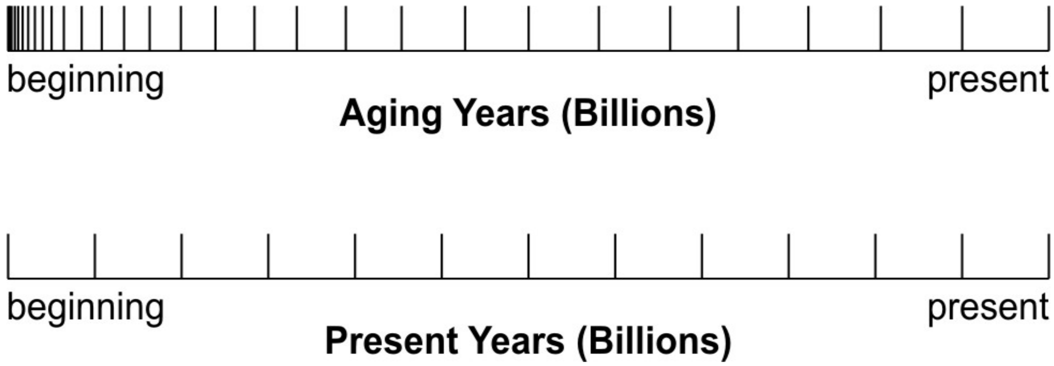

Figure 4: The SEC and SCM time-scales

Cosmic Drag

In Appendix I the SEC geodesic of GR for free translational motion is derived from the SEC line-element:

$$\beta = \frac{v}{c} = \frac{\beta_0 \cdot e^{-t/T}}{\sqrt{1-\beta_0^2+\beta_0^2 \cdot e^{-2t/T}}} \qquad \text{(II.5)}$$
$$\beta_0 = \frac{v_0}{c}$$

Here v is the velocity and t>0 is the time of travel. There is another form of (II.5) relating "relativistic" velocities of Special Relativity:

$$\frac{\beta}{\sqrt{1-\beta^2}} = \frac{\beta_0}{\sqrt{1-\beta_0^2}} e^{-t/T} \qquad \text{(II.6)}$$

Note that if the initial velocity v_0=c in (II.5), then v=c for all t.

However, if the initial velocity v_0<<c, then:

This will be denoted "Cosmic Drag". It diminishes relative velocities for freely moving objects.

Note that this invalidates Newton's first law of motion cosmologically!

The angular momentum also dissipates in the SEC:

$$r^2 \cdot \dot{\theta}^2 = \frac{r_0^4 \cdot \dot{\theta}_0^2 \cdot (1 - \dot{r}^2) \cdot e^{-2t/T}}{r^2 \cdot [1 - \dot{r}_0^2 - (r_0 \cdot \dot{\theta}_0)^2] + r^4{}_0 \cdot \dot{\theta}_0^2 \cdot e^{-2t/T}} \qquad \text{(II.8)}$$

Here *Θ* is the angular location and *r* the radial distance. For velocities much smaller than c we get:

$$r^2 \cdot \dot{\theta} = (r_0^2 \cdot \dot{\theta}_0) \cdot e^{-t/T} \quad \text{(II.9)}$$

For small radial velocities the angular momentum decreases exponentially with time in the SEC.

This invalidates the conservation of angular momentum of classical physics.

However, in the SEC the energy-momentum is still conserved four-dimensionally.

In a recent book: “Irreversible Time Physics” Dr. Igor Taganov considers a slowing progression of time and investigates several of its consequences. He finds many aspects in agreement with the SEC model, for example cosmic drag [Taganov, 2013].

The cosmological redshift

For a fixed location *dx=dy=dz=0* the SEC line-element (II.1) gives:

$$ds = e^{t/T} dt \qquad \text{(II.10)}$$

Counting time positive in the past by setting -t=tp we find that the scale expansion will cause past time intervals dt_p to seem longer:

$$ds = dt_0 = e^{-t_p/T} dt_p$$

$$dt_p = e^{t_p/T} dt_0 \quad \text{(II.11)}$$

Therefore, the redshift *z* for light received from the past is given by the relation:

$$\begin{aligned} f_p &= f_0 \cdot e^{-t_p/T} = f_0 / \left(1 + z\right) \\ 1 + z &= e^{t_p/T} \end{aligned} \qquad \text{(II.12)}$$

Relation (II.11) also implies that there is time dilation in addition to the redshift, since the photon arrival frequency also decreases by the factor 1/(1+z). This will be used below when deriving the apparent luminosity relation for the SEC.

The SEC redshift-distance relation

The distance to a source with redshift z follows directly from the redshift relation above:

$$
\begin{aligned}
&1+z = e^{t_p/T} \\
&t_p = T \cdot \ln(1+z) \qquad \text{(II.13)} \\
&d = c \cdot t_p = c \cdot T \cdot \ln(1+z) = D \cdot \ln(1+z)
\end{aligned}
$$

The distance to the source is *d* and the Hubble distance is *D=cT*.

The SEC apparent luminosity relation

Since there are two dimming factors *1/(1+z)* the apparent luminosity *L* of a source of flux intensity *I* is given by:

$$L = \frac{I}{4\pi \cdot d^2 (1+z)^2} = \frac{I}{4\pi \left(D \cdot (1+z) \cdot \ln(1+z) \right)^2} \qquad \text{(II.14)}$$

This relation will together with the distance relation above be used in testing the applicability of the SEC model.

Cosmological tests

Several observational programs have been designed with the main objective of testing cosmological models. One might think that if the SCM's predictions disagree with these tests it ought to defuse enthusiasm for the theory. However, this has not been the case. The support is as strong as ever for the SCM despite its several indisputable observational discrepancies. Instead of rejecting the SCM, its supporters keep adding new speculative (and mythological) features to this model in order to explain away all of its discrepancies.

Several investigators beginning with Edwin Hubble have found that astronomical observations agree better with the tired-light redshift model than with the Doppler-like redshift of the SCM. According to the tired-light model photon energies decrease with distance as in (II.13), but there is only one dimming factor, 1/(1+z), in (II.14).

In an important paper Dr. Paul LaViolette [LaViolette, 1986] presents clear observational evidence showing that the tired-light redshift–distance relation (which is the same as in the SEC) agrees with cosmological tests without resorting to any of the many speculative evolutionary scenarios needed to reconcile the observations with the SCM. But, unfortunately, this significant contribution has largely been ignored. Since 1986, our observational capabilities have improved dramatically with new tools like the Hubble space telescope and Very Long Baseline Interferometry (VLBI), and as we shall see, it has gradually become clear that the SCM simply does not agree with the observations.

Three standard cosmological tests are discussed in the following; the galaxy number count test, the angular size test, and the surface brightness test. Also, recent supernovae observations are examined.

The Galaxy Number Count Test

Any candidate cosmological model should be able to predict how the number of galaxies (galaxy count) we see from the Earth increases with distance. Since the apparent luminosities of galaxies depend on their distances, there is also a corresponding test for number count as a function of apparent luminosity. However, several observational programs have repeatedly found that *the SCM's predictions do not agree with observational data.*

Figure 5 shows a summary from sixteen different number count programs taken from a paper by Metcalf et al. [Metcalf et al., 1995]. Galaxies seen in the sky within a spatial square degree and a 0.5 magnitudes luminosity range are counted and displayed as a function of luminosity magnitude. The SEC theory's prediction has been added to a figure presented in the Metcalf paper. It is clear that the SCM model fails the test, since its graph lies well below the observations, while the SEC model agrees well with the observations.

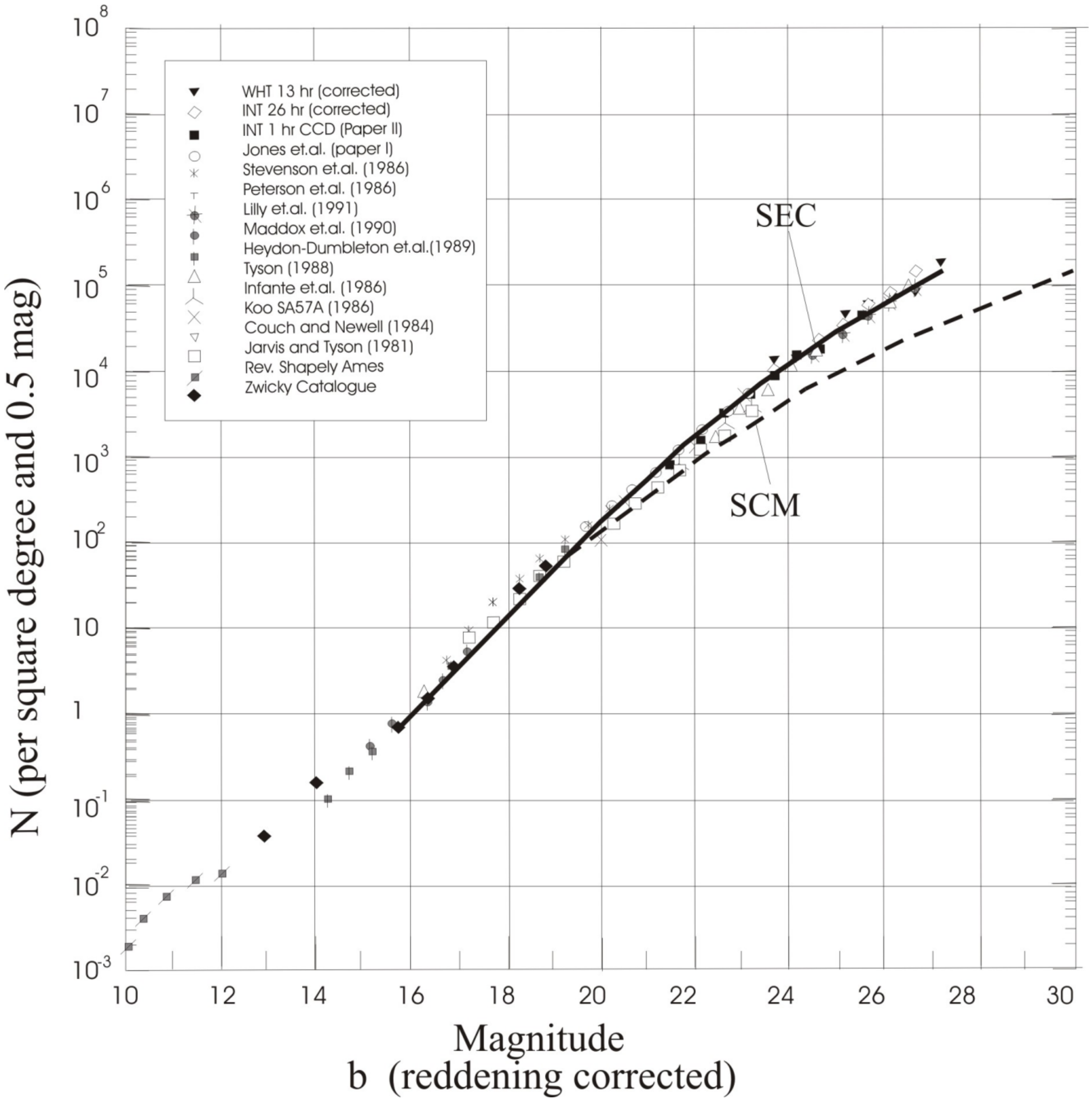

Figure 5: Galaxy number count test

The magnitude displayed on the x-axis indicates apparent luminosity of galaxies; the larger the magnitude is, the dimmer is the galaxy. The magnitude scale is logarithmic and a difference of one in magnitude corresponds to a factor 2.512 dimmer luminosity. As seen by the human eye, visible stars have luminosities less than 6. Therefore, galaxies at magnitude 26 are a hundred million times dimmer than what we can see with the naked eye, which explains why we have to use the Hubble Space Telescope and charge-coupled devices to see them. The y-axis indicates the number of galaxies observed within one square degree of the sky and a 0.5 magnitude band.

The SEC graph in the plot was obtained using the apparent luminosity relation (II.14).The y-axis on the graph is the galaxy count, *dN,* per spatial degree and 0.5 magnitude, *dm*. This may be approximated by the differential *dN/dm=(dN/dz)/(dm/dz)* , which may be obtained from the two relations:

$$N(z) = Const \cdot d^3 = C_1 \cdot \left[\ln(1+z)\right]^3 \qquad \text{(II.15)}$$

$$m(z) = -2.5 \cdot \log(d_l^2) + Const = 5 \cdot \log\left[\ln(1+z) \cdot (1+z)\right] + C_2 \qquad \text{(II.16)}$$

The galaxy number density is assumed to be constant regardless of distance. The constant C_1 merely causes a vertical displacement on the log scale of the y-axis while C_2 either disappears in the differentiation *dm/dz* or causes horizontal adjustment of the *m* values on the x-axis.

The SEC model perfectly agrees with the shape of the curve in the figure after adjusting its location for best fit using $\log(C_1)=5.7$ and $C_2=24$. The good fit in the figure was obtained with z running from z=0.002 at m=10.5 to z=1.0 at m=25.7.

Metcalf et al. attempt to explain the clear discrepancy between the SCM's prediction and the observations by proposing several evolutionary scenarios, but none of these fits the data as well as the SEC.

Since the number count data was obtained from 16 different programs this close agreement between the observational data and the SEC model's prediction provides irrefutable evidence in favor of the SEC model, which is obtained without any fudging factors. The SEC parameter *T* does not appear in the shape of the plot since it becomes part of the two constants C_1 and C_2.

The Angular Size Test

The angular size of a cosmological object, for example a galaxy, may also be used to test candidate models. The SCM predicts that beyond a certain distance, the angular size will start to *increase* with increasing distance rather than decrease; in the SCM there is a minimum in the graph of angular size versus distance. However, observations do not support this; they show that the observed angular sizes decrease monotonically with increasing distance.

In the SEC the observed angular size Θ of a galaxy with diameter D_g decreases inversely proportional to the distance:

$$\theta = \frac{D_g}{d} = \frac{D_g}{D \cdot \ln(1+z)} \qquad \text{(II.17)}$$

Figure 6 is from a paper by Djorgovski and Spinrad [Djorgovski and Spinrad,1981]. The SEC prediction (II.17) has been added. Clearly the SEC model's agreement with the observations is superior. There is no evidence that the angular size has a minimum value.

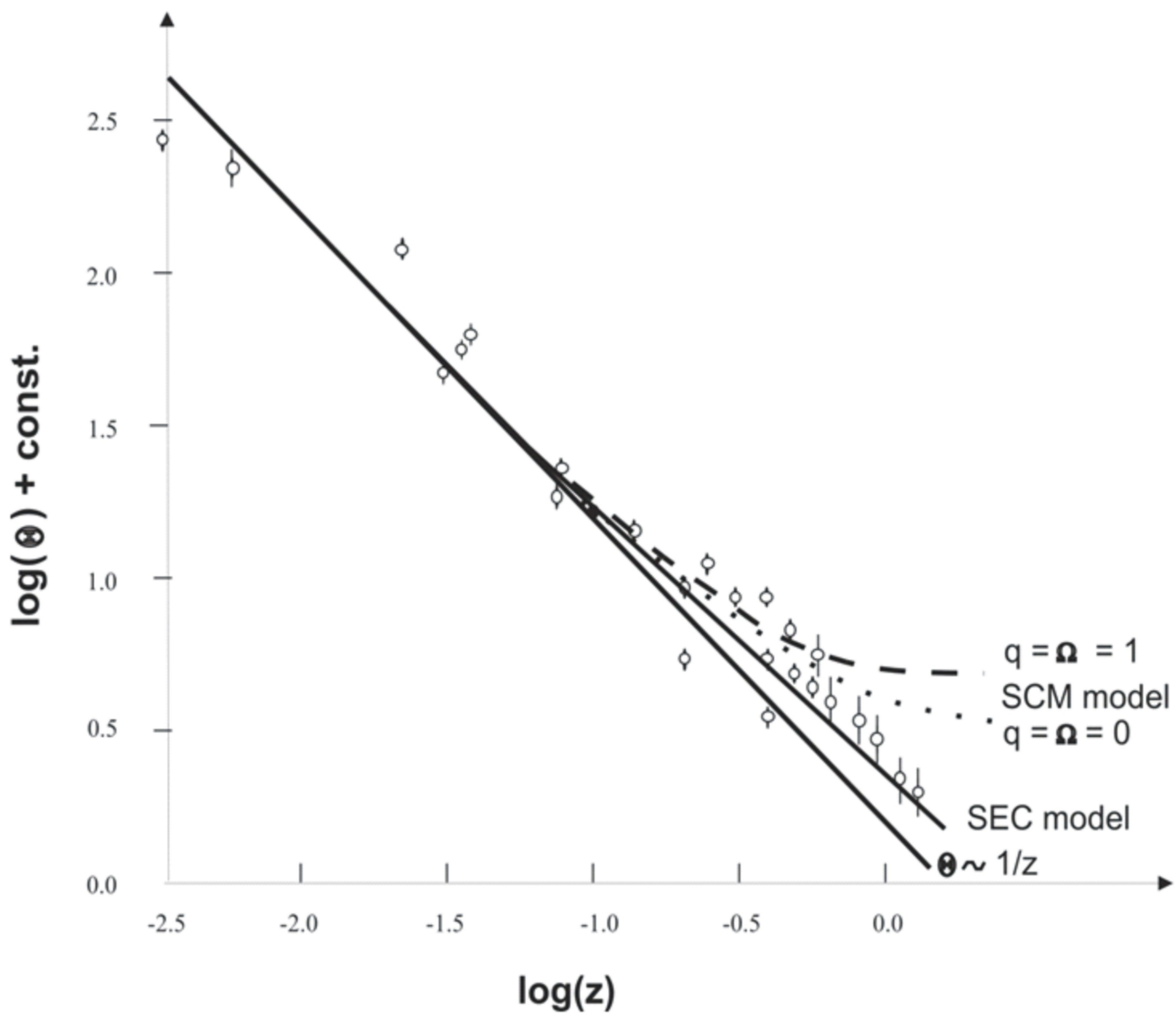

Figure 6: Angular size test

For small redshifts the distance is proportional to z*, which is the lower line in the figure. However for the SEC model, the distance is proportional to ln(1+*z*), which is shown as the middle line. The distance relation for the SCM is more complicated, because it depends on parameters like the mass density parameter,* Ω*, and the deceleration constant,* q*. Two cases for the SCM are shown. By the SCM model, the angular size should decrease more slowly with distance, which partly is due to the fact that the maximum distance in the SCM universe is the Hubble distance, which in the SCM occurs at infinite redshift. However, in the SEC model, the Hubble distance is reached at* z*=1.7. Clearly, the data supports the SEC.*

The Surface Brightness Test

The surface brightness test is a powerful and robust discriminator between candidate cosmos theories. Surface Brightness is defined as observed luminosity per surface area of the observed object. Usually, surface brightness of galaxies is estimated based on apparent luminosity per observed surface area as measured in squared arc-seconds. The SCM fails this test since its predicted values do not agree with observations.

In the SEC the surface brightness may be estimated using the two relations:

$$L = \frac{I}{4\pi \cdot d^2 (1+z)^2} \qquad \text{(II.18)}$$

$$A = \left(\theta \cdot d\right)^2 \qquad \text{(II.19)}$$

A is the surface area of the source and Θ the angular size of the source.

The surface brightness becomes:

$$sb = \frac{I}{A} = \frac{L \cdot 4\pi \cdot d^2 \cdot (1+z)^2}{\left(\theta d\right)^2} = \frac{L \cdot 4\pi \cdot (1+z)^2}{\theta^2} \qquad \text{(II.20)}$$

$$SB = 2.5 \cdot \log_{10}(sb) + \text{Constant}$$

Note that the dependence on the distance to the source has disappeared. This makes the surface brightness test very robust.

Observational results reported by Lubin and Sandage [Lubin and Sandage, 2001] show that the SEC theory agrees with observed galaxy surface brightness while the SCM does not. 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.

Again, the agreement between observations and the SEC model's predictions must be acknowledged; distant galaxies appear to have the same surface brightness as nearby galaxies.

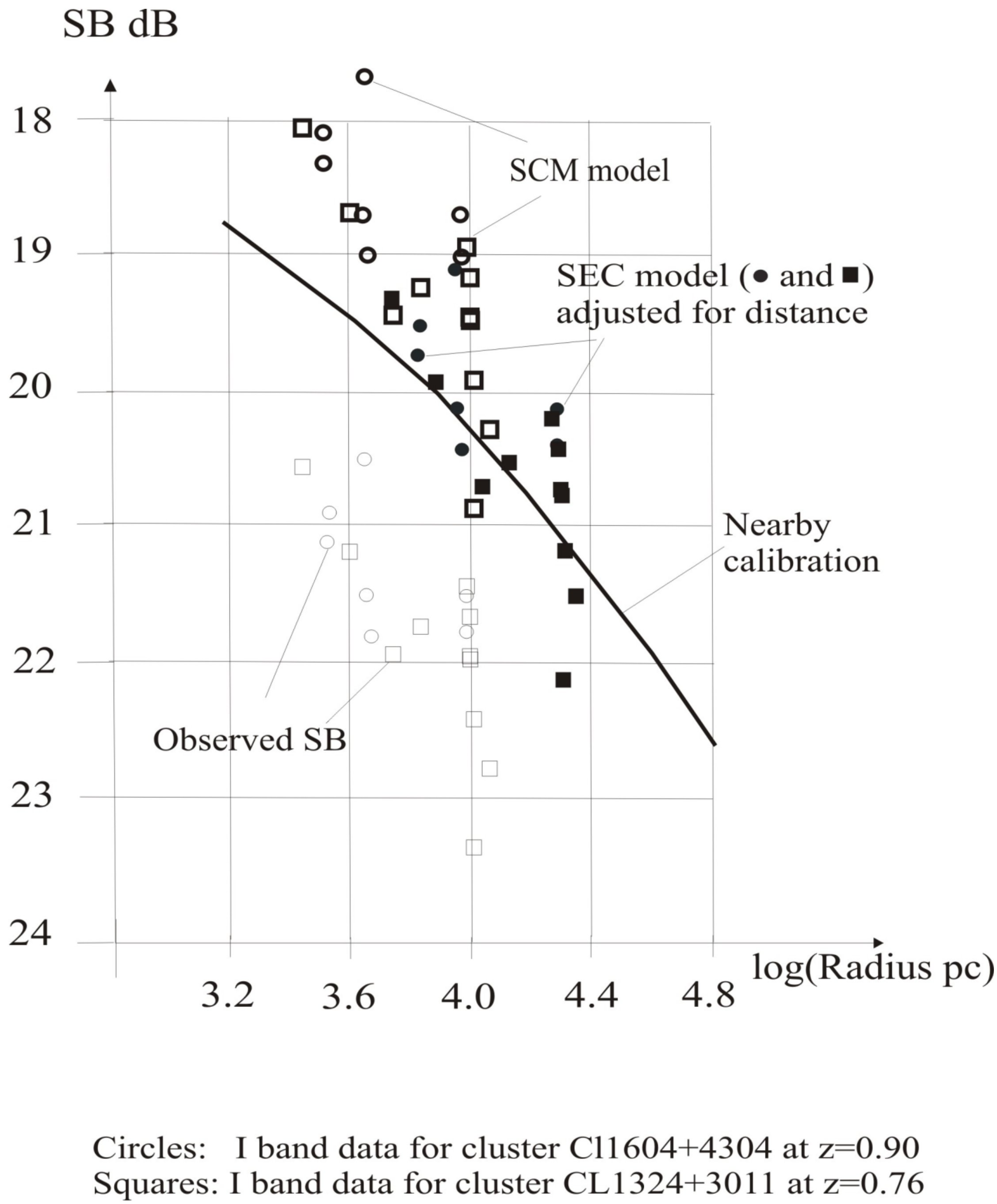

Figure 7: Surface Brightness test

The lower left part of the graph shows the observed surface brightness of galaxies in two clusters at redshifts close to one (z = 1) as represented by the faint open squares and circles. The x-axis shows the logarithms of the estimated radii of these galaxies, and the y-axis the surface brightness magnitudes. Observations of nearby galaxies are represented by the solid curved line. Any candidate *cosmological model can be used to predict what the surface brightness of a distant galaxy would have been if it instead had been located nearby. The solid open symbols represent the SCM model's predictions and the filled symbols the SEC model's predictions. The figure shows that the SEC model predicts surface brightness of distant galaxies that, on the average, are the same as for nearby galaxies. On the other hand, according to the SCM model, distant galaxies were brighter, a discrepancy that typically is explained away by "evolution".*

According to SCM the distance to the source increases with time while it remains constant in the SEC. Therefore, by the SEC model the surface brightness is proportional to the *square* of (1+z) while by the SCM it is the *fourth* power of (1+z).This difference causes the SCM predictions to lie above the solid line in figure, which is the calibrated surface brightness baseline estimated from nearby galaxies. Note that the negative correction in magnitude relative to the observed data for the SCM is about twice that of the SEC model. Also, the estimated radii for the SEC model are larger than for the SCM because the distance increases faster with redshift in the SEC.

Accelerating Cosmological Expansion*?*

A startling recent finding that contradicts the SCM is based on supernovae observations, in particular a certain type of supernovae—the so-called supernovae 1a (SN 1a).

In this scenario, a carbon-oxygen rich white dwarf star is accreting matter from a companion star. (The kind of companion star that is best suited to produce type Ia supernovae is hotly debated.) In a popular setting, so much mass accumulates on the white dwarf that its core reaches a Critical Density of $2 \cdot 10^9$ g/cm^3. This causes uncontrolled fusion of carbon and oxygen, thus detonating the star.

This is believed to be a repeatable process, always resulting in a characteristic radiation signature. I will not go further into these details more than to say that the duration and shape of the light-curve from an SN1a is closely related to its light output. The light-curve is a graph of its luminosity as a function of time that typically could last a month or longer, and its intrinsic luminosity may be estimated from the shape and duration of the light-curve. Also, the spectrum of an SN1a can be recognized and distinguished from other types of supernovae.

The longer the duration of the light-curve, the brighter is the supernova, which makes it possible to use them as "standard candles." Since we can measure the apparent luminosity and can use the light-curve to estimate the emitted, intrinsic luminosity, we can use this information to estimate its distance and test the validity of different cosmos models. Furthermore, since the light output is enormous, often greater than that of a typical galaxy, and since they flare up and die away over a couple of months, the SN1a can be detected against the background light (typically a host galaxy) and give information on geometrical properties of the very distant universe.

SN1a observations have given important but unexpected information. It appears that the cosmological expansion is now *accelerating*. An accelerating universe suggests a new force, possibly implying a cosmological constant as originally proposed by Einstein, and this force could be related to the missing dark energy predicted by the Inflation theory.

However, this interpretation crucially depends on the redshift–distance relation of the SCM. As we shall see there is another, better, interpretation to the SNe Ia observations.

The recently reported SNe Ia observations by the Supernova Cosmology Project [Perlmutter 2003; Perlmutter et al. 1995, 1997, 1999] and by the High-Z Supernova Search Team [Schmidt et al., 1998] seemingly confirm that these observations do not agree with the SCM unless the cosmological expansion accelerates. However, as shown in figure 8 below, the SNe Ia observations agree very well with the theoretical predictions of the SEC model. This good agreement with the SEC model is obtained without adjusting any parameters.

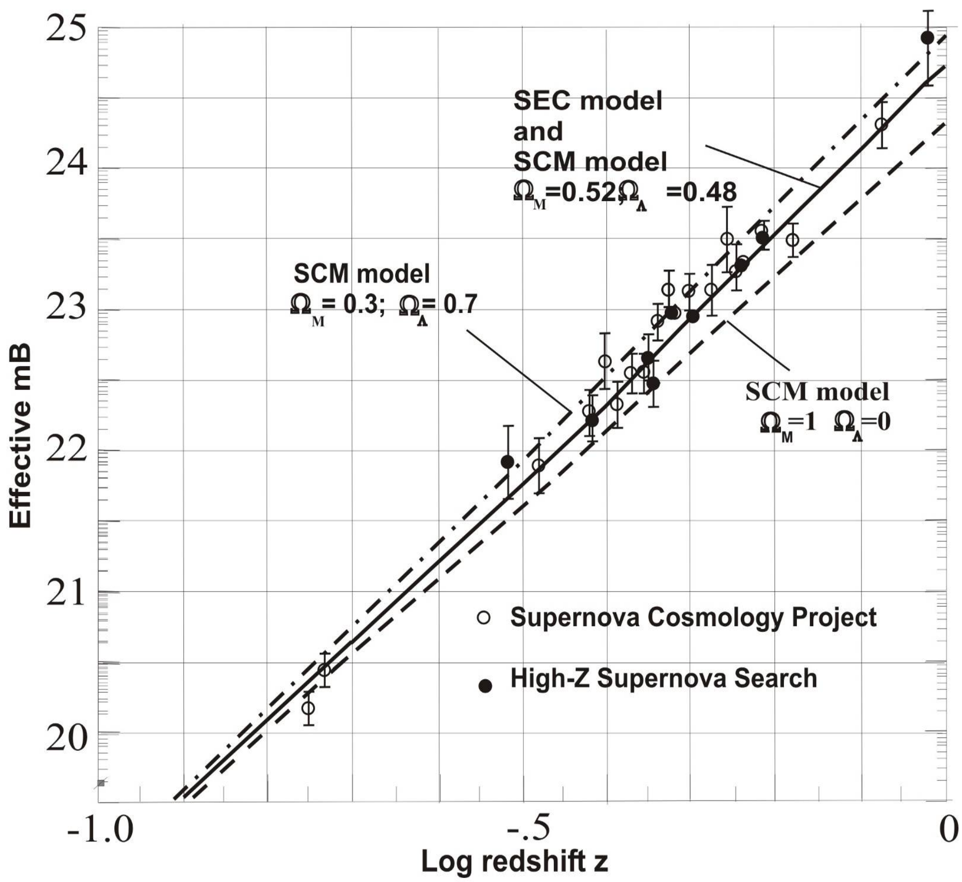

Figure 8: Supernova 1a observations

The lower dashed line is the prediction of the SCM if the cosmological mass-density equals Einstein's Critical Density Ω. The upper dashed curve is the SCM with 30 percent mass density and 70 percent cosmological constant, which together makes Ω = 1. This interpretation is currently favored by the SCM supporters. The solid line is the SEC model's prediction.

Note that the SCM model's predictions assume that the energy density equals Einstein's Critical Density for which Ω = 1, which is about twenty times larger than the visible mass-energy density in the universe. The missing 95 percent is believed to be a combination of dark matter (about 30 percent) and dark energy (about 65 percent) of unknown origin. This is one of the most puzzling unresolved problems in contemporary cosmology. On the other hand, since the SEC model's predictions agree with observations, no energy is missing. In fact, what in the SCM appears as missing, unexplainable energy, is in the SECenergy contained in spacetime itself; it is induced by the cosmological scale expansion! This directly follows from the vacuum energy-momentum tensor for the SEC theory, see further below.

An even more recent paper by Riess et al. [Riess et al, 2004] presents data for 16 newly discovered SNe Ia, 6 of them observed in the redshift range z >1.25 using the Hubble space telescope. These new observations suggest that the universe initially went thought a phase with a decelerating expansion rate, which later was followed by accelerating expansion. Riess et al. modeled the evolution of the luminosity distance by assuming an initial phase with a decreasing positive deceleration constant, later followed by an accelerating phase with negative constant. The parameters of this model as well as the redshift at which the deceleration constant is zero may be estimated from observational data and be used to model the evolution of the luminosity distance. The transition from decelerating to accelerating expansion is estimated by Riess et al. to occur at z = 0.46. Our figure 9 (which is figure 4 in Riess et al. with the SEC prediction added) shows the fit to the observations assuming flat SCM cosmology with $\Omega_M = 0.29$ and $\Omega_\Lambda = 0.71$.

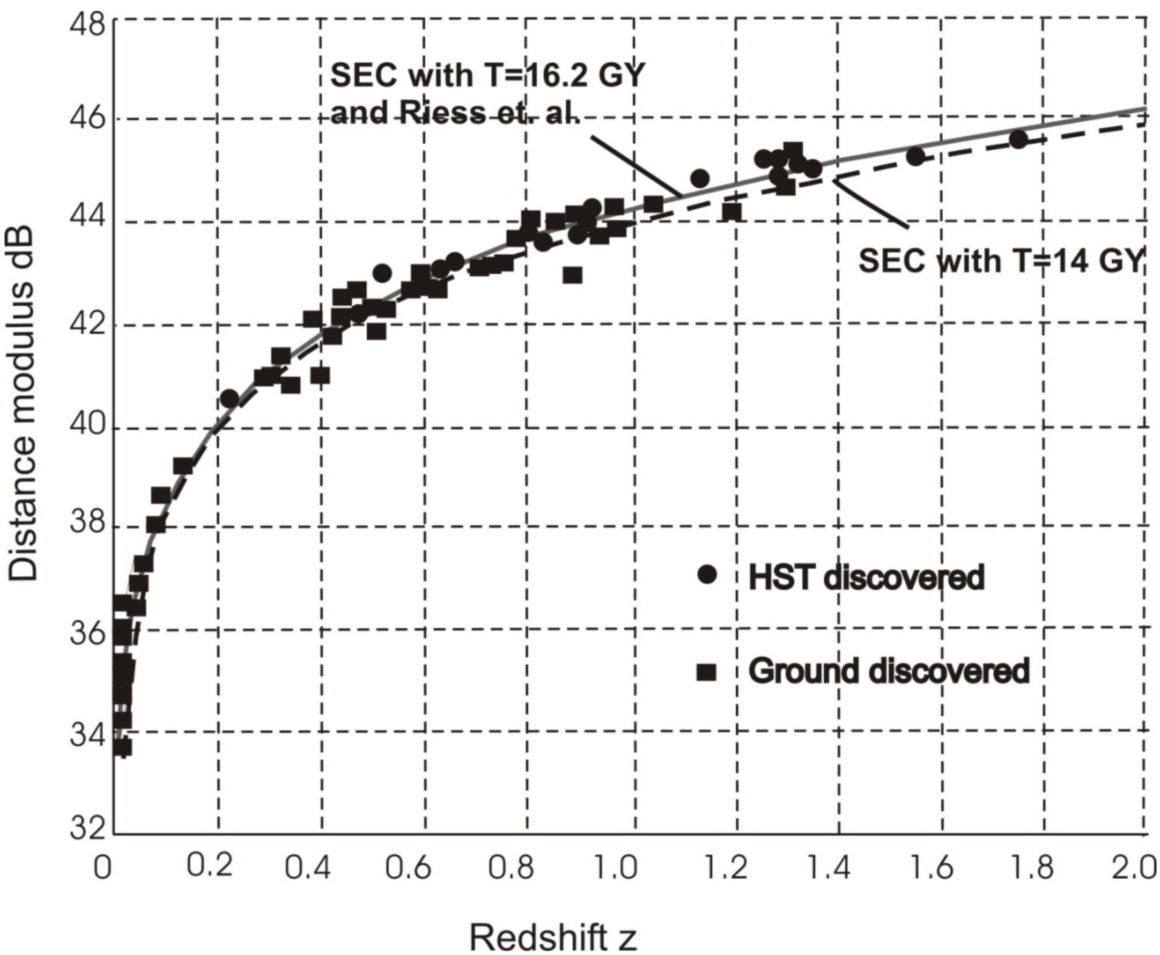

Figure 9

Explaining the figure: (Caption for figure 9)

Here the redshift is plotted on the x-axis and the distance modulus in magnitude, as predicted by the cosmos model used, is on the y-axis. The distance modulus is proportional to the logarithm of the predicted distance to a source expressed as a function its redshift. Again, the agreement with the SEC prediction is obtained without any adjustments.

The SEC theory's prediction is identical to the curve in figure 4 in the paper by Riess et al.) if the Hubble distance is D=16.2 billion light-years; there is no difference whatsoever between the two curves over the whole range from z=0 to z=1.8. The SEC graph for D=14 billion light-years is very close with a slightly better fit at higher redshifts.

This excellent agreement provides strong support for the SEC theory without requiring additional speculation on cosmological acceleration or deceleration.

Summarizing the observational evidence:

Three cosmological tests and the recent SNe Ia observations all agree with the SEC model, while the SCM model's predictions disagree with all these observational tests.

New possibilities in a new world

The excellent agreement between the SEC model's predictions based on formulas (II.13) and (II.14) strongly suggests that this new model is correct. It may therefore be used to estimate the absolute flux in different spectral bands for selected sources based simply on their redshifts and the apparent luminosities. Moreover, the distance relation would allow the estimation of the absolute size of selected sources from its measured angular size.

Thus, the two simple formulas for distance and apparent magnitude that only depend on one parameter, the Hubble time, may open up a new window to the cosmos that allows a more detailed insight.

The objective of cosmological test programs is to access the validity of various cosmological models. Clearly the agreement with observations is superior for the SEC model. Although the primary objective of science is to explain our world sometimes a conflict appears between this objective and the predominant scientific understanding. We have experienced this in the past when trying to make sense of the planetary motions based on the (erroneous) understanding that the Earth is fixed at the center of the world, and that the motions of the planets are circular. The Copernican revolution drastically changed this understanding by not only making the Earth move around the Sun but with Kepler's contribution also making the planetary orbits elliptical.

Now we are facing a similar situation. Our current understanding is that the world is four-dimensional and that the metrical scale of existence is fixed and does not change with time. However, this understanding is not founded on facts; it is merely presumed and has during the past centuries formed the basis for our exploration. As was the case in the past we may be facing a revolution that will forever change our perception of the world.

Dark Energy

We have seen that the SEC line-element yields relations for distances and luminosities that perfectly agree with our observations. This provides strong support for the new cosmos model. Additional support comes from evaluating the energy-momentum tensor for the SEC line-element (II.1).

The assumption that the only contribution to the energy-momentum tensor is the cosmological mass distribution is questionable since it appears that the universe contains much more energy than what is contained in baryonic mass and radiation. This has motivated a so far futile search for the missing energy. However, there is another possibility - perhaps the assumption that the cosmic energy is dominated by mass is erroneous.

Einstein's General Relativity equation is usually stated in a form, which may be interpreted as saying that the curving of spacetime (left hand side) is caused by the energy density (right hand side):

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} \cdot R = K \cdot T_{\mu\nu} \qquad \text{(II.21)}$$

However, this equation may also be put in the equivalent form:

$$T_{\mu\nu} - \frac{1}{2} g_{\mu\nu} \cdot T = K^{-1} \cdot R_{\mu\nu} \qquad \text{(II.22)}$$

This relation maybe interpreted as saying that the energy distribution in the universe is caused by spacetime curvature. The view that the geometry of spacetime defines the energy-momentum tensor is as valid as the view that the energy-momentum tensor decides the geometry of spacetime. Both views apply - the energy defines the spacetime geometry and vice versa.

Instead of postulating some energy-momentum tensor and then deriving the corresponding line-element as traditionally is done in cosmology including the SCM, the SEC model takes the opposite approach by assuming that a certain spacetime curvature determines the energy-momentum tensor for vacuum. This curving of spacetime is generated by the scale expansion, and the energy momentum tensor for vacuum is the tensor satisfying Einstein's General Relativity equations given by the SEC line-element. The energy-momentum tensor for vacuum therefore directly follows from scale equivalence and scale expansion.

Substituting the metrics given by the SEC line-element into Einstein's GR relations we find that these relations are satisfied with the following "Cosmic Energy Tensor" CET:

$$CET = \begin{vmatrix} \frac{3c^2}{8\pi G T^2} & 0 & 0 & 0 \\ 0 & -\frac{c^2}{8\pi G T^2} & 0 & 0 \\ 0 & 0 & -\frac{c^2}{8\pi G T^2} & 0 \\ 0 & 0 & 0 & -\frac{c^2}{8\pi G T^2} \end{vmatrix} \qquad \text{(II.23)}$$

Figure 10: The SEC energy-momentum tensor

The off-diagonal elements all equal zero. The equivalent mass density corresponding to the energy density component T_{00} equals Einstein's Critical Density. Therefore, there is no missing Dark Energy - *spacetime itself contains energy equivalent to the critical density making $\Omega=1$.*

In the SEC model the tensor CET is the fundamental energy-momentum tensor for the cosmos – it is the energy-momentum tensor of vacuum. It is invariant for all co-expanding observers regardless of their location or epoch.

The equivalent energy corresponding to the Cosmic Energy Tensor is zero since the sum of the diagonal elements is zero (zero equivalent mass density). This suggests that, although the net energy content of vacuum is zero, the energy-momentum tensor of vacuum is not identically equal to zero. The principle of dynamic scale-equivalence implies a Cosmic Energy Tensor with zero net gravitational energy consisting of non-zero components, which contribute equal amounts of positive and negative energy.

The spatial expansion corresponds to a *Cosmological Constant* with negative equivalent energy. This negative energy is in the SEC balanced by the temporal expansion, which has the effect of generating a cosmological pressure with positive energy density. Informally, the Cosmic Energy Tensor may be viewed as consisting of positive "Field Pressure" with positive energy due to the temporal acceleration, and with corresponding negative energy and "Negative Field Pressure" due to the spatial expansion.

The SEC model resolves the mystery of Dark Energy by showing that it may be caused by using the wrong cosmological model. There is no Dark Energy in the form of mass density or radiation.

Dark Energy is created by the cosmological scale expansion!

Dark Matter

Dark Matter may like Dark Energy also be a consequence of using the wrong cosmological model. Spiral galaxies are mysterious mass accumulations that cannot be explained by standard physics. Stars in these galaxies move with tangential velocities that appear to be independent of their radial distances; their "rotation curves" are "flat". However, by standard physics based on Newton's laws the velocity should decrease roughly proportional to the square root of $1/r$ with increasing radial distance.

This discordance could be explained if there was invisible dark matter in each spiral galaxy in the form of a "halo" with a total gravitational mass about ten times the visible mass. Moreover, this halo should then also somehow absorb angular momentums, since the loss of angular momentums for the stars in a galaxy also is unexplained.

The SEC elegantly resolves both these conundrums.

Consider the SEC line-element:

$$ds^2 = e^{2t/T}\left(dt^2 - dr^2 - r^2 \cdot (d\theta^2 + \sin^2(\theta)\cdot d\varphi^2)\right) \qquad \text{(II.24)}$$

And apply the coordinate transformation:

$$\begin{aligned} t' &= T \cdot \cosh(r/T)\cdot e^{t/T} \\ r' &= T \cdot \sinh(r/T)\cdot e^{t/T} \end{aligned} \qquad \text{(II.25)}$$

The SEC line-element becomes:

$$ds^2 = dt'^2 - dr'^2 - r^2 \cdot e^{2t/T}(d\theta^2 + \sin^2(\theta)\cdot d\varphi^2) \qquad \text{(II.26)}$$

Here *r* and *t* in the last term are implicitly defined by the two relations above. However, using Taylor expansion:

$$r' \approx r \cdot e^{t/T} \cdot \left(1 + \frac{1}{6}\left(\frac{r}{T}\right)^2 + \text{higher order terms}\right) \qquad \text{(II.27)}$$

The second term is very small even for a galaxy; with r=100kLY it is in the order 10^{-10}. Therefore:

Tatyana: Change the equation below to this.

$$r' \approx r \cdot e^{t/T} \qquad \text{(II.28)}$$

The transformed coordinates therefore with excellent accuracy yield the Minkowskian line-element:

$$ds^2 \approx dt'^2 - dr'^2 - r'^2\left(d\theta^2 + \sin(\theta)^2 d\varphi^2\right) \qquad \text{(II.29)}$$

This means that standard physics applies with the transformed coordinates, for example the conservation of angular momentum:

$$r'^2\,\omega' = Const \qquad \text{(II.30)}$$

However, since we have:

$$\begin{aligned} dt' &\approx e^{t/T}dt \\ \omega &\approx \omega' \cdot e^{t/T} \end{aligned} \qquad \text{(II.31)}$$

We find that the angular velocity ω accelerates with the SEC coordinates if ω' is constant!

By (II.9) the angular momentum decreases in the SEC:

$r^2\omega = Const \cdot e^{-t/T}$ (II.32)

Relations (II.31 and II.32) imply that the radius must decrease:

$r = Const \cdot e^{-t/T}$ (II.33)

Stars in a galaxy slowly spirals toward the core.

The tangential velocity remains constant:

$r \cdot \omega = Const$ (II.34)

Therefore, the cosmological scale expansion explains the shape of spiral galaxies and their flat rotation curves.

Furthermore, the angular momentum problem is also resolved since in the SEC angular momentums are steadily dissipated by cosmic drag.

The Dark Matter enigma simply disappears in the SEC!

Figure 11 below shows the shape of a spiral galaxy arm obtained from relations (II.31) and (II.33). Note that since the radius decreases in proportion to *exp(-t/T)* we may from the shape of a spiral arm estimate the time scale for motions of stars in a galaxy. For example, the time for a star to move within a spiral arm 360º from its outer location in the figure may be estimated from $r=r_0 \cdot exp(-t/T)$. In the figure we have approximately exp(-t/T)=0.65. With T=14 billion years this would give about t=6 billion years. Meanwhile the galaxy has rotated many complete turns. (The picture illustrates a Milky Way type galaxy with the outermost region of the arm at r=100kLY=30.7 parsecs. During 6 billion years the outer region of this galaxy has completed 5 rotations and the inner regions many more.)

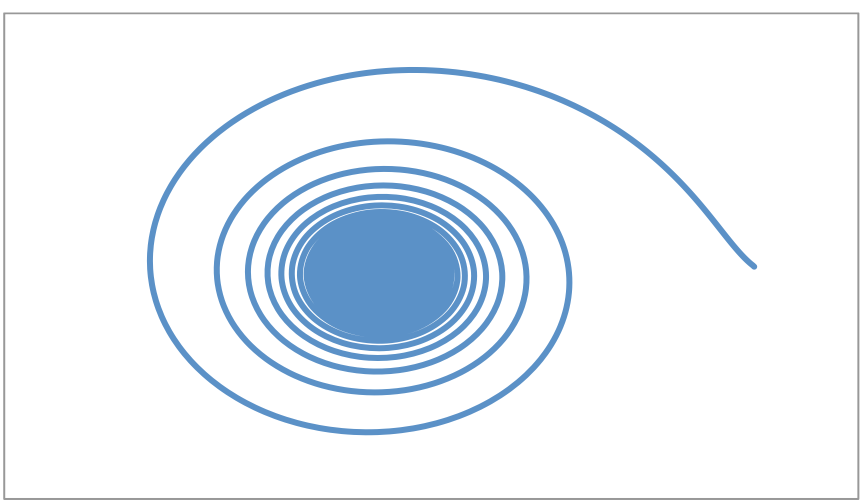

Figure 11: Modeled spiral galaxy star motion

We also note that Kepler's law changes in the SEC. With a central mass M we have:

$$\omega^2 \cdot r^3 = G \cdot M \cdot e^{-t/T} = \frac{G \cdot M}{(1+z)} \qquad \text{(II.35)}$$

Looking back at the earlier epochs of the cosmos it appears as if the gravitational potential has dissipated over time due to the cosmological scale expansion similar to the loss of energy due to redshifting. However, Newton's law of gravitation always applies locally where t=0. Thus the gravitational constant *G* is not changing, although it from the observed motions of ancient stars in a galaxy appears as if Newton's law of gravitation is changing with time.

This situation is unfamiliar, but we have to realize that what we see when observing stars in a galaxy is the perspective from our local spacetime looking back to earlier spacetime geometries with smaller scales.

As we shall see in what follows (II.35) will also resolve the Neuman-Seeliger gravitational paradox whereby the gravitational potential in an infinite universe of constant mass density becomes infinite as well as Olber's Paradox by which the night sky should be as bright as the Sun.

(MOVE)Here it should also be noted that the coordinate transformation (II.25) may be used to find the ephemerides expressed in the *t, r* coordinates of the SEC model from the coordinates of Newtonian model, which uses *t'* and *r'*.

$$\begin{aligned} T \cdot e^{t/T} &= \sqrt{t'^2 - r'^2} \\ e^{r/T} &= \sqrt{\frac{t'+r'}{t'-r'}} \end{aligned} \qquad \text{(II.36)}$$

From which:

$$\begin{aligned} t &= T \cdot \ln\sqrt{\left(\frac{t'^2 - r'^2}{T^2}\right)} \\ r &= T \cdot \ln\sqrt{\frac{t'+r'}{t'-r'}} \end{aligned} \qquad \text{(II.37)}$$

Note that t=0 implies t'=T and that c=1 in these expressions.

If the planetary ephemerides were to be computed based on the assumption that Newton's laws of motion apply, the coordinates for these ephemerides would be given by the primed coordinates above, which easily may be converted to the SEC coordinates by (II.36) and (II.37). This might eliminate planetary drifts in relation to optical observations.

The origin of the Moon mystery and the Pioneer Anomaly

It is estimated that the Moon recedes from the Earth by about 3.8 cm/year. If this is true the Moon must have been in contact with the Earth about 1.5 billion years ago. But we know that is not the case because rocks on the Moon are of the same age as on the Earth.

However, the estimate 3.8 cm-year is based on celestial mechanics using Newton's laws of motion and gravitation and is therefore based on the transformed coordinates in relation (II.25). The relationship between the radial distance to the Moon expressed by these coordinates and the radial distance of the SEC model is given by (II.27). Differentiating this relation with respect to time yields:

$$v' = \left(v + \frac{r}{T} \right) e^{t/T} \qquad \text{(II.36)}$$

This implies that the rate of recession might be overestimated by *r/T,* which for T=10 billion years is 3.8 cm/year (!) and for T=14 billion year 2.7 cm/year. This shows that the estimate 3.8 cm/year might be erroneous, and that the Moon's recession rate could be much smaller or perhaps non-existent.

The SEC theory might resolve the enigmatic origin if the Moon. It might have been created at the same time as the Earth.

The Pioneer Anomaly is another unexplained mystery [Anderson et. al, 2003]. It is a persistent difference in the space probe's velocity estimated by two different methods:

1. Direct measurement of the Doppler shift of a signal received from the space probe.

2. Measurements of the distance by ranging combined with trajectory (ephemeris) modeling to find the velocity.

By the first method the phase shift is directly measured using atomic time, which is the SEC time t in the relations above. This is then used to measure the velocity assuming that the phase shift is a Doppler shift.

The second method is based on ephemeris modeling and uses coordinates that are found by fitting the planetary ephemerides with the assumption that Newton's laws apply. *Therefore this method uses the transformed, primed, coordinates.*

The following explanation to the Pioneer Anomaly may be found in [Masreliez, 2005b].

The phase shift of the signal returned by Pioneer 10 is a combination of Doppler shift due to the outward motion of and the SEC model's redshift, which is present even in the solar system. The normalized cosmological frequency shift is given by:

$$\frac{f - f_0}{f_0} = e^{-\Delta t/T} - 1 \approx -\frac{\Delta t}{T} \qquad \text{(II.37)}$$

Here f is the part of the received signal frequency that is due to the cosmological redshift, and f_0 is the by the space probe transmitted frequency. The time Δt is the signal transmission time between the probe and the Earth.

The second method first estimates the velocity of the space probe based on ranging data. Then the frequency shift is estimated as the corresponding Doppler shift. However, instead of the SEC model's time base, t, the estimate is based on t' in relation (II.26) resulting in a lower frequency.

$$\text{Normalized frequency error due to the time base} = -\frac{\Delta t}{T} \qquad \text{(II.38)}$$

This is the same as the cosmological redshift (II.39), which does not exist when using the (quasi-) Minkowskian coordinates of (II.29).

However, according to (II.38) these coordinates also over-estimates the outward velocity by $\Delta v = r/T$, which gives an additional frequency shift error:

$$-\frac{\Delta v}{c} = -\frac{r}{cT} = -\frac{\Delta t}{T} \qquad \text{(II.39)}$$

The net result is a discrepancy in the estimated frequency, which explains the Pioneer Anomaly.

$$\text{Pioneer Anomaly's normalized frequency error} = -\frac{\Delta t}{T} \qquad \text{(II.40)}$$

If we believe that the velocity estimate due to the Doppler shift is correct and that the ephemeris modeling approach also is correct there is an apparent inward acceleration that during the signal transition time causes a velocity error and a Doppler shift discrepancy:

$$\frac{\Delta v}{c} = -\frac{\Delta t}{T}$$
$$\frac{\Delta v}{\Delta t} = a = -\frac{c}{T} \qquad \text{(II.41)}$$

It appears as if the outward motion is being slowed down by a mysterious inwardly pointing acceleration c/T. This agrees well with the actually observed Pioneer Anomaly acceleration:

$$a = -\left(8.74 \pm 1.33\right) \cdot 10^{-8} cm / s^{2} \qquad \text{(II.42)}$$

This corresponds to a Hubble Time, *T*, in the range: 9.9-13.4 billion years.

Therefore, the SEC theory might also explain the Pioneer Anomaly.

The Pioneer Anomaly could be a direct verification of the SEC model based on measurements in the solar system.

The Planetary Ephemerides

The ephemerides tabulate planetary positions on the sky as seen from the Earth. The construction of planetary ephemerides probably is the most ancient task of astronomy beginning with early observations of so-called wandering stars, that is, the planets.

The Copernican worldview made the epicycles obsolete, and Kepler's elliptical orbits dramatically changed the techniques used for ephemeris construction. With the shape of the orbits now known, they could be fitted to the observations merely by adjusting a few parameters of an ellipse. Then Newton's laws of motion and gravitation arrived to further help in determining the ephemerides.

The method in use today is based on Newton's laws (with relativistic adjustments), and takes into account the combined gravitational influences from different planets and asteroids. The modern ephemerides generated by Jet Propulsion Laboratory(JPL) use numerical integration where the motions of all the planets are computed simultaneously, using repeated iterations in order to arrive at the best fit of the observational data to the theoretical orbits. This is a demanding computational task using techniques developed and refined over centuries [Standish and Williams, 1990].

The parameters determined by this approach of fitting the observations to the theoretical orbits also include *fitting the time-base*. In other words, the times at various locations in the orbit are determined so that the orbits fit the mathematical Newtonian model. Since an accurate temporal reference was missing in the past the planetary motions were used as a clock with a rate determined by fitting the observations to orbits determined by Newton's laws. Today JPL uses the same approach; the assumed mathematical model together with the observations determines the time-base.

This means that the primed coordinates of (II.29) are being used!

Time in Astronomy

The question of a time-base has always been of central importance for astronomy. Traditionally, positions of the planets were recorded by noting the year, the date, and the time of day of the observations. Hence early on, the clock used in astronomy was the rotating Earth. This solar time, or Universal Time (UT) as it is now called, was used from the beginning of modern astronomy until the middle of the twentieth century when it became clear that UT was no longer accurate enough for astrometry, because the rotation of the Earth fluctuates due to influences like ocean tides, winds, inner magma flow, and so on. The motion of the Earth around the Sun became a more accurate temporal standard, which could be derived from fitting the observations to Newtonian orbits as predicted by Newton's laws of motion and gravitation. However, this time-base was difficult to use in practice. For a brief time in the middle of the twentieth century, Ephemeris Time (ET) was the temporal standard in astronomy until it was replaced by the more easily accessible Atomic Time (AT) in 1955.

Meanwhile, the method of fitting the ephemerides to observations was steadily being refined by adding relativistic corrections and by taking into account gravitational influences from the other planets and from several of the largest asteroids. Also, computer programs that automatically fit the observations to the Newtonian orbits from which ET could be determined were developed by JPL. After the introduction of AT in 1955, the continued use of a fitted time-base was challenged by the suggestion that AT should replace ET.

However, this suggestion was rejected.

There might have been two main reasons for this decision: first, the classical, proven approach was still in use and a large investment had already been made in developing techniques that simultaneously and automatically fit the time-base to the observations. The use of AT would require revision of this approach and would obsolete computer programs already developed at great cost [Standish, 1998]. Second, the fit of planetary observations to Newtonian orbits proved to be excellent, which seemingly confirmed the equivalence of ET and AT. If this were the case, nothing would be gained by revising the established methodology.

But, now we know that the primed coordinates allow Newtonian orbits!

In the 1970s, a new program was initiated by which distances between the Earth and the planets Mercury, Venus, and Mars were measured using radar ranging. If a radar pulse is sent in the direction of one of these nearby planets, the distance it travels can be determined quite accurately from the radar echo. The accuracies of these measurements far exceed those of the optical observations, but with one important caveat: optical observations measure planetary positions relative to the stellar background while there is no such external reference with the ranging measurements. However, this obstacle was overcome by combining range measurements with optical and Very Long Baseline Interferometry (VLBI) measurements. Modern ephemerides published by JPL rely heavily on range data and VLBI measurements. The ephemeris time-base, which JPL now calls T_{eph}, is still fitted to the observations, assuming Newtonian orbits. (JPL uses the notation T_{eph} rather than ET since these two time-bases are slightly different.) T_{eph} is then adjusted to AT as closely as possible *with the assumption that it is proportional to AT [Standish, 1998]*.

However, lately disturbing and unexplainable discrepancies have surfaced. Optical observations drift away from the computed ephemerides, which have to be updated at regular intervals by adding new observational data while discarding older data that are deemed unreliable. The general belief is that there might be some kind of modeling shortcoming or that optical observations are afflicted by some kind of systematic error, since it is well-known that the ranging data is superior.

Recently several independent investigators have reported discrepancies between the optical observations and the planetary ephemerides. Some research [Yao and Smith 1988, 1991, 1993; Krasinsky et al. 1993; Seidelman et al. 1985, 1986; Kolesnik, 1995, 1996; Poppe et. al. 1999] indicate that residuals of right ascensions of the Sun show nearly a one arc-second per century (″/cy) negative drift before 1960 and an equivalent positive drift after that date. Yuri Kolesnik reports on positive drifts of the planets relative to their ephemerides based on optical observations covering thirty years with atomic time. He uses data from many observatories around the world, which all independently detect these planetary drifts [Kolesnik, 1995, 1996], [Kolesnik and Masreliez, 2004].

Explaining the Planetary Observational Discrepancies

According to the SEC theory, spacetime is curved, not just cosmologically but even locally in the solar system. Here, the term *curved* means that the cosmological expansion influences the geometry of the 4D spacetime, which causes new phenomena. For example, we saw that the SEC model implies cosmic drag and that the planetary orbits no longer are Newtonian but follow spiral trajectories toward the Sun.

The excellent agreement between observations and the computed ephemerides found by JPL seems irrefutable and appears to rule out the SEC theory as well as any problem with the ephemeris construction process.

Unfortunately, this is not the case.

If we use the primed coordinates of a Minkowskian tangent spacetime instead of the curved coordinates of the SEC, *the planetary orbits will automatically become Newtonian!* In other words, Newton's laws hold true with the "right" choice of coordinates. And, with this choice of coordinates, discrepancies from Newton's laws cannot be detected.

It can be shown that the Minkowskian tangential coordinates fit the curved SEC coordinates with a fractional error of about 10^{-28} in the inner solar system, which is totally negligible. Therefore, when fitting the planetary ranging observations to Newtonian orbits, the computer program will *automatically select the flat Minkowskian spacetime* rather than the SEC curved spacetime, and the observations will (almost) perfectly fit the orbits. In other words, assuming that the orbits are Newtonian will with the selected coordinates guarantee that that the observations fit!

However, the fact that the ranging observations fit Newtonian orbits does not mean that the AT and T_{eph} time scales are proportional.

Arguing that AT must be equal to T_{eph} since the orbits are Newtonian amounts to circular reasoning, since the presumption that the orbits are Newtonian automatically selects the primed coordinates (II.29) for which this is true.

But, according to the SEC model, T_{eph} accelerates relative to AT.

Therefore, like was the case with the Pioneer Anomaly, the observational discrepancies with the planetary ephemerides may be due to the inadvertent use of two different coordinate systems; JPL uses T_{eph} while the optical observations use AT. Eventually this temporal acceleration discrepancy will become glaringly apparent. A few studies have already discovered it, for example the one by Oesterwinter and Cohen, who constructed planetary and lunar ephemerides with AT as the time-base rather than fitting the time-base to the observations [Oesterwinter and Cohen, 1972]. They found that ET drifts positive relative to AT. Also, using AT two teams, one American and one Russian, independently found that the planets accelerate based on ranging data [Reasenberg and Shapiro, 1978; Krasinsky et al., 1986].

If these planetary accelerations really exist, one might rightly wonder why they haven't already been acknowledged. The explanation might partly be that the traditional approach of fitting the ephemerides described above hides the accelerations. Since the ephemerides are fitted mainly by using ranging data, the secular drift in relation to the stellar background is not detected. However, at the present time some 40 years after the inception of the ranging program, the planetary accelerations should become noticeable—at least for Mercury, for which the drift is largest. On the other hand, optical observations, for which over 50 years of observational data are available based on AT, detect secular acceleration of the planets relative to the stellar background.

However, there is another possible explanation to why the drifts have not been acknowledged:

A man receives only what he is ready to receive… The phenomenon or fact that cannot in any wise be linked with the rest of what he has observed, he does not observe.

—H. D. Thoreau

In the belief that the Newtonian model is absolutely correct, the answer to these puzzling discrepancies is being searched for elsewhere, but in the wrong places. The possibility that the orbits do not follow Newton's laws is simply unthinkable for the experts.

(MOVED HERE)However, in the SEC where there is cosmic drag Newton's laws no longer hold. Consequently, as we have seen, the coordinates that make Newton's law valid are not the right cosmological coordinates to use. In particular, the time-base obtained from fitting the ephemerides does not agree with atomic time. Here it should also be noted that the coordinate transformation (II.25) may be used to find the ephemerides expressed in the *t, r* coordinates of the SEC model from the coordinates of Newtonian model, which uses *t'* and *r'*.

$$T \cdot e^{t/T} = \sqrt{t'^2 - r'^2}$$
$$e^{r/T} = \sqrt{\frac{t'+r'}{t'-r'}} \qquad \text{(II.43)}$$

From which:

$$t = T \cdot \ln\sqrt{(\frac{t'^2 - r'^2}{T^2})}$$
$$r = T \cdot \ln\sqrt{\frac{t' + r'}{t' - r'}} \qquad \text{(II.44)}$$

Note that t=0 implies t'=T and that c=1 in these expressions.

If the planetary ephemerides were to be computed based on the classical assumption that Newton's laws of motion apply, the coordinates for these ephemerides would be given by the primed coordinates above, which easily may be converted to the SEC coordinates by (II.44).

This might eliminate the planetary drifts for optical observations.

Fossil Coral Evidence

Evidence initially presented by John Wells supports the proposition that the number of days in the year has changed over time [John Wells, 1963]. The observational material used for this data consists of fossil corals, brachiopods, and bivalves from the Phanerozoic period and stromatolites and tidal deposits from the Proterozoic period. The growth characteristics of these organisms change daily and also with the season of the year, which makes it possible to deduce the number of days in the year during prehistoric times much like tree rings record the age of a tree. With the assumption that the length of the year remains constant, one can conclude that the apparent length of day (LOD) was considerably shorter in the past and that the estimated LOD steadily is growing longer *at an accelerating rate*.

Thus, the evidence shows that the rate of change was slower in the distant past than it is today.

This came as a great surprise, since this finding makes it very difficult to explain the change by a tidal slowing of the Earth's rotation. Since the Moon is currently believed to be receding at the rate of 3.8 cm/year due to transfer of angular momentum from the rotating Earth, it must have been much closer to the Earth in the past. This means that the tidal action should have been greater in the past and therefore that the LOD should have increased at a faster rather than slower pace in the past.

However, this disagrees with what the coral evidence indicates.

The coral data actually reflect the number of days in a year rather than the length of the day. Therefore, a greater number of days in the year may also mean that the year was longer in the past. By the SEC theory, the Earth spirals closer to the Sun at an exponentially increasing rate. This explains not only why the number of days in a year was greater in the past but also why the rate is changing faster today than it did a long time ago.

Thus, coral evidence further supports the SEC model.

Quasar Distribution

Zhuck et al. analyzed the spatial distribution of quasars based on the distance gauge $d = R_o \cdot \ln(1 + z)$, where R_o is in the order of 10^{26} meters [Zhuck et al., 2001]. This distance gauge is identical to the SEC theory's redshift–distance relation if the Hubble distance is about 11 billion light-years. Zhuck et al. concluded that the quasar distribution is uniform without any indication of spatial or temporal variation, which supports the SEC theory by showing that no particular age is associated with the existence of quasars. This contradicts the SCM claim that quasars were more prevalent during a certain epoch in the past—the epoch between 1.9 and 3 billion years after the creation. It appears that this claim is based on the erroneous distance gauge of the SCM, and exemplifies how a wrong model could lead to wrong conclusions and to evolutionary speculation.

Pulsar Spin-Downs

Although the cosmic drag effect is quite tiny and very difficult to detect in the planetary motions, it may be detected and directly measured in the spin-down of pulsars.

Pulsars are believed to be strongly magnetized rotating neutron stars, which emit rotating electromagnetic radiation beams much like the beams from lighthouses. These beams are detected by radio telescopes as regular pulse trains with periods indicating the pulsar rotation rates. These pulse trains are extremely stable, but on average, the rate of rotation decreases very slowly with a time-constant that agrees with the SEC model's prediction.

If the spin-down were caused by cosmic drag, we would expect the period to increase exponentially due to loss of angular momentum:

$$p = p_0 \cdot e^{t/T} \qquad \text{(II.45)}$$

Here p_0 is the initial rate at some arbitrary time t=0. This may also be written:

$$T = p \cdot \left(\frac{dp}{dt} \right)^{-1}. \qquad \text{(II.46)}$$

One of my paper's [Masreliez, 1999] lists 25 pulsars together with their corresponding spin-down rates, dp/dt. 17 of them with periods ranging from 1.6 to 196 milliseconds give values of the Hubble time, T, as given by the relation above, in the range 3 to 25 billion years, corresponding to a factor 8 variation in spite of that their rates of rotation is varying by a factor 122. This strongly suggests that the pulsar spin-downs have a common origin, with cosmic drag being a possible explanation.

This chapter has presented strong evidence in support of the SEC model obtained from several different observational finds as well as explanations of hitherto unresolved enigmas. Next we will address the subject of gravitation.

Is the SEC going to be our new cosmos paradigm?

The reasonable, but perhaps surprising, suggestion that the scale of existence may be a dynamic cosmological parameter (dimension) leads to a new cosmos model that so far seems to agree with all astronomical observations. It also appears to resolve a number of issues ranging from the creation of the universe, to Dark Energy and Dark Matter, to the planetary motions; issues that previously have remained unresolved.

It should not be any doubt that the SEC is a better cosmos model than the SCM. The only difficulty seems to be that it would have far-reaching implications. It would invalidate some well establish knowledge, and some ongoing research. It will therefore be meet with considerable emotional resistance. This is unfortunate, but we must come to terms with the fact that the universe is what it is regardless of our human preconceptions and emotions.

I know that most men, including those at ease with problems of the greatest complexity, can seldom accept even the simplest and most obvious truth if it be such as would oblige them to admit the falsity of conclusions which they have delighted in explaining to colleagues, which they have proudly taught to others, and which they have woven, thread by thread, into the fabric of their lives.

—Leo Tolstoy

Chapter III: Gravitation in the SEC

The question of gravitational field energy has been investigated by many including Einstein, who was puzzled by the fact that according to GR and SCM the gravitational field energy disappears in vacuum. He felt that the gravitational field energy should be negative and that there must be some way of expressing it. He therefore invented a "pseudo-tensor" for this purpose. However, this tensor does not really belong in GR since it does not transform like an ordinary tensor. Other investigators have since proposed different gravitational pseudo-tensors, but recent investigation has shown that all these pseudo-tensors can be made to disappear with special choices of coordinates [Neto and Trajtenberg, 2000]. Therefore, these pseudo-tensors are nothing but smoke and mirrors; they do not have any physical meaning.

Although there can be no vacuum energy or gravitational field energy in the SCM, we know that the cosmological vacuum contains Dark Energy and therefore that our understanding lacks something very important. The SEC theory resolves these issues in a simple and straightforward manner. The problem can be traced all the way back to Galileo's assumption that relative velocities for freely moving objects will not diminish over time. This became Newton's first law of motion, which in the context of special relativity must imply that inertial frames are equivalent and that there is no cosmological reference frame. But in the SEC, there is cosmic drag, which violates Newton's first law and defines an absolute cosmological reference frame toward which all free motion converges. The material summarized in this section may be found in [Masreliez, 2004c].

Karl Schwarzschild's Solution

In standard physics, there is an exact solution to Einstein's GR equations, *provided that all components of the energy-momentum tensor disappear*. This solution was discovered by Karl Schwarzschild and published in 1916 [Schwarzschild K., 1916], the year of his premature death at the age of 42. His solution is remarkably simple and is the basis for the belief that black holes exist, a belief that unfortunately over the years has been accepted as a proven fact.

But, black holes are purely hypothetical objects, based on the assumption that the energy-momentum tensor of GR disappears and that there is no cosmological scale-expansion. If this is not the case and there is vacuum energy induced by the scale-expansion, black holes do not exist, even theoretically.

Schwarzschild's solution, as well as Newton's law of gravitation, implies that in the far field far away from gravitating matter, the gravitational potential takes the following well-known form as a function of radial distance:

$$P(r) = \frac{G \cdot m}{r} \qquad \text{(III.1)}$$

As usual, G is the gravitational constant and m the gravitating mass.

Since the days of Newton, this relation has been puzzling since it implies that the net gravitational potential from all the matter in a homogenous infinite universe must be infinitely large and that the gravitational force acting on any particle (pulling it in all directions) is also infinitely large (this is known as Neumann-Seeliger gravitational paradox). Of course, this is quite disconcerting. Over the years, many have attempted to resolve this puzzle. Perhaps there is a limited amount of matter in the universe? Perhaps the observable cosmos is only an island in empty space?

Some people have proposed a modified potential that diminishes its action at large distances. The most well-known is probably the Yukawa potential with an exponential "roll-off" factor:

$$P(r) = \frac{G \cdot m}{r} e^{-r/R} \qquad \text{(III.2)}$$

This attenuates the potential at some large distance R.

But, (III.2) is just (II.35) with r=ct and R=D=cT!

Therefore, the reach of gravitational influences dissipates at the Hubble distance resolving the Neumann-Seeliger Paradox (see further below).

There is another already mentioned strange property of Schwarzschild's solution: it assumes that the energy-momentum tensor in vacuum disappears everywhere, even very close to gravitating matter. This means that the cosmological vacuum does not contain gravitational energy, which conflicts with the conclusion based on other considerations that the gravitational field energy ought to be negative. The SEC model resolves even this issue.

The SEC Solution

If black holes do not exist, we may wonder what happens during gravitational "collapse."

However, in the SEC total gravitational collapse is prevented by the cosmological scale-expansion.

In order to understand how this might be possible, we will assume that the line-element of GR, which models a spherically symmetric field, includes two modifications compared to the corresponding SCM line-element:

- There is cosmological scale-expansion acting on all four metrics of spacetime.
- The energy-momentum tensor for cosmological vacuum no longer disappears but equals the cosmic energy tensor of the SEC model.

We then find that an exact solution to the GR equations no longer exists! There is an approximate solution similar to the Schwarzschild solution, but it does not hold for very small and very large distances [Masreliez, 2004c]. How should we interpret this?

I think it tells us that the presence of a mass accumulation influences the energy-momentum tensor in the vicinity of matter.

Thus, the presence of matter changes the vacuum energy density.

Moreover, we can guess how the energy-momentum ought to change since we know that the solution should be almost exactly the same as the Schwarzschild solution at intermediate distances. At large distances we then find that the gravitational potential effectively disappears close to the Hubble distance; regions even farther away do not influence us gravitationally. Furthermore, assuming constant cosmological mass density, the gravitational potential from all matter in the universe is finite, and the total gravitational field energy from a point mass m is negative; *it equals* $-mc^2$.

Not only does the SEC model limit the range of gravitation, but the gravitational field energy also equals that of gravitating matter, but with the opposite sign. Thus the presence of matter does not contribute to the net cosmological energy. This is consistent with the hypothesis that the cosmos contains no net energy.

The details of this development may be found in [Masreliez, 2004c].

The SEC near-field solution

In the SEC, black hole formation is prevented by the scale-expansion. Since the vacuum energy-momentum tensor does not disappear, Schwarzschild's exterior solution, which implies the possibility of black holes, no longer exists. We can show this by applying GR in a rather technical discussion, which is beyond the scope of this book. The interested reader might find the details of this development in my paper [Masreliez, 2004c]. However, I will summarize the main conclusions here.

In the SCM, the temporal metric of Schwarzschild's solution becomes zero and the radial metric becomes infinite at a radial distance called the event horizon. This is the distance that signifies the radius of a black hole, its "event horizon". Since the temporal metric goes to zero, it means that the progression of time stops at the event horizon. These are well-known aspects of a black hole.

When approaching the event horizon, the solution for the SEC line-element closely follows the same trend, but with the difference that gravitational field energy density becomes sharply negative close to the event horizon. This suggests that inward motion is prevented since negative energy will cause gravitational repulsion rather than attraction.

It is possible to find an approximation to the SEC solution that holds very close to the event horizon and use this solution to investigate the trajectory of a particle falling inward. We find that it never reaches the event horizon and therefore that a black hole cannot form. Technically, *the event horizon becomes a singularity in the SEC;* it is a forbidden radial distance at which matter cannot exist. By the SCM an object may fall straight through the event horizon and be swallowed by a Black Hole, but this cannot happen in the SEC.

The Neumann-Seeliger and Olbers' paradoxes

In an infinite cosmos with constant matter density the gravitational potential will by Newton's law of gravitation become infinite. Integrating the contribution from matter at constant mass density ρ_m over increasing radii we get:

$$P = \int_0^\infty \frac{G\rho_m}{r} \cdot 4\pi r^2 dr = \infty \qquad \text{(III.3)}$$

However, in the SEC the gravitation potential decreases with time and distance according to (II.35). Using the redshift-distance formula we get:

$$P = \int_0^\infty \frac{G\rho_m}{r} \cdot \frac{4\pi r^2}{(1+z)} dr = \int_0^\infty \frac{G\rho_m}{D\ln(1+z)} \cdot \frac{4\pi\left[D\ln(1+z)\right]^2}{(1+z)} \frac{Ddz}{(1+z)} =$$

$$\int_0^\infty \frac{4\pi G\rho_m \left[D\ln(1+z)\right]D}{(1+z)^2} dz = 4\pi G\rho_m D^2 \qquad \text{(III.4)}$$

In the SEC the gravitational potential from all matter in the cosmos is finite.

Neumann-Seeliger's Paradox disappears.

By Olbers' Paradox the total light received from all sources with average flux I and number density ρ_n is infinite:

$$L = \int_0^\infty \frac{I\rho_n}{4\pi r^2} \cdot 4\pi r^2 dr = \infty \qquad \text{(III.5)}$$

But, in the SEC this becomes:

$$L = \int_0^\infty \frac{I\rho_n}{4\pi r^2(1+z)^2} \cdot 4\pi \frac{I\rho_n r^2 Ddz}{(1+z)} = \frac{1}{2} I\rho_n D \qquad \text{(III.6)}$$

Olbers' Paradox disappears.

The SEC resolves gravitational puzzles

It is intriguing that the tiny vacuum energy density and the very slow scale-expansion of the SEC theory limit gravitational action at cosmological distances and prevent black hole formation at very small distances. Two main enigmas with the current theory of gravitation "magically" disappear. Also, the presence of a cosmological reference frame allows the existence of negative gravitational field energy $-mc^2$ that balances the gravitational matter energy [Masreliez, 2004c].

Epistemological implications

I have presented these implications of the SEC theory with some trepidation, realizing that they may be hard to digest, in particular for the reader well versed in current physics. But I have found it impossible to present this material in a piecemeal way without leaving too many unanswered questions.

It is tempting to ignore the SEC model altogether rather than having to face the possibility that the SCM falls short, but unfortunately the SEC model cannot be accommodated merely by making adjustments; it implies a major revision of our worldview and of physics.

For creatures of the ocean their water-world encompasses all existence. They live oblivious of the world above water, not to talk about the cosmos beyond. Similarly we humans may be oblivious of additional dimensions of existence of which the metrical scale of spacetime might be the most important. We may find that this additional dimension may explain many aspects of our existence that in the past have been mysterious and unexplainable.

Chapter IV: New physics of the SEC model

We have seen how the SEC model provides simple and elegant resolutions to several observational discrepancies both at cosmological distances and locally in our solar system. Furthermore, the SEC resolves several cosmological enigmas.

But these advantages come at a cost: they imply that currently accepted epistemology will have to be revised, starting with Newton's first law of motion. This may become a major obstacle for the SEC theory's general acceptance by the scientific community, since it is difficult to abandon concepts firmly imbedded in the very foundation of physics. But regardless of this, if the theory turns out to have merit, it should eventually prevail.

There are a number of further implications that the concepts of scale-equivalence and a dynamic space time scale would have - implications that could change physics.

The progression of time

A possible solution to the puzzle of the progression of time is one of the most important and (to me personally) satisfying aspects of the new theory.

We have always believed that time progresses at the same continuous pace so that each second is as long as the previous second. However, this might not be the case; the duration of a second could change together with the scale-expansion. Since scale-expansion means that the temporal metric expands together with the spatial metrics, the duration of time intervals like a second could increase with time. However, as I have argued earlier, it is inconceivable that the duration of a second can change continuously relative to itself. The progression of time relates an earlier time interval to a later time interval via a relative scale adjustment.

Therefore, the progression of time must occur in discrete steps if modeled by the four dimensions of spacetime.

We owe (or should I say we may blame) the currently accepted way of dealing with motion to Newton and Leibniz, who both claimed they had invented differential calculus. In modeling motion, we use a mathematical trick by which we treat motion as a limit of ever-shortening intervals of length and time. In mathematical terms we form the *time derivative*. Since its invention, differential calculus has become the workhorse of science.

Our indiscriminate use of differential calculus and differential geometry may explain the current crisis in physics and cosmology.

It appears that Zeno with his paradoxes made a fundamentally important point: we have to be very careful when applying differential methods, since physical processes may exist that cannot be modeled by differential calculus. We already suspect that this might be the case in quantum mechanics, but we have not yet fully grasped and squarely faced all of its implications.

GR is based on differential geometry in four-dimensional continuous manifolds. In a continuous manifold locations in space and time change smoothly. No matter how close two points are located, there are points that are even closer, which makes the differential limiting process work. Ironically, although the 4D spacetime manifold modeled by GR is continuous, the progression of time might not be continuous but take place via a discontinuous stepwise process.

Processes might not be continuous at the atomic-particle level for an excellent reason. By the SEC theory, the universe expands by increasing the scale of spacetime, and we saw that this must be a stepwise process. After each tiny scale-expansion increment, all four metrics have expanded by the same tiny scale-factor, but the universe always still remains the same relative to its inhabitants, since universes of different scales are equivalent. The DIST cycle illustrated in Figure 12 is a (very simplified) representation of the cosmological expansion cycle.

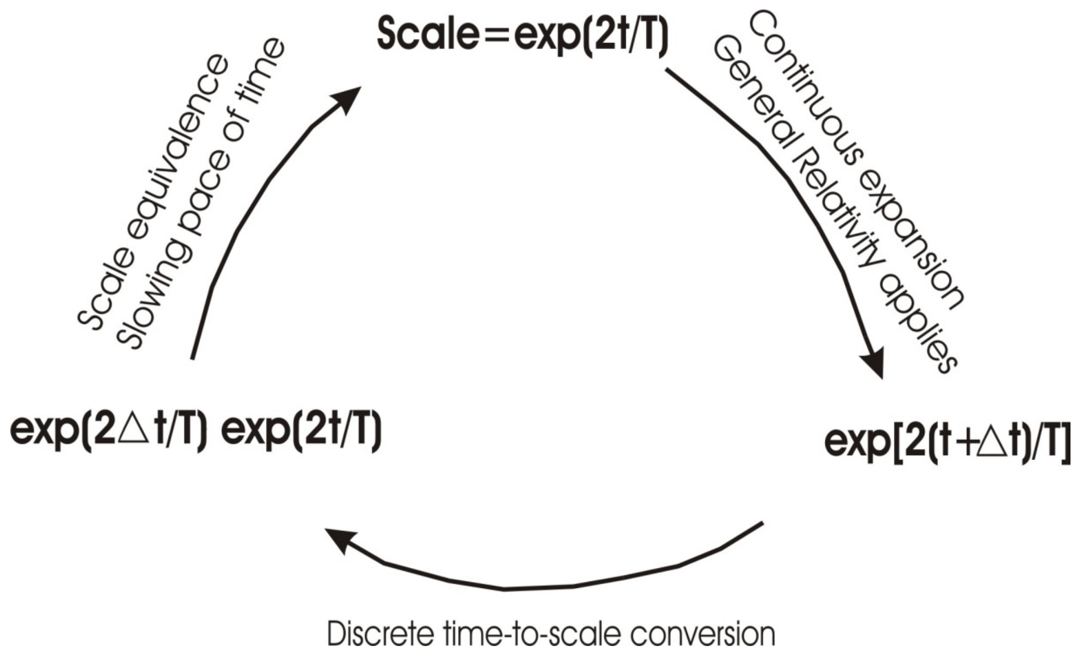

Figure 12: The Discrete Incremental Scale Transition cycle

The cycle in the figure illustrates the SEC expansion process. It suggests stepwise scale-expansion that preserves symmetry between the four spacetime metrics.

This expansion mode might be the essence of the progression of time.

During the continuous part of the short SEC expansion cycle, the metrics expand while keeping the increment *ds* of GR the same. After a short time interval *Δt*, the scale has increased by the factor *exp(2Δt/T)*. Due to scale-equivalence, the universe is at this point in the cycle scale-equivalent to what it was at the beginning of the cycle. The universe stepwise transits into a new and slightly larger scale while decreasing the pace of "proper time" as modeled by GR. This cycle, which makes time progress, repeatedly returns to its beginning.

This last step can be addressed in GR by changing the reference incrementèèè. This process extends GR to also cover discrete scale transformation, which retains the original line-element. In other words, it extends GR to handle the additional scale dimension.

The possibility that the pace of proper time might change with the cosmological expansion is not covered by standard GR.

You may think of the scale-expansion process as being similar to a child growing out of her clothes. Old clothes, when outgrown, are replaced by new ones on a regular basis. Similarly, the universe changes the pace of proper time incrementally to "fit" the expanding space. The cosmos remains the same, and time always appears to progress at the same pace as experienced by us as inhabitants. The fact that the scale of spacetime is dynamic, and changes all the time, has remained hidden to us. It is understandable if you at first have problems with this novel expansion mode, since it is beyond of common experience as well as known physics.

The SEC expansion cycle is reminiscent of a movie by which a sequence of two-dimensional images gives the impression of motion. In the SEC motion results from a sequence of four-dimensional geometries that each separately may be modeled by GR. However, the transition process between these 4D geometries, which might be the essence of the progression of time, cannot by modeled in four dimensions.

It is interesting to note a similar idea was introduced by Dr. John Wheeler in his "Geometrodynamics" by which the cosmological evolution in time is treated as a sequence of 3D geometries [Wheeler, 1963].

An improved mathematical representation will likely be found in the future, possibly based on a five-dimensional application of GR (see below).

The SEC cycle shown in the figure is a new kind of physical process. It will be shown that this process not only may model the SEC expansion, but also might close the gap the between Quantum Mechanics (QM) and GR. It may also help explain the phenomenon of Inertia.

Modeling the SEC as geodesic motion in five dimensions

By the SEC model the scale of spacetime becomes a new dynamic degree of freedom, which also may be modeled by five-dimensional application of GR.

One possibility is the 5D "hyperspace" line-element (with c=1):

$$ds^2 = u^2(dt^2 - dx^2 - dy^2 - dz^2) - (T \cdot du)^2 \qquad \text{(IV.1)}$$

The first term models scale-equivalent 4D spacetime with *u* being the scale, while the second models the scale expansion step.

We may in this five-dimensional hyperspace consider a null-geodesic given by $ds=0$. If an observer is fixed in her local 4D frame we have $dx=dy=dz=0$ and therefore on this 5D null-geodesic:

$$\begin{aligned} u^2 dt^2 &= T^2 du^2 \\ u &= e^{\pm t/T} \end{aligned} \qquad \text{(IV.2)}$$

The corresponding 4D part of the line-element is:

$$ds^2 = e^{\pm 2t/T}(dt^2 - dx^2 - dy^2 - dz^2) \qquad \text{(IV.3)}$$

The SEC line-element may be associated with motion on a 5D null-geodesic! This is consistent with the right hand side of the DIST cycle where the scale expansion is modeled as a function of time in 4D GR. Thus, the positive sign may correspond to the segment of the DIST loop where GR applies.

Therefore, we may consider the SEC model as representing motion on a null-geodesic in 5D "hyperspace".

We also find that:

$$dt = T\frac{du}{u} \qquad \text{(IV.4)}$$

In other words, cosmological scale-expansion in five dimensions provides an ontological explanation to the progression of time. The Hubble Time T becomes a cosmological constant that relates the cosmological scale u to time t similar to how the "speed of light" c relates time t to space (x, y, z) in the 4D spacetime.

Thus geodesic motion of 4D spacetime in the 5D hyperspace could explain the cosmos as it is observed and experienced. Motion in general takes place in the metrical scale as well as in the four spacetime dimensions.

It is interesting to further investigate geodesic motion of the temporal coordinate in this hyperspace when $ds \neq 0$. With the index 4 corresponding to the dimension u the geodesic equation is:

$$\frac{d^2t}{ds^2} = -\Gamma^0_{04}\frac{dt}{ds}\frac{du}{ds} - \Gamma^0_{40}\frac{dt}{ds}\frac{du}{ds} = -\frac{2}{u}\frac{dt}{ds}\frac{du}{ds} \qquad \text{(IV.5)}$$

$$\Gamma^0_{04} = \Gamma^0_{40} = \frac{1}{u} \qquad \text{(IV.6)}$$

This may be integrated:

$$\ln(dt/ds) = -\ln(u^2) - \ln(C) = -\ln(Cu^2)$$
$$\frac{ds}{dt} = C \cdot u^2 \qquad \text{(IV.7)}$$

The time NOW is *t=0,* and we may set *ds=dt* and *u=1* so that constant of integration is *C=1*. From the line-element (IV.1) we get:

$$\left(\frac{ds}{dt}\right)^2 = u^2(1-v^2) - T^2\left(\frac{du}{dt}\right)^2 \qquad \text{(IV.8)}$$

Consider the stationary case v=0 corresponding to motion in time only. From (IV.7) and (IV.8) we get:

$$u^4 = u^2 - T^2\left(\frac{du}{dt}\right)^2$$
$$\frac{du}{u\sqrt{1-u^2}} == \pm\frac{dt}{T} \qquad \text{(IV.9)}$$

Changing in integration variable:

$$u = \sqrt{1-w^2} \qquad \text{(IV.10)}$$

Inserting this in (IV.9) we get:

$$-\frac{dw}{1-w^2} = \pm\frac{dt}{T} \qquad \text{(IV.11)}$$

This may be integrated selecting w>0:

$$\sqrt{\frac{1+w}{1-w}} = e^{\frac{t}{T}} \qquad \text{(IV.12)}$$

The cosmological redshift satisfies:

$$z+1 = e^{\frac{t}{T}} \qquad \text{(IV.13)}$$

Therefore we note that:

$$\sqrt{\frac{1+w}{1-w}} = 1+z \qquad \text{(IV.14)}$$

This may be compared to the relativistic Doppler redshift, z, which with c=1 for a receding source *in space* at velocity *v* is:

$$\sqrt{\frac{1+v}{1-v}} = 1+z \quad \text{(IV.15)}$$

The cosmological redshift is related to the integration variable w as if it were caused by outward motion in space at velocity w instead of being caused by "motion in scale" via the cosmological scale-expansion.

This development suggests that:

1. The cosmological redshift may directly result from geodesic motion in a five-dimensional hyperspace with the metrical scale as the fifth dimension. We might say that an object at rest in an inertial Minkowskian frame of 4D spacetime is "freely falling" on a geodesic in the 5D hyperspace.
2. The cosmological redshift gives the erroneous impression that a radiating source is receding in space, and that the redshift is due to a Doppler shift.
3. The integration parameter *w* may be seen as corresponding to "inertial motion in scale" with decreasing scale when moving back in time with w=1 at u=0. The "inertial scale factor" corresponding to this motion would then be given by relation (IV.10).
4. *This explains the origin of the cosmological scale expansion as being the most natural kind of motion for our 4D spacetime in the 5D hyperspace of (IV.I).*

This demonstrates that geodesic motion of 4D spacetime in 5D hyperspace could explain cosmos as observed and experienced, and that there is symmetry between motion in scale and in space. Motion in general takes place in the metrical scale as well as in the four spacetime dimensions. And, as we shall see, the scale changes correspondingly for relative motion in space.

The scale of four-dimensional spacetime is an active cosmological degree of freedom that makes the world fundamentally five-dimensional. This suggests that the scale should be taken into account when modeling any kind of motion whether in space or time.

Theodor Kaluza showed that Maxwell's equations may be derived from a five-dimensional version of GR if the four off-diagonal metrical components of the fifth dimension in the metric tensor correspond to the electromagnetic vector potential [Kaluza, 1921]. However, there is also a scalar component of the fifth dimension of unknown origin, which in the context of the SEC could model be the oscillating spacetime scale as envisioned by Oskar Klein [Klein, 1926]. This would be consistent with Klein's interpretation of the fifth dimension as being "curled up" and modeling quantum properties.

This also suggests that the electromagnetic field might be a particular mode of metrical oscillation in 5D hyperspace.

Universal perpetual motion

We may naively visualize the effect of a slowing progression of time by considering an object in motion. If our clock were to slow down and the second become longer an object would move farther in a given time interval, which we would interpret as a higher velocity. Thus, slowing down the pace of our reference clock seemingly generates kinetic energy. Similarly, slowing the progression of time elevates temperatures since the molecules in a gas or liquid move faster. In all instances, a slowing pace of time generates energy. This is illustrated in the figure.

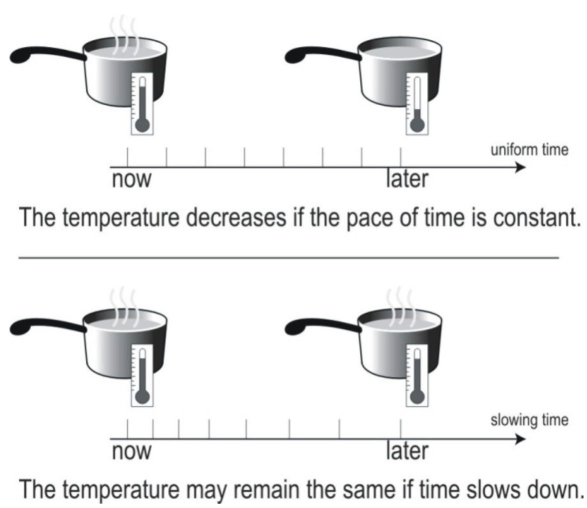

Figure 13: Illustrating energy induced by the scale expansion

However, this illustration does not take into account the expanding space, which dilutes the cosmological energy density. In the SEC, the energy density lost due to the expanding space exactly matches the energy generated by the expanding time, and the net cosmological energy is always zero. This balance eternally sustains the SEC universe *as an open thermodynamic system* that is continually in motion. It implies new physics that perhaps should not be totally unexpected. Since all epochs are equivalent in the SEC it must imply the conservation of the cosmological energy density. Technically the energy of the four-dimensional energy momentum tensor is conserved.

Thus, the SEC is energized by the scale-expansion, and as we saw, its vacuum energy-momentum tensor (of GR) contains cancelling positive and negative components. The universe is perpetually in a state of non-equilibrium, where energy generated by the slowing progression of time "flows" to the expanding space in a process that sustains all existence.

To further illustrate this new process we may think of keeping a slowly leaking balloon inflated by repeated puffs of air. Similarly the "SEC balloon" is kept inflated by the incrementally increasing temporal metric that slows the pace of time while the expanding space causes cosmological energy to slowly leak away, for example via redshifted electromagnetic radiation.

Thermodynamics in the SEC

The standard cosmological model is facing a troublesome enigma with its cosmological entropy. The closed universe of the SCM requires that the entropy should always increase, bringing with it a steadily increasing cosmological disorder. But, rather than becoming more and more disordered, it appears that the universe of today is much more ordered than what it would have been just after the Big Bang.

If the SEC model is correct, the energy of all matter could be sustained via oscillating modulations of the spacetime metrics, which would imply that the cosmological scale-expansion is the origin of all energy in the universe. The radiating energy from suns and other sources is dissipated via the redshift. The cosmos is in thermal equilibrium, which explains the cosmic microwave background [Masreliez, 1999].

This means that the cosmos is a thermodynamically open system in which the net entropy may forever remain constant.

The zero-point vacuum energy enigma

The zero-point energy (ZPE) density of the cosmological vacuum is yet another unresolved problem with the SCM. The ZPE is the lowest possible energy that a quantum mechanical physical system can have; it is the energy of its ground state. All quantum mechanical systems (particles) undergo fluctuations even in their ground states at zero absolute temperature, and have associated zero-point energies, as a consequence of the Heisenberg uncertainty principle.

The net vacuum energy is the combined zero-point energy of all fields in space. The problem with the SCM is that the predicted ZPE is enormously large when adding the contributions from all possible oscillatory frequencies. Based on quantum mechanics it is estimated that the ZPE density is a factor 10^{110} larger than the energy density at the center of the Sun! In the SCM, this is an unexplainable embarrassment. Clearly this shows that we do not really understand the physics of the ZPE.

On the other hand, if the vacuum oscillations are in the scale of spacetime rather than in the 4D coordinate space, the net contribution from each mode of oscillation will disappear because the corresponding energy-momentum tensor takes the same form as the cosmic energy tensor; its diagonal components sum to zero and the net contribution for each oscillatory mode disappears.

In the SEC the zero-point vacuum energy disappears!

We may have failed to realize that the ground state of quantum theory might refer to oscillations in the *metrical scale* rather than to waves in 4D spacetime. As we shall see in what follows this also agrees with the finding that the domain of the quantum mechanical wave-functions is the metrical scale of spacetime rather than the four coordinate dimensions of space and time.

The SEC violates the "laws of physics"

From the discussion above we may surmise that the SEC model violates Newton's laws of motion as well as the laws of thermodynamics. The main reason is that these laws do not take into account the dynamic scale dimension, which may play a crucially important role in our existence by making time progress. This omission explains why the progression of time has been mysterious. And, when taking into account this new dimension it should not come as a surprise that the cosmological symmetry of scale-equivalence dominates over, and overrides, the classical symmetries of conservation of momentum and energy.

We have seen that dynamic scale-equivalence of the SEC model allows perpetual existence in a self-sustaining world. By Parmenides' line of reasoning creation of the world from nothingness is impossible, and therefore the SEC model is to prefer, which also means that the energy needed to sustain the world should be a natural and integral aspect of existence. The old view of energy as being an outside agent supplied to, or consumed by, a closed universe like the SCM is replaced by a perpetually self sustaining cosmos in which the scale-expansion induces positive and negative energy without any net energy.

If we postulate perpetual existence of a world with never changing physical laws in which all epochs are geometrically identical we will likely end up with something like the SEC model. And, if we do this we will have to accept that Newton's laws of motion and gravitation, the laws of thermodynamics, and also Einstein's two relativity theories must be revised.

This would of course have major impacts on physics. However we must accept that the world is what it is and there is no escape from the fact that revisions of the current laws of physics may become necessary.

This should be seen as an opportunity rather than a threat.

Chapter V: Quantum Mechanics and its link to General Relativity

There are many comments expressing confusion with quantum theory, for example quotes by Albert Einstein,

"God does not play dice!"

And:

"The more success the quantum theory has, the sillier it looks."

—Albert Einstein

There is another one by Richard Feynman in his book "QED, The Strange Theory of Light and Matter", Princeton University Press, (1985):

"I have pointed out these things because the more you see how strangely Nature behaves, the harder it is to make a model that explains how even the simplest phenomena actually work. So, theoretical physics has given up on that."

—Richard Feynman

Not many would admit to not understanding quantum mechanics, but Feynman's stature as a famous Nobel laureate allowed him to do it. It speaks volumes about our current state of knowledge; we simply do not understand our quantum world.

As we shall see, Quantum Theory (QT) might be explained by the additional scale-dimension and the DIST process, a fact that perhaps may be seen as a direct confirmation of the new physics presented in this monograph. The generalization of GR implied by the DIST process allows the derivation of QT from GR! This would bridge the gap between GR and QT and thus resolve perhaps the greatest mystery of modern physics.

An ontological Hint

Let us take a second look at the cyclic DIST process that illustrates the cosmological scale-expansion cycle. This might very well be a simplified picture, since it is conceivable that the cosmological expansion better could be modeled by a five-dimensional version of GR. However, the DIST loop suggests that the metrical scale of everything in the cosmos oscillates relative to a co-expanding observer, which suggests that there might be some kind of connection between the cosmological scale-expansion and QT, since QT is dealing with waves and discrete processes.

This might actually be the case: The oscillating scale-expansion may explain our quantum world!

By the cosmological DIST cycle, the scale expands by a tiny fraction during each cycle. At the end of each cycle of the DIST loop, spacetime "jumps into" a new, slightly larger scale via a discrete scale transition. According to GR the reference increment *ds* in GR remains constant everywhere. However, as experienced by an inhabitant of the universe, who expands together with spacetime, the discrete scale transition in effect resets the relative scale of spacetime. Therefore, the scale appears to oscillate at extremely high frequencies. This oscillation cannot be directly observed because the amplitude, superposed on the scale, is extremely small and the frequency extremely high. However, this might be what causes the familiar vacuum fluctuations, and it might be the domain where QT is active. If you wonder why Nature is "quantum mechanical" it might be because of the cosmological scale-expansion!

The technical details of this development may be found in Appendix III: Deriving Quantum Mechanics from General Relativity.

The de Broglie Matter-Wave

Consider a small spatial region (particle) with a metrical scale oscillating at a very high frequency. We can model this in GR by a Minkowskian line-element with oscillating metrics. To model motion, we apply the Lorentz transformation (LT) or the Voigt transformation (VT). We then find that motion will cause spatial modulation of the phase of the scale-oscillation. This is a relativistic consequence of the term $-xv/c^2$ in the temporal transformation. If the scale-oscillation, which is associated with the particle, matches its Compton frequency, we recognize this phase modulation of the scale as being identical to the de Broglie matter-wave!

The QM waves may therefore be real physical modulations in the metrical scale of spacetime!

The Compton frequency, *f*, is related to the energy, *E*, of a particle by the relationship

$$E = h \cdot f \quad .$$

Here *h* is Planck's constant. This simple but important observation suggests that:

Scale-oscillation of small amplitudes at the Compton frequency might accompany and sustain all particles.

The deBroglie matter-wave might appear as a modulation of the Compton oscillation of the scale. It is a relativistic effect, which is a direct consequence of a particle's motion.

Thus, the wave and particle aspects of QT are inseparable—they are two sides of the same coin.

This would immediately explain the wave-particle duality. These simple but important observations reveal a great deal about the nature of QT.

This suggests an ontological explanation: The QT wave-function represents modulation of a particle's Compton oscillation in the scale of spacetime. By this interpretation, the quantum wave is not a separate, independent entity but represents modulation of already existing particle-oscillation. Like a radio signal is modulated to transmit speech and music, the Compton oscillation is modulated by the QT wave-function. The complex nature of the wave-function now finds its explanation; it expresses amplitude and phase modulation of the Compton "carrier" wave. This suggests that the essence of QT is oscillation in the scale of spacetime and that the QT wave-functions are real physical entities, not just probabilistic functions. The modulation of spacetime is primary; Born's probability interpretation is secondary.

This would also discredit the Copenhagen interpretation with its "Complementarity Principle" by providing a simple and direct physical explanation to QT. People who over the years have felt that something is missing in the way QT is to be understood would be right. Thus, Einstein might have been right and Bohr wrong after all! However, ironically this should not be blamed solely on Bohr and the Copenhagen School because it could also be due to shortcomings of GR, which cannot model the DIST process or the progression of time. And, QM may be intimately connected with both the missing scale dimension and the progression of time. Both GR and QM will have to be modified before reconciliation becomes possible.

According to the Copenhagen School, the wave-functions represent particles without giving any ontological explanation. Motion of a particle is modeled based on the corresponding wave-function. By this approach, QT wave-functions are interpreted as being the primary observable entities while the particles become secondary. Thus, quantum mechanics deals with wave-functions rather than with particles. This is like learning the properties of an object from the behaviour of its shadow. Like the shadow, the wave-function depends on the surrounding geometry and might give strange interpretations if one thinks the shadow is actually the object, in particular if the object casts several different shadows, which in QT would correspond to different branches of the wave-function.

The new interpretation suggests that particles could be standing wave oscillations in the metrics of spacetime sustained by the cosmological scale-expansion. Oscillation of the metrics may generate both positive and negative energy in GR, and it is possible that the Compton oscillation generates a particle's rest mass energy. In this case, matter (particles) would be nothing but oscillating spacetime energy.

Let's see if this rather speculative conjecture finds additional support!

The Origin of Mass?

The currently accepted model of particle physics proposes that all particle masses are induced via a hypothetical fundamental particle called the Higgs boson.

In the SEC energy is steadily being induced by the expanding scale of space and time. Whether the resulting oscillating scalar field is the Higgs field remains to be seen. It may easily be shown that an oscillating scale will induce spacetime energy with an energy-momentum tensor of the same form as the Cosmic Energy Tensor of the SEC theory. Like this CET it has cancelling positive and negative contributions. This might be the Zero Point Energy of vacuum.

However, it is possible that all four spacetime metrics do not oscillate in exactly the same way but exhibit internal phase differences and overtones.

This could be the ultimate origin of mass energy.

This means that the cosmological scale-expansion could be the ultimate energy source, not only for the Dark Energy, but also for all matter-energy. And, as already mentioned, this matter-energy is exactly balanced by the negative energy of the corresponding gravitational field; the net energy of the universe disappears.

However, if oscillating spacetime metrics is the ultimate origin of matter energy it is not yet known exactly how fundamental particles may be formed from spacetime energy induced by the cosmological expansion.

The de Broglie–Bohm Pilot-wave

Over the years since the discovery of the matter-wave, several attempts have been made to find an ontological interpretation for QT. Louis de Broglie suggested at the Solvay conference in 1927 that a particle might be guided by a pilot-wave directly related to the QT wave-function. At this meeting Wolfgang Pauli challenged him to explain what happens to his pilot-wave at the "scattering" of a particle, that is, when a particle hits an object and scatters away. This is usually modeled as a single QT wave-function that splits up into a superposition of several different components representing different scattering outcomes. But, a single pilot-wave corresponding to this superposed wave-function cannot explain the different possible trajectories taken by the scattered particle, since it would mean that the particle had to follow several different trajectories at the same time. De Broglie did not have a good answer.

Later, in the 1950s, David Bohm independently revived de Broglie's idea [Bohm, 1952]; [Bohm and Vigier, 1954]. He attempted to counter this scattering challenge by speculating that "de-coherence" quickly occurs between the different branches of the scattered wave-function and that the scattered particle selects only one of the possible branches, leaving the other branches empty. However, he did not clarify the reason for this de-coherence. (The explanation may be found in what follows.)

Bohm's explanation should be compared to how QT is being taught today. The different branches of the wave-function are thought to represent "potentialities"; these branches represent different possibilities that the particle will follow a particular branch. After scattering, but before an observation is made, the particle is believed to be "hovering" in all different branches simultaneously; the act of observation "collapses" the wave-function into one of the possible branches. This "collapse of the wave-function" is a very strange mental "move," which has been discussed and debated at length over the years. It is central to current QT epistemology and has been the subject of many articles and much speculation. It is undoubtedly the most unsatisfactory aspect of the Copenhagen interpretation; it is something unexplainable and mysterious.

There might be another interpretation.

The Compton carrier frequency is proportional to the relativistic energy of the particle. This energy, which also includes its kinetic energy, changes with the particle's velocity, which means that the relativistic Compton frequency also changes with the velocity. In scattering, the particle bounces off in a different direction and its velocity might change. The Compton carrier frequency then shifts slightly and may therefore select a different branch of the QT wave-function. By this mechanism, the different branches of the wave-function will become de-correlated, just as Bohm guessed, due to their different Compton frequencies. Just like radio signals in different bands do not interfere, the branches of the wave-function do not interfere because their carrier waves differ. As soon as we realize that the QT wave-functions do not have an independent existence but merely modulate the Compton carrier wave, we begin to understand what is happening. Possible trajectories appear as different branches, one for each Compton frequency. After scattering, the particle will take one of these possible trajectories corresponding to its energy. This eliminates the troublesome and conceptually ugly "collapse of the wave-function." The selection of a particular branch simply corresponds to a particular scattering velocity.

This explanation, that the branches of a wave-function may represent various modulations of the metrical Compton wave**,** might not have been suggested in the past.

The de Broglie–Bohm pDeilot-wave may be derived from GR

There are more recent versions of Bohm's theory championed by John Bell, [Bell, 1987] and others—for example, Peter Holland [Holland, 1993)] and Dürr, Goldstein, and Zanghi [Dürr, Goldstein, Zanghi, 1996]. They show that a consistent quantum mechanical theory may be derived based on just three assumptions:

There exists a function, ψ (of unspecified ontology) with the following properties:

1. It satisfies Schrödinger's wave equation.

2. The momentum p of a particle satisfies the pilot-wave relation:

$$\boldsymbol{p} = \hbar \cdot \mathrm{Im}\frac{\nabla\psi}{\psi}; \nabla = \text{gradient operator}$$

(Here Im stands for the imaginary part).

3. Some random disturbance is present.

David Bohm and his followers have shown that the pilot-wave relation together with the Schrödinger equation may be used to construct a theory that in all respects is equivalent to elementary quantum mechanics, provided that also some random disturbance is present.

However, one puzzling aspect of Bohm's theory is the nonlocal character of the pilot-wave. Since it contains the ratio between two functions, the momentum *p* could become very large even when the magnitude of the wave-function is close to zero. Therefore, it could exert possibly non-local influences over vast distances even at very low amplitudes. It is difficult to understand how this might be possible and how distant wave-functions of negligible power could influence the local motion of particles. Bohm called this property "active information", proposing that the pilot function somehow "informs" each particle how to move without exerting any physical force. Since this appears rather speculative, the mysterious long-range action could have discouraged more substantial support for Bohm's theory. It might also have deterred Einstein from fully supporting the de Broglie interpretation.

But there is a physical explanation to the pilot-wave that Einstein probably would have appreciated. If the metrics oscillate, de Broglie–Bohm pilot-wave relation may be derived from the geodesic equation of GR!

At first I thought that this only holds for small velocities [Masreliez, 2005a], but a closer investigation has shown that it is true in general as shown in Appendix IV. Oscillating metrics in GR would not only explain why there is a quantum world but also explain the role of the pilot-wave. In the derivation of the geodesic from GR (assuming that the metrics oscillate), we find that the sum of a few oscillating terms must equal zero. This leads to a geodesic equation that involves velocity rather than acceleration like in the usual geodesic.

This is a relativistic version of the pilot-wave relation.

It is derived in Appendix IV. With this interpretation, the pilot-wave finds its natural explanation; it expresses how a particle responds to modulation of the spacetime metrics. A particle moves on its GR geodesic without being subjected to any external force. A particle's trajectory could be curved, and certain regions of resonance might be preferred. In this way, the pilot function could influence the motion of a particle via the scale of spacetime without energy transfer. This action could even take place non-locally since it occurs in the metrical scale of spacetime. A particle follows a path in spacetime determined by its oscillating metrics. The wave-function that modulates the metrics shifts the phase depending on the trajectory and its surrounding. Regions of resonance are created where the phases of vid different alternate paths coincide. The particle prefers these resonating regions, which means that energies and locations might be quantized. Resonances will occur only at certain Compton frequencies (energies) and at specific spatial locations. This explains the discrete nature of QT and its wave-mechanical features.

The Schrödinger equation

Bohm and his followers were able to show that classical QT may be derived from the pilot-wave if the wave-function ψ *satisfies the Schrödinger equation* and there also is some random disturbance. It turns out that the Schrödinger equation also may be derived from GR with oscillating metrics if we assume that the "Ricci scalar" of GR equals zero. The Ricci scalar also disappears for the gravitational field in vacuum (disregarding the small contribution from the SEC expansion), and it seems reasonable that this also should be the case for oscillating metrics.

This assumption leads to a wave equation from which the Schrödinger equation may be derived, assuming that the phase of the metrical Compton oscillation depends on a field potential, which is a function of location. This assumption is reasonable if the field potential influences the velocity, because it will then also change the frequency and the phase of the Compton oscillation.

The Ricci scalar turns out to be a complicated sum of wave terms. We get the Schrödinger equation by setting the sum of these terms equal to zero. Appendix IV gives this derivation.

Thus, modeling scale-oscillation in GR yields the Schrödinger equation.

This tells us that if a field potential influences the phase of the oscillating spacetime metrics, a particle's Compton carrier wave is modulated by wave-functions that satisfy the Schrödinger equation. It is interesting that this derivation of the Schrödinger equation holds true independently of the particle's trajectory, which means that the Schrödinger equation expresses spacetime resonances that only depend on the particles energy (i.e. Compton frequency), on the imposed field, and on the surrounding spatial geometry; the equation does not model a particle's motion. Like a terrain map, the Schrödinger equation describes peaks and valleys but does not describe motion through this terrain. This is also consistent with the continuous representation in terms of wave-functions, which do not model quantum jumps.

In [Masreliez, 2005a] the Schrödinger equation for the electromagnetic field is also derived from oscillating metrics in GR. We might therefore speculate that the electromagnetic field could be a modality of spacetime metrical oscillation for which the mathematical CURL of a vector field (the electromagnetic vector potential) does not disappear.

This would explain the many similarities between the electromagnetic waves and QT waves such as for example interference.

Furthermore, if the scale of spacetime corresponds to a fifth dimension it would also be consistent with Theodor Kaluza's finding that Maxwell's equations may be derived from a five-dimensional version of GR.

Since both the pilot-wave and the Schrödinger equation may be derived from GR if the metrics of spacetime oscillate, quantum mechanics follows directly from GR since random disturbance is always present.

This provides a clear and direct link between GR and QT that previously has been missing!

The double-slit experiment

Next, I will make a few comments on the double-slit experiment, which often is used as an introduction to the quantum world. Many, including Richard Feynman, have given up on trying to make sense of this seemingly mysterious experiment. But there may be a simple explanation.

Here is the experiment.

Consider a particle moving toward a screen with two narrow slits. After passing through one of the slits, the particle strikes a second screen, where an interference pattern develops even when particles arrive one at a time. With "interference pattern," is meant the fact that particles seem to prefer certain fringelike bands on the screen, which gradually will appear after many particles have passed through the slits. This unexplainable and strange phenomenon initially motivated the particle/wave duality idea and Bohr's Principle of Complementarity. The interference indicates the presence of some kind of wave while the dots where particles hit the screen show that there are individual particles.

According to the standard interpretation, a particle somehow simultaneously passes through both slits and strangely "interferes with itself." The wave-function with its different branches corresponding to the fringes on the screen collapses when the particle strikes the screen. This seems strange to say the least! It seems like with this interpretation something must be missing.

David Bohm and others have shown that an interference pattern develops if his pilot-wave guides the particle, assuming that the pilot-wave simultaneously passes through both slits. However, this does not really explain the physical mechanism at work either. This problem is addressed here, together with a possible explanation.

Explaining the double-slit experiment

When the particle passes through one of the two slits, it might randomly become slightly deflected—for example, by interacting with an edge. The particle's matter-wave interferes with the double-slit geometry. This sets up a wave pattern behind the screen in the scale of the oscillating spacetime, which depends on the particle's location and velocity, and guides the particle via the corresponding geodesic. Note that the matter-wave derived in Appendix III is a phase modulation of the Compton wave caused by the term $-\gamma xv/c^2$ that extends both in front of and behind the particle and guides it even after passing the slits. Thus, the particle is guided by its own matter-wave and by the double-slit geometry via feed-back action. The particle prefers regions with large wave amplitude and avoids regions with small amplitude. It is likely to end up in one of several interference fringes. Should it initially by chance move into a region with small interference amplitude, where the wave-function is close to zero, the geodesic will guide it into a region with larger amplitude. Remember that the momentum becomes large when ψ is small, which means that the particle avoids regions with smallerψ.

Figure 15 shows a numerical prediction of how the particle fringes could be created if the spacetime metrics oscillate. This prediction is based on analytic expressions for the geodesic derived in [Masreliez, 2005a].

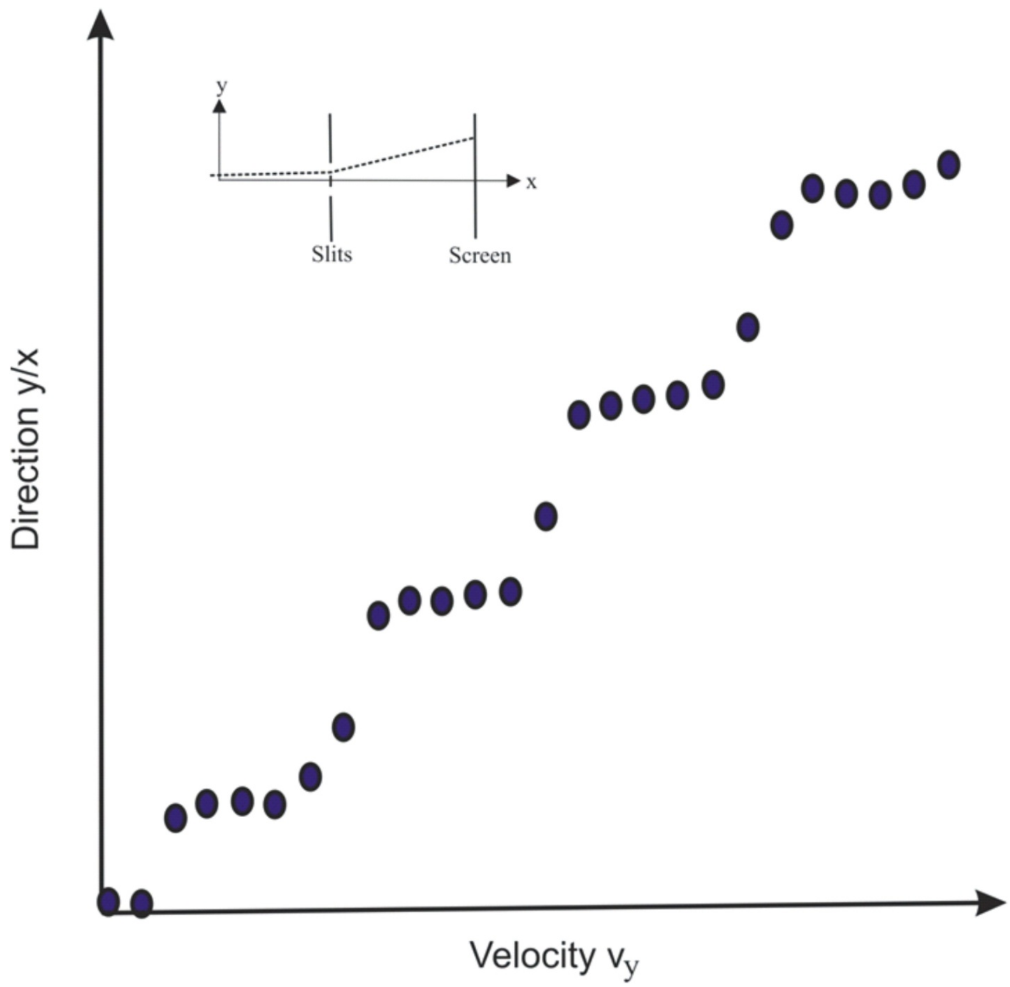

Figure 15: Computed double-slit fringes

Thus, a particle may be guided by its own matter-wave, with the new and interesting insight that the guiding mechanism is the geodesic of GR. This connects QT firmly with GR. It also illustrates a unique property: the guiding action is controlled via feedback. Spacetime resonance guides the particle, and the resonance pattern depends on the particle's motion. This explains how a particle finds its way into interference fringes and how resonance patterns surrounding the atomic nucleus may constrain electrons to their orbits.

We saw that wave-functions are solutions to the Schrödinger equation. They describe the response of spacetime if a particle were to be present. Thus, these wave-functions are not "active" unless a particle is present. This clarifies the role of the wave-functions and explains how they represent potentialities rather than physical waves. The quantum wave that modulates the metrics will materialize only when activated by the presence of a particle.

The Compton carrier also explains why a multi-particle wave-function only depends on particle locations and not on their velocities. Different velocities mean different relativistic Compton frequencies and therefore non-interference. Interference will only occur if identical particles move at the same velocity, and in this case, interference only depends on the locations of the particles. Thus, wave-functions modeling interference imply that particles are in the same energy state with the same Compton frequency. Their velocities do not appear explicitly because they are the same for all particles. If this is not the case, there is no interference.

Finally, let me offer a possible physical explanation to why particles might prefer locations with positive interference where the wave amplitude is large. If a particle is sustained by the Compton oscillation, its energy must somehow originate in the cosmological scale-expansion. In resonating states, the energy needed to sustain the particle is less than in other states. Since in nature energy is minimized, resonating states are preferred.

Spooky Action at a distance and Quantum Entanglement

QT implies the existence of seemingly instantaneous influences between particles well separated in space, which would violate the claim that that highest possible velocity is the speed of light. Einstein rightly believed that either something must be wrong with this or that something is lacking in our understanding. He called it "spooky action at a distance". He opposed QT throughout his life, contending that something important must be missing in the theory; he concluded that QT is an incomplete theory.

Here is an excerpt from a paper he published in 1948 [Einstein 1948], where he expresses his concerns:

"If one asks what, irrespective of quantum mechanics, is characteristic in the world of ideas in physics, one is first of all struck by the following:

The concepts of physics relate to a real outside world, that is, ideas are established relating to things such as bodies, fields, etc., which claim "real existence" that is independent of the perceiving subject…. It is further characteristic of these physical objects that they are thought of as arranged in a spacetime continuum. An essential aspect of this arrangement of things in physics is that they lay claim, at a certain time, to an existence independent of one another, provided these objects are situated in different "parts of space". Unless one makes this kind of assumption about the independence of existence (the "being thu") of objects which are far apart from one another in space, which stems in the first place from everyday thinking, physical thinking in the familiar sense would be impossible. It is also hard to see any way of formulating and testing the laws of physics unless one makes a clear distinction of this kind."

Here is another quote from the same source:

"There seems to me no doubt that those physicists who regard the descriptive method of quantum mechanics as definite in principle would…drop the requirement…for the independent existence of physical reality present in different parts of space; they would be justified in pointing out that quantum theory nowhere makes explicit use of this requirement. I admit this, but would point out: when I consider the physical phenomena known to me…I still cannot find any fact anywhere which would make it appear likely that (the requirement) will have to be abandoned."

These statements express Einstein's doubts regarding QT in clear language. He states his unwillingness to accept non-locality without any ontological explanation for it. It appears that he wanted to be able to understand QT at a deeper level and not merely to accept spooky non-locality as being an unexplainable fact. He also makes the point that non-locality would conflict with SR.

Clearly Einstein's reasoning makes perfect sense if one does not know that in addition to the four spacetime dimensions there exists a fifth dimension in the form of the dynamic scale. We should sympathize with him rather than discard his objections as an old man's ruminations, because nobody could claim to understand QT, not even Richard Feynman. And we should admire Einstein's uncompromising conclusion that the Copenhagen interpretation cannot be the last word. In fact, QT cannot be understood in the same way as classical physics is understood. We can visualize classical physics, but we cannot visualize QT within the four-dimensional world of SR and GR.

In the past, nobody suspected that the four dimensions of spacetime were insufficient to describe the world. They did not realize that the scale of spacetime may participate in all dynamic processes as a hidden fifth dimension. And, since there is no speed of light constraint for influences via the metrical scale, which may act instantaneously by curving space, the troublesome non-locality of QT might find a physical explanation. What seems to be "spooky action at a distance" could be nothing but a particle response to the metrical wave-field. If this response does not transmit energy but acts via a geodesic, it could be instantaneous and could alter conditions even at a very distant location, which might change the outcome of a measurement there.

By this mechanism, the outcome of a measurement taken of a certain particle "A" may influence the outcome of a distant measurement of another particle "B." We say that A and B are "entangled." This entanglement could take place via the scale of spacetime beyond its four dimensions. This makes sense since we saw that the QT wave-functions could be modulations of the scale of spacetime.

QT cannot be explained without knowing about this dependence via the scale, and if we don't know about it, we might, to use Einstein's words, believe that there is spooky action at a distance.

But, by incorporating the new scale dimension, QT becomes explainable.

Hence, influence via the scale would explain quantum entanglement by which the local behavior of a particle may depend on another possibly very distant particle. This entanglement acts instantaneously in violation of any velocity constraint like the speed of light. We might visualize this as a scale resonance condition in a fifth dimension between the particles that makes them act in unity.

This would also imply simultaneity, which is in conflict with SR. However, the new theory of Inertia to be presented below allows simultaneity since it is compatible with absolute cosmological time.

The SEC theory implies non-local action via the changing cosmological scale; it assumes that the scale-expansion acts simultaneously across the universe. If this wasn't the case, regions with different scale-factors could coexist, which would create streaming galaxy motion due to gravitational gradients. Although such streaming has been observed to some extent over regions spanning hundreds of millions of light-years, these streaming velocities are quite small compared to the speed of light, suggesting that the cosmological scale-expansion tracks closely across the universe. It is also possible that a feedback mechanism might exist that equalizes the cosmological expansion rate much like air pressure is being equalized by streaming air masses here on Earth.

A new view of the quantum world

The link between GR and QT suggested by the SEC theory and its DIST process is both direct and clear. Hopefully, this connection will explain the following fundamental but previously poorly understood issues in QT:

• The nature of the QT wave-functions: Each particle is associated with a Compton oscillation in the metrics of spacetime, which is modulated by the QT wave-functions.

• The particle/wave duality: Modulation of the Compton oscillation during motion causes the de Broglie matter-wave. Particle and wave are two sides of the same coin.

• Discrete quantum states: A particle's energy determines its relativistic Compton frequency, which generates a corresponding QT resonance pattern. Therefore, there is a direct correspondence between energy states and distinct resonance states. Since particles prefer resonating states, the energy we observe is quantized.

• Nonlocal action: The non-local action does not occur via spacetime, but via the metrics of spacetime. There is no light-speed constraint for influence via the metrics.

• Superluminal correlation: May exist via the metrics of spacetime, which is a new "channel" of influence beyond spacetime.

We have seen that the quantum world might result from the wavelike nature of particles and their Compton oscillation. Particles or fields that are not represented by such oscillation cannot be quantized. One example is the gravitational field expressing the curvature of spacetime due to matter-energy. If matter is formed as standing waves of the spacetime metrics, it is possible that matter-energy is generated by the nonlinear rather than by the linear part of the energy-momentum tensor of GR. This energy does not appear in the form of harmonic oscillation and therefore cannot be readily quantized. This might explain the difficulty encountered when trying to quantize gravity and could explain the much lower field strength of gravitational interaction.

Although this section on quantum theory does not address all aspects of quantum theory it offers a possible ontological explanation to our quantum world, which is better than no explanation at all.

Hopefully it will inspire further investigation and lead to an improved appreciation of the world we inhabit. Appendix IV firmly establishes the link between general relativity and quantum mechanics by deriving the deBroglie-Bohm pilot wave and the Schrödinger equation directly from general relativity.

Chapter VI: On Motion and Inertia

The problem addressed in this chapter

There is a problem with discussing Motion since we all ”know” what motion means and therefore have difficulties admitting that our understanding might be faulty. We have lived with a hidden, unrecognized, incomprehension regarding motion since the beginning of human civilization and have in the past existed and thrived while not understanding it. Anyone challenged with the task of understanding motion in detail is faced with the problem of having to unlearn what is (considered) known before being able to absorb a new interpretation.

Below this subject is approached by first reviewing how people have addressed Motion in the past, and as usual it seems that the ancient Greeks were far advanced even here, and that we today to some extent have forgotten their valuable insight.

A fresh look at Motion

If the SEC model is right, and the expanding scale causes time to progress, it would also mean that the cosmological scale expansion acts as a universal clock for the cosmos. However, this disagrees with the celebrated as well as contested finding by Special Relativity that “time is relative”. By SR clocks in different states of inertial motion run at different paces, which would means that there is no common absolute time. This is perhaps the most surprising and vigorously debated consequence of SR.

The origin of the inertial force has been unknown ever since Newton introduced his second law of motion, $F=am$, which deals with this force F. Nowadays there is a general agreement that the inertial force is closely related to the gravitational force, which by GR is caused by spacetime curvature. However, by SR all inertial frames have the same flat Minkowskian spacetime geometry, which implies that there should be no curvature of spacetime when transiting from one inertial frame to another via acceleration.

Therefore, by current physics the inertial force cannot be explained as being a curved spacetime phenomenon. The development of this section attempts to resolve this issue by showing that acceleration may cause spacetime curvature while preserving an absolute pace of time.

This sharply disagrees with current physics and would have revolutionary implications for future science if it is correct. It will be justified by taking a close look at our treatment of "Motion" in the past. I ask the reader to have patience when I retrace the familiar path of thought that led to our current treatment of motion, while along this path pointing one where we might have gone wrong in the past. This soul searching review is necessary, and could lead to a very different perception of the world.

Reviewing the historical treatment of motion

The nature of "motion" has always been mysterious. People have wondered how a rigid object can move at all, noting that it at one time is in one location and at some later time in another location, but how does it transit between these locations? Does it do it in a stepwise manner, or does it somehow change its shape and move like an inchworm? Although this question was discussed at length by the ancient Greeks (for example Zeno) it is not generally posed nowadays. However, it is still fundamentally important, since the mystery of motion still remains unresolved and appears to defy detailed analysis.

If motion of a rigid object proceeds in a stepwise manner that mimics continuous transition these steps must be very small, and the smaller they are the higher their frequency must be. If such motion approaches a smooth continuous state this frequency increases beyond any limit. The ancient Greeks thought that this is impossible, and now we know that they actually were right, because Heisenberg's uncertainty relation prevents the incremental steps from becoming arbitrary small; stepwise motion dissolves in a fuzziness of uncertainty.

In the past people thought that this objection might be overcome by differential calculus, originally developed by Isaac Newton and Gottfried Leibnitz, which allowed the increments to become "infinitely small", but in the beginning of 20th century we learned that this does not resolve the problem due to quantum mechanical constraints. In fact, this issue has never been resolved, and nowadays people in science and engineering rely heavily on differential methods when modeling motion while seldom questioning their applicability, although we have come to realize that these methods no longer work in quantum theory.
There is also the question of what might cause time to progress, a question intimately related to the concept of "Motion". We know that we are somehow moving "forward in time", but how and why this should be the case is still a mystery.

We may paraphrase Augustine of Hippo:

"What, then, is motion? If no one asks me, I know; if I wish to explain to him who asks, I do not know."

Without knowing the answer to this question I think it is fair to say that we really understand cannot the world.

In the 1600s René Descartes and others introduced the use of coordinate systems into science, which made it possible to describe motion mathematically by using coordinate representations. In a two dimensional coordinate representation of motion "time" may be handled by letting points along the abscissa represent moments in time, and points on the ordinate represent locations in space. Nowadays people in science and engineering do not think twice about this, although representing time via a coordinate on a line obscures its most important aspect; the fact that time always moves forward. In this respect locations in time clearly differ from locations in space. Representing it as increments on a line allows us to think of time as being able to run both forwards and backwards. In spite of the fact that we know that something must be wrong with this representation we typically ignore it.

Since motion now was modeled via graphs using coordinate systems, the next step was to use these coordinate systems to relate points in space and time in two different coordinate systems, one at rest and the other in relative motion. For each instant in time the same location becomes different points in these two coordinate systems, and in each system motion may be described by tracing the location of a point as a function of time given by a graphical representation in three dimensional (3D) space. Still, this did not resolve the neglected irreversibility of time.

After the introduction of differential calculus Newton's law of motion formed the basis for differential equations of motion, which soon became the preferred way of expressing motion mathematically, and today this approach is extensively used in numerous applications. For example, the planetary ephemerides are currently computed by numerical integration based on differential equations that take into account the gravitational attraction of the Sun and all the planets as well as a large number of asteroids.

But, in spite of these very impressive achievements, we are still far away from thoroughly understanding the essential nature of "motion", and might have overlooked a fundamentally important aspect to be discussed in this monograph.

The presentation in this chapter will proceed along the following lines:

- The use of coordinate representations in modeling motion is examined. Although they may be used to relate points in a coordinate system at different instants of time, they do not capture the irreversible nature of the progression of time or the process of motion. This poses a problem since the most important aspect of time is that it is irreversible; time never runs backwards. Another problem is that when coordinate graphs first were introduced into science the geometric properties of spacetime were not taken into account, since at the time people did not know that geometrical properties of space and time might influence motion via gravitational-type, curved spacetime, action due to changing spacetime metrics.
- Einstein's Special Relativity (SR) theory was a significant development in the modeling of motion. It is based on two postulates:
  1. *The Principle of Relativity* by which all free coordinate frames moving at constant velocities (inertial coordinate systems) are physically equivalent.

2. *A constant speed of light* whereby the velocity of light remains the same relative to these inertially moving coordinate frames.

Using these assumptions Einstein derived a coordinate transformation for the temporal and the three spatial coordinates. However, in doing this he also made an additional implicit, but important, assumption; he assumed that the transformed coordinates he derived for a moving frame based on a constant speed of light have the same metrical meaning as those experienced by an observer at rest in this moving frame (co-moving observer). With this assumption he derived the Lorentz Transformation (LT). However, since the moving coordinates of SR are constructed using light signals of constant but limited velocities it is possible that these coordinates might appear to be distorted; they might not be the same as those experienced locally in the moving frame.

- The LT implies one of the most hotly contested claims of the SR theory, a concept of "relative time", according to which time may proceed at different paces in different inertial frames, suggesting that the progression of time is not a universal concept but is in the eyes of the beholder. This has caused a lot of confusion and consternation and appears to be in conflict with non-local influences in quantum theory as well as with our intuition.
- Rather than synchronizing clocks by the use of light signals we may instead adhere to the postulate of "Principle of Relativity" by which time always runs at the same pace in all inertial coordinate systems (coordinate frames), which would mean that the progression of time would be a universal aspect of existence. We then find that Woldemar Voigt's Transformation of 1887 (preceding the LT) will make time run at the same pace. Voigt's Transformation (VT) differs from the LT by a constant scale factor that depends on the relative velocity, but it also satisfies the two SR postulates [Voigt, 1887].
- The LT and the VT are modeling motion via coordinate transformations. However, coordinate transformations are also used in General Relativity (GR) where they express spacetime geometries via line-elements. If we treat the VT as a coordinate transformation of GR we find that it implies that the scale of moving coordinate systems would appear to be contracted by the same scale-factor as the

one which in SR accounts for time dilation and length contraction. This brings up the question of whether the VT should be seen as a transformation of GR that relates geometries of moving frames. This interpretation would make time dilation and length contraction purely geometrical aspects caused by an apparent relative scale-contraction during motion.

- Coordinate transformations of GR deal with spacetime geometries, which define physics via the field equations of GR. If these field equations are identical for two different coordinate representations these representations are physically equivalent. *This is the case for the VT and the LT*; their GR field equations are identical because their Christoffel symbols are identical, which explains why they both satisfy the two postulates of SR. *This makes us wonder if the success of these transformations primarily might be due to conserving the GR field equations.*
- The origin of the phenomenon of *Inertia* (what causes the inertial force during acceleration) has remained elusive in spite of the fact that Newton's second law of motion, which deals with this phenomenon, is one of the cornerstones of mathematical physics; we know that acceleration is resisted by an inertial force but we do not know why this should be the case. A thought experiment previously used by Einstein comparing the gravitational force acting on an object on the surface of the Earth to the inertial force experienced by an observer inside an accelerating box in outer space suggests that acceleration may induce spacetime curvature similar to that of a gravitational field.
- In investigating this possibility the author found a certain dynamic scale factor for the Minkowskian line-element of GR with the interesting property that *all accelerating trajectories will take place on GR geodesics of spacetime* [Masreliez, 2007a, 2008, 2010 and Appendix VI]. Motion will take place on a GR geodesic regardless of the magnitude and direction of the acceleration!
- This "inertial scale factor" is identical to the scale contraction implied by the Voigt Transformation! This "coincidence" suggests that the phenomenon of inertia might be caused by spacetime curvature induced by acceleration, and therefore that the VT might model motion better than the LT. This would make inertia a curved spacetime phenomenon, just like gravitation.

- In our daily life we often use the terms, "past", "present" and "future", with the clear understanding that the past differs from the present and the present from the future. Yet, strangely our current mathematics used in modeling motion does not distinguish between these fundamentally different concepts! This should be a clear signal that something is seriously wrong with our treatment of motion in science. Since our equations do not imply any difference between the past, the present and the future they suggest that time should be allowed to run both forwards and backwards. Obviously this is not right, and we have to conclude that the current the treatment of motion in science is incomplete.
- There are two aspects of "time" that never have been clearly delineated in the past - the duration of time intervals like the second, and the pace of time. Time may always progress at the same incremental pace, but the *perceived* durations of these increments may vary depending on relative motion. This would imply the existence of an additional dynamic degree of freedom in addition to the four spacetime dimensions.

The following discussion might be a bit challenging, not because it is hard to understand, but because it introduces an unfamiliar view of existence. In the presentation to follow I have avoided mathematical details as far as possible, partly because the concepts presented do not require them, partly because they tend to obscure the message and objective of this chapter. The interested reader may find the details in the Appendices or in the listed references.

However, it should be noted that the development doesn't follow the well trodden path, but introduces a new idea in the form of a dynamic scale of four-dimensional spacetime making the world fundamentally five-dimensional.

The SEC model assumes that the expanding cosmological scale marks out the progression of time, and that this is the same across the cosmos. Therefore, the new thinking is based on the following postulate:

Simultaneity Postulate: The present time, NOW, is the same across the cosmos.

Although this postulate disagrees with Special Relativity by which time is relative, it will be shown that it is possible to reconcile it with the observational consequences of SR. Thus, the cosmological temporal reference is always the present time, it is not some time in the past, for example a postulated time of creation.

The role of coordinate transformations in the context of motion

A classical coordinate transformation used in modeling motion is the so-called Galilean Transformation (GT) whereby the location of a coordinate point is given in two different coordinate systems, one at rest and the other in relative motion with constant velocity v.

For motion in the x-direction at the velocity v the GT takes the modern form:

$$\begin{aligned} x' &= x - vt \\ y' &= y \\ z' &= z \\ t' &= t \end{aligned} \qquad \text{(VI.1)}$$

Here the primed coordinates represent a Moving Frame (MF) and the un-primed a Stationary Frame (SF). By this transformation an observer who is fixed in the MF at x'=0 is moving with velocity v in the SF, since then x=vt. Time is treated as an independent coordinate used as a temporal label for absolute time instants in the two frames. The velocity v may be defined as being the distance between two locations x_1 and x_2 that is covered during the time interval t_2-t_1 as measured by observers with synchronized clocks at the fixed locations x_1 and x_2.

$$v = \frac{x_2 - x_1}{t_2 - t_1} \qquad \text{(VI.2)}$$

This coordinate representation does not capture, or even consider, what might be called "the process of motion". It doesn't describe the physical process that makes an object change its location; a process that clearly distinguishes between the past and the future. This is not surprising since such a process would be intimately connected with the progression of time for which no explanation has existed. Although the passage of time should have a physical explanation such an explanation has been missing.

Galileo realized that physics locally is the same for observers in motion at constant velocities. This is now referred to as "Galilean Relativity". It is interesting to note that the ancient Greeks were well aware of this aspect of motion. Here is Aristotle's version of Zeno's Arrow Paradox:

1. When the arrow is in a place just its own size, it's at rest.

2. At every moment of its flight, the arrow is in a place just its own size.

3. Therefore, at every moment of its flight, the arrow is at rest.

It is aerie how Aristotle could so clearly have expressed a key aspect of motion by realizing that the arrow actually is at rest in its local space even during motion (he speculated that the arrow somehow carries the surrounding air with it).

It appears that something more than coordinate transformation is required to model motion.

In fact, as we shall see, four-dimensional (4D) coordinate transformation cannot model motion.

Special Relativity and the Lorentz Transformation

The Special Relativity (SR) theory implies a generalization of the GT, which was motivated by the fact that, as modeled by the GT, the laws of physics appear to change depending on motion; the equations of physics do not remain the same after applying the GT. This is in conflict with Galilean Relativity, by which everything should remain the same within inertial frames that move at constant velocities.

In the late 1800s Henrik Lorentz and Henri Poincare suggested the following transformation as a modification of the GT – the Lorentz Transformation (LT), which for motion in the x-direction takes the form:

$$
\begin{aligned}
x' &= \gamma\left(x - xt\right) \\
y' &= y \\
z' &= z \qquad\qquad\qquad \text{(VI.3)} \\
t' &= \gamma\left(t - xv / c^2\right) \\
\gamma &= \frac{1}{\sqrt{1-(v/c)^2}}
\end{aligned}
$$

This transformation preserves the laws of physics, but there are two rather strange aspects of it:

First: The temporal relation involves the spatial coordinate x, which was introduced to make it "work" in the sense that the laws of physics are conserved using the LT rather than the GT.

Second: Letting $x=0$ we find that $t'=\gamma t$, which implies that the temporal coordinate in the MF does not agree with that in the SF, seemingly in violation Galilean relativity.

In his paper on Special Relativity in 1905 Einstein derived the LT, and ever since then people have had diverse, and sometime adverse, attitudes regarding this theory. Many use the SR theory routinely without further reflection since it seems to "work".

The most controversial aspect of SR undoubtedly is its claim that "time is relative", which goes against Newton's concept of "absolute time" as well as our own instinctive ideas about time. Also, according to SR, traveling at high velocities may cause us to age slower. This seems very strange since SR tells us that all free motion at constant velocities (inertial motion) are physically equivalent, and therefore that the local conditions within any moving frame should be the same, including aging. So, how can time slow down in motion, yet remain the same? This dilemma is popularly known as the "Twin Paradox", by which twins traveling apart and later when reuniting both claims that their sibling should be younger. Einstein made the observation that a traveler moving on a circular path should be younger when returning to the point of departure.

However, this assertion has come under repeated scrutiny over the years, the challenges posed by Dr. Herbert Dingle being the perhaps most persistent. Dingle argued that since all inertially moving objects are equivalent, with the same local physics, they should all experience the same pace of time. But, according to SR, a moving clock ticks slower. This time dilation is a symmetric situation in the sense that a clock that moves in relation to any other clock picked as reference always appears to run slower with a rate that depends on its velocity relative to the chosen reference frame. How can this be possible? According to SR time dilation is "real" and motion is believed to change the pace of clocks! Dingle repeatedly challenged several well known scientists trying to get and explanation to this mystery, but he never got an acceptable explanation. In desperation he then published the book "Science at the Cross Roads [Dingle, 1972].

Dingle was right; as we shall see there is no physical explanation to time dilation in current physics!

People have tried to invoke acceleration in "explaining" the twin paradox, but this cannot be done as is shown by the following thought experiment based on symmetrically accelerating twins.

Let the twins initially be stationary at the same location O in the beginning of the thought experiment and then let them accelerate symmetrically in opposite directions for the same time as shown by their onboard clocks. After this first phase they slow down symmetrically, turn around and start moving inertially toward each other at the same time (as shown by their local clocks). On the way back they will by SR then both conclude that the other's clock is running slower, yet their clocks must agree due to symmetry when they reconvene at the original location O. There is no escape from this fact; we must conclude that the observed time dilation *merely is an apparent effect that does not influence the pace of local clocks.*

A potential problem with Special Relativity

In his SR paper Einstein thought that the transformed coordinates he derived for the moving coordinate frame must be equivalent to those of the stationary frame. Consequently he assumed that *they must have the same metrical meaning* as those of the local stationary frame. If this actually is the case coordinate increments in the moving frame may be directly compared to those of the stationary frame. In particular, coordinate increments perpendicular to the motion should remain the same. He used this assumption to determine the constant γ in the relations for the LT (see below) [Einstein, 1905].

As we shall see there might be a problem with this derivation.

Most people, active in physics today, are familiar with Einstein's derivation of his SR theory. However, there is one aspect of this derivation that needs to be carefully reexamined because of an implicit assumption, which at the time seemed eminently reasonable.

In deriving the Lorentz Transformation (LT) Einstein used symmetry between inertial frames to arrive at the conclusion that the forward transformation must be identical to its inverse. Einstein's reasoning in his 1905 paper is here recalled in detail. Coordinates of the rest frame K are denoted *(t,x,y,z)* and those of the moving frame *k* are denoted *(τ,ε,η,ς)*.

Quoting his paper of 1905:

> *In the equations of transformation which have been developed there enters an unknown function Φ of v, which we will now determine.*
>
> *For this purpose we introduce a third system of co-ordinates K', which relatively to the system K is in a state of parallel translatory motion parallel to its x-axis such that the origin of co-ordinates of system K', moves with velocity -v on the axis of k. At the time t=0 let all three origins coincide, and when t=x=y=z=0 let the time t' of the system K' be zero. We call the co-ordinates, measured in the system K', x', y', z', and by a twofold application of our equations of transformation we obtain*

$$\begin{aligned} t' &= \Phi(-v)\gamma(-v)(\tau + v\varepsilon / c^2) = \Phi(v)\Phi(-v)t \\ x' &= \Phi(-v)\gamma(-v)(\varepsilon + v\tau) = \Phi(v)\Phi(-v)x \\ y &= \Phi(-v)\eta = \Phi(v)\Phi(-v)y \\ z &= \Phi(-v)\varsigma = \Phi(v)\Phi(-v)z \end{aligned}$$

> *Since the relations between x', y', z' and x, y, z do not contain the time t, the systems K and K' are at rest with respect to one another, and **it is clear that the transformation from K to K' must be the identical transformation**. Thus*

$$\Phi(v)\Phi(-v) = 1$$

> *We now inquire into the signification of Φ. We give our attention to that part of the y-axis of system k which lies between ξ=0, η=0, ς=0 and ξ=0, η=l, ς=0. This part of the axis is a*

rod moving perpendicularly to its axis with velocity v relatively to system K. Its ends possess in K the co-ordinates

$$x_1 = vt, y_1 = 0, z_1 = 0$$

and

$$x_1 = vt, y_2 = 1/\Phi(v), z_2 = 0$$

The length of the rod measured in K is therefore 1/Φ(v); and this gives us the meaning of the function Φ(v). From reasons of symmetry it is now evident that the length of a given rod moving perpendicularly to its axis, measured in the stationary system, must depend only on the velocity and not on the direction and the sense of the motion. The length of the moving rod measured in the stationary system does not change, therefore, if v and -v are interchanged. Hence follows that 1/ Φ(v)= 1/ Φ(-v), or

$$\Phi(v) = \Phi(-v)$$

It follows from this relation and the one previously found that Φ(v)= 1, so that the transformation equations which have been found become

$$\begin{aligned} \tau &= \gamma(t - vcx/c^2) \\ \varepsilon &= \gamma(x - vt) \\ \eta &= y \\ \varsigma &= z \end{aligned}$$

In this line of reasoning Einstein's claim that the transformation from K to K' must be the identical transformation is highlighted.

<u>However this claim is not necessarily correct</u>.

It may in fact have been a mistake because it is possible that the velocity may change the metrics of spacetime *as perceived* by an observer in K.

The coordinates obtained by the LT may not have the same meaning as the coordinates experienced by a co-moving observer.

Considering the fact that the moving coordinates are constructed based on light signals of limited velocities it seems likely that this might distort the constructed coordinates, in particular when the motion approaches the speed of light. Although the relationship between space and time might remain the same, it is possible that coordinate increments in the two frames do not have the same meaning; for example, their metrical scales might differ. This would put into question the use of the Lorentz transformation in modeling motion, since it implicitly assumes that the transformed, moving, coordinates have the same meaning and metrics as the stationary coordinates.

The derived LT coordinates might differ from the local coordinates in the MF.

Of course, in 1905, when SR was proposed, the concept of different spacetime metrics was less known and therefore this possibility was overlooked.

Unfortunately this may have prevented us from discovering the origin of Inertia.

In addition, fundamental concepts like temporal irreversibility and the progression of time are lost in these coordinate manipulations of SR. Today people seem to have forgotten these fundamental aspects of time.

Woldemar Voigt's transformation

In the context of SR it is interesting to note that a similar transformation actually preceded the LT; it was introduced by Woldemar Voigt in 1887. Voigt's Transformation (VT) differs from the LT by a constant scale-factor multiplying all four coordinate relations of the LT. When Henrik Lorentz derived his transformation he was unaware of the VT and later regretted that he hadn't given Woldemar Voigt proper recognition. The VT is:

$$
\begin{aligned}
x' &= \left(x - xt\right) \\
y' &= y / \gamma \\
z' &= z / \gamma \qquad \text{(VI.4)} \\
t' &= \left(t - xv / c^2\right) \\
\gamma &= \frac{1}{\sqrt{1-(v/c)^2}}
\end{aligned}
$$

In physics the VT "works" equally well as the LT does, and satisfies the two postulates upon which Einstein based his SR theory. In retrospect, and with the help of GR, we now understand why:

The LT and the VT line-elements are "scale-equivalent" in the sense that they give the same, identical, field equations of GR!

This means that according to GR physical laws are satisfied regardless of which transformation we use. This is true for all line-elements that differ from the LT or the VT by a constant scale factor. As we shall see it implies the existence of an additional degree of dynamic freedom beyond the four dimensions of spacetime.

The novel cosmological expansion process of the SEC model repeatedly reproduces the four-dimensional spacetime geometry of GR by semi-continuous, incremental, scale transitioning at ever increasing scales, with the scale of spacetime acting as an additional degree of dynamical freedom beyond the four of spacetime. However, this process cannot be modeled by GR, but may be modeled by a five-dimensional version of GR where the fifth dimension models a dynamic scale of 4D spacetime.

Although this chapter addresses motion in space rather than motion in time, the success of a dynamic scale factor in explaining the cosmos suggests that it also could play a fundamental role for motion in space. As we shall see this might actually be the case.

If the VT applies rather than the LT it would eliminate a most controversial aspect of SR, by restoring a common, absolute, cosmological temporal reference; Newton's absolute time would make a comeback! A common temporal reference would be welcome if it also preserves the relativistic aspects of time and space implied by SR. Although this possibility today may seem unconventional, not to say heretical, we shall see that there are valid arguments in support of it.

Motion in General Relativity

We saw that SR mixes time and space in its temporal coordinate relation, which suggests that time and space may be treated on equal footing. Time then becomes just one of four dimensions of space and time (spacetime), which further suggests that it might be possible to model motion by the use four-dimensional (4D) geometry. Instead of modeling motion by a trajectory in space indexed by time we could model motion as a one-dimensional "world-line" in four-dimensional spacetime.

Einstein developed this idea in his celebrated General Relativity (GR) theory [Einstein, 1915] by which he was able to explain *gravitation* as being a curved spacetime phenomenon resulting in motion on geodesics of GR. However, GR deals with geometry, and *in geometry a coordinate point cannot move*. Therefore, GR cannot model the *process of motion* or the progression of time; it does not distinguish between, the past, the present, and the future.

With this development physics lost sight of a most fundamental aspect of our existence; we are trying to understand the world without knowing what is causing the progression of time, which is the most keenly experienced aspect of our lives!

If we treat the LT and the VT as transformations that define line-elements of GR we find that applying the LT yields the Minkowskian line-element:

$$ds^2 = (cdt')^2 - dx'^2 - dy'^2 - dz'^2 \qquad \text{(VI.5)}$$

While the VT yields the "scaled" Minkowskian line-element:

$$ds^2 = \left[1-(v/c)^2\right]\left[(cdt')^2 - dx'^2 - dy'^2 - dz'^2\right] \qquad \text{(VI.6)}$$

As already mentioned, these line-elements are physically equivalent because their Christoffel symbols are identical and therefore also their GR field equations. The strange term $-\gamma xv/c^2$ in the temporal transformations may now find its explanation; *it gives a scale-equivalent Minkowskian* *form of the line-element*! This fact may explain why they both "work" equally well in physics. With this interpretation we have in effect moved away from modeling kinematic motion of a point, as is done by the GT, to instead relate spacetime geometries via GR. This suggests that motion in general somehow involves scale transition and conservation of local spacetime geometries similar to in Aristotle's version of Zeno's arrow paradox.

Inertial motion as a limiting case of rotational motion

The line-element in GR for rotation around an axis with constant angular velocity ω may be expressed by Born's cylindrical coordinates:

$$ds^2 = \left(1-\left(\frac{r\omega}{c}\right)^2\right)(cdt)^2 - dr^2 - 2r^2\omega dt d\theta - dz^2 \qquad \text{(VI.7)}$$

In this line-element the temporal factor may be associated with "spacetime curvature" that induces a centrifugal acceleration.

For a fixed location on the cylinder with $dr=d\theta=dz=0$ this becomes:

$$\begin{aligned} ds^2 &= \left(1-\left(\frac{r\omega}{c}\right)^2\right)(cdt)^2 = \left(1-\left(\frac{v}{c}\right)^2\right)(cdt)^2 \\ ds &= \sqrt{1-\left(\frac{v}{c}\right)^2}\, cdt \end{aligned} \qquad \text{(VI.8)}$$

Here v is the velocity at radius r. We see that the temporal metric is the same as for Voigt's transformation.

Consider a clock at a radial distance r. From the point of view of a stationary observer there is time-dilation due to spacetime curvature; the clock appears to run slower. Note that since the temporal metric only depends on the velocity, it is independent of the radial distance if the velocity is constant.

Now consider the situation where this radius becomes arbitrary large. The inertial acceleration is given by (see Appendix V):

$$a = r \cdot \omega^2 = \frac{v^2}{r} \qquad \text{(VI.9)}$$

We find that this acceleration disappears when *r* goes to infinity and the motion will then approach that of an inertial frame moving rectilinearly at a constant velocity.

In other words, the object will be in an inertial frame of SR.

Since the increasing radius does not alter the temporal metric if the velocity is constant we conclude that according to GR the temporal metrics in inertial frames, as experienced by a stationary observer, are contracted by the inertial scale-factor. This observation argues in favor of the VT over the LT, and provides additional support for the contention that motion curves spacetime in a relative sense via the inertial scale-factor. It also demonstrates that SR is inconsistent with GR.

Since the character of the temporal metrical factor in rotating frames should not change when the radius of the motion increases the same metrical factor should also exist with inertially moving frames.

This means that inertial frames in relative motion are in different Minkowskian manifolds.

The Twin Paradox inconsistency is caused by the failure to conceptually, and mathematically, distinguish between a local rest frame and a moving frame in the belief that both these frames belong to the same four-dimensional Minkowskian manifold.

The mystery of Inertia

From the very beginning of Western science the origin of *Inertia* has been mysterious. We know that acceleration is resisted by an inertial force, we feel it in an accelerating or sharply turning vehicle, but we do not know why it should exist. This is disturbing, because the physics of motion is based on Newton’s second law, which deals with the inertial force, but does not explain it.

A cornerstone at the foundation of science has not yet found its physical explanation.

Newton and Einstein, as well as people in physics in general, have concluded that Inertia and Gravitation must be closely related. The mass that appears in Newton's law of gravitation is the same as the mass, by which acceleration induces the inertial force. Newton noticed that the inertial centrifugal force acting on an orbiting stellar object like the Earth in its motion around the Sun, which is proportional to the mass of the Earth, is balanced by a gravitational centripetal force from the Sun that also is proportional to the mass of the Earth, and all observations and experiments have shown that the inertial mass is the same as the gravitational mass. This is a well known and accepted fact, which has been confirmed by experiments. But, we may still ask why these two mass concepts should be the same.

Einstein simply assumed that this is the case and explored the consequences of this assumption. This eventually led him to General Relativity via a line of reasoning, which will not be elaborated here. However, we will make use of, and further develop, a thought experiment originally used by Einstein in comparing inertia and gravitation.

If inertia has the same origin as gravitation it should be caused by spacetime curvature, but the LT implies that inertial frames have identical Minkowskian geometries and can therefore not explain inertia. On the other hand, the VT implies that the scale of spacetime differs for moving frames and, as we shall see, this would explain inertia!

Einstein's thought experiment revisited

Consider an object at rest on the surface of the Earth. It is subjected to a gravitational force that pulls it down, and is supported by a force from the ground of equal magnitude opposing the gravitational force, keeping it at rest. Although the object seemingly is at rest it is actually accelerating in the upward direction in relation to what it would do if it wasn't supported from the ground. We may say that falling is the most natural state for an object in a gravitational field because when falling no forces act on it. This was one of Einstein's most important insights; free fall is the most natural motion, in fact**,** the Earth is in free fall in its motion around the Sun.

Let's now compare this situation to an object inside an accelerating box far out in space away from gravitating bodies. An observer inside the box would feel a force from the bottom of the box that points in the direction to the (upward) acceleration, similar to the supporting force from the ground here on Earth. Therefore, this observer is in a situation similar to an observer on the ground; if the bottom of the box would disappear the observer's acceleration would cease and the box would keep accelerating away. Relative to the box the observer would accelerate way. In this scenario free motion is accelerating away, just like falling in a gravitational field.

Now, let us drop a number of pebbles down a well, or mine shaft, on the Earth; we see these pebbles accelerating away downwards, and we say that this acceleration is caused by the Earth's gravitational field. Let us next make a hole in the bottom of the accelerating box and drop the same kind of pebbles through this hole; we see these pebbles also accelerating away and we conclude that the reason is that the box accelerates. *On the other hand, if we did not know this we might conclude that the acceleration is caused by a gravitational field.* If this is the case it would mean that this gravitational field, which I will denote "the inertial field" should be caused by spacetime curvature just like the gravitational field.

In other words, we conclude that acceleration might cause spacetime curvature. This is an interesting proposition, and we might wonder if it may be substantiated.

The origin of Inertia

When comparing the LT to the VT we noticed that they differ by a scale factor, and that these two transformations are physically equivalent. The scale factor for the line-element of GR that corresponds to the LT equals one, while the scale factor for the line-element corresponding to the VT is $1-(v/c)^2$.

If Inertia and Gravitation both are caused by spacetime curvature it would mean that the line-element somehow changes during acceleration, which seems to contradict SR where the scale factor is the same for all inertia frames. This seems to rule out spacetime curvature during acceleration.

On the other hand, if we instead use the VT the scale depends on the relative velocity, and we may ask if perhaps this might curve spacetime and induce the inertial force.

In order to investigate this possibility I applied an *arbitrary scale factor,* $\phi^2(x,y,z)$, which I assumed was a function of the spatial location *x, y, z*, to the Minkowskian line-element. Since the gravitational field on the surface of the Earth depends on the spatial location this should also be the case for a scale-factor that might explain inertia. With this assumption I derived the geodesic of GR, which describes how a particle will move in a gravitational field. The derivation may be found in appendix V.

Here something surprising happens!

There is a certain scale factor for which this geodesic becomes an identity! This means that an accelerating object would always be on a geodesic of GR, regardless of the magnitude or direction of its acceleration.

In other words, this particular scale factor might create an "inertial field" similar to the gravitation field that induces the inertial force.

The dynamic scale factor that causes motion on a geodesic of GR is 1/γ! - I will call it the "Inertial Scale Factor". It depends on the relative velocity between the box and the pebble.

Inertial Scale Factor: $\phi = \sqrt{1-(v/c)^2}$

We recognize this scale factor from SR where is appears in the expressions for length contraction and time dilation.

It is also the (square root of) the scale-factor appearing in the VT line-element! It suggests that the VT rather than the LT ought to be used in physics.

The similarity between Inertia and Gravitation is illustrated in Figure 16.

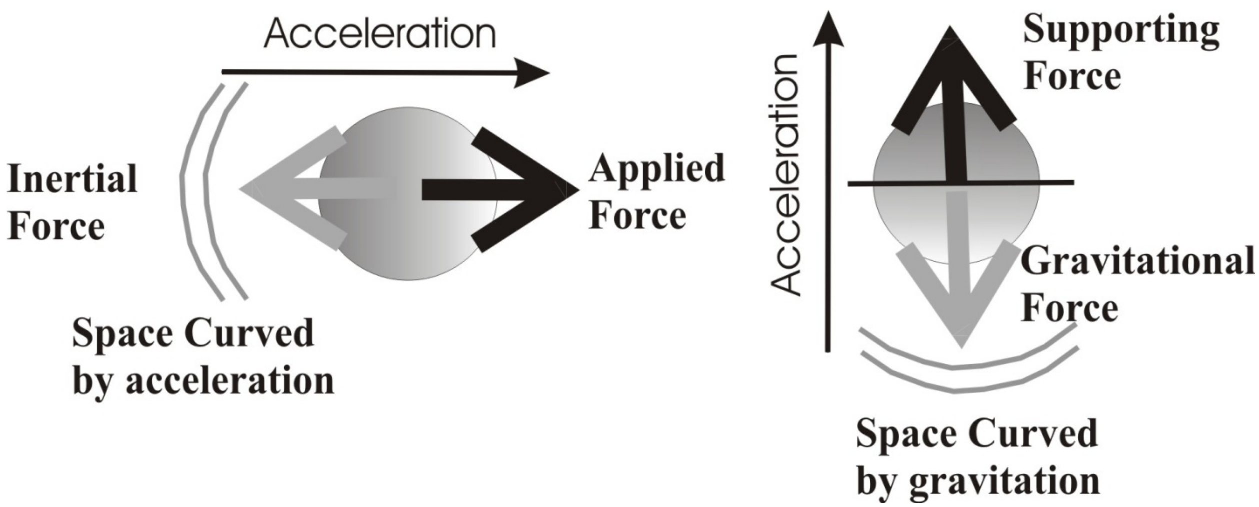

Figure16: Acceleration curves spacetime

An object subjected to a force is accelerating relative to an "inertial geodesic" (which in this case is motion with constant velocity) exactly like an object on the surface of the Earth is accelerating relative to free fall. In both situations free fall is accelerating away. This development may be found in Appendix V and in [Masreliez, 2007a].

An ontological explanation to the inertial scale factor

Let us assume that all particles are standing waves of some undefined nature confined to small spatial volumes that oscillate at the speed of light. How a particle actually is formed by these standing waves, and what constitutes them, is immaterial to the following line of reasoning.

When a particle moves it might preserve its oscillation properties including its oscillation period as illustrated in figures 17 a, b, and c where IRF stands for Inertial Reference Frame (here c=1).

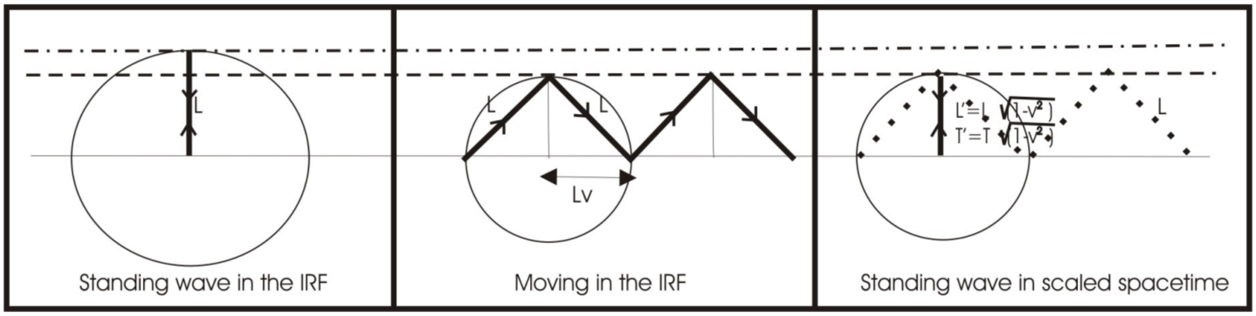

Figure 17 a, b and c: Relative scale contraction during motion

If the period of the oscillation remains the same it would imply that there is scale contraction perpendicular to the motion since the path length of the light path is unchanged. This contraction is in agreement with Voigt's Transformation where it corresponds to the scale factor of the GR line-element given by the VT. It is also consistent with the inertial scale factor that explains the inertial force. This suggests that:

The Inertial Scale Factor expresses how a particle with its pace of time is unchanged appears to respond to a changing velocity.

Since motion appears to change the scale perpendicular to the motion it will also appear to change it in the direction parallel to the motion. Let the observed distance between two mirrors in motion be D' as illustrated in Figure 18, and the distance between these mirrors at rest be D.

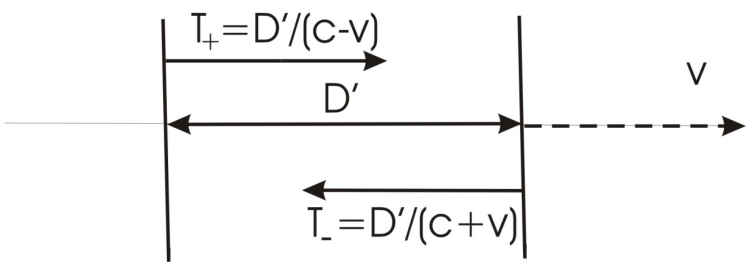

Figure18: Scale contraction parallel to the motion

If the period remains the same both in motion and at rest we have:

$$\text{Period}=T_{+}+T_{-}=\frac{2D}{c}=\frac{2D'}{c-v}+\frac{2D'}{c+v}=\frac{2D'}{c[1-(v/c)^2]} \quad \text{(VI.10)}$$

This implies that distance increments parallel to the motion are contracted:

$$D' = [1-(v/c)^2]\cdot D \quad \text{(VI.11)}$$

Here the apparent inertial scale contraction acts via the Inertial Scale Factor $[1-(v/c)^2]^{1/2}$, but there is also additional apparent length contraction due to the motion. The latter length contraction is also present in SR. If the pace of time is adjusted by the same scale factor, all four coordinates are scaled equally, and the moving frame appears to be contracted in scale as illustrated by Figure 17c. This scale contraction is consistent with the VT rather than the LT.

Physical properties that sustain a particle (regardless of what they might be) are conserved by scale-contraction due to scale-equivalence. In other words, by retaining its local spacetime geometry a particle is conserved during motion without changing its oscillation frequency.

This suggests that the pace of atomic clocks does not change during inertial motion. Time-dilation is a purely apparent phenomenon.

Summarizing, it appears that all objects in motion may appear to respond to acceleration by contracting their spacetime scales in an apparent and relative sense.

Relative scale contraction during acceleration

Let us return to the thought experiment with the accelerating box. In dropping the pebbles though the hole in the bottom we observe how they move away and how the pebbles dropped earlier have reached higher relative velocities since the box keeps accelerating. At the moment we drop a pebble its relative velocity is zero and the inertial scale factor then equals one. But, the farther away the pebbles are the higher their velocities are, and the smaller are the corresponding inertial scale factors. This suggests that spacetimes in motion appears to be contracted in relation to the stationary scale factor of the box, which always equals one.

Furthermore, since this scale contraction at all time is relative to the box, the scale contraction between inertial frames is a relative phenomenon that does not influence the local scale of spacetime for an observer at rest in the moving frame, which always equals one.

This situation would be impossible in the context of a single, unique, 4D spacetime world, but would become possible in a 5D world where the Inertial Scale Factor, acts as a fifth dynamic degree of freedom.

Two aspects of time

Time is often treated as a coordinate dimension in physics, making the world four-dimensional. However, current physics does not take into account the fact that there are two aspects of time; the pace of its progression via the passage of time, and the duration of time intervals. It is commonly believed that these two aspects are synonymous; that an observed time interval also gives the elapsed number of seconds. However, this might not be true if the scale of spacetime is an additional degree of freedom, which would allow all clocks to always run at the same pace, yet also allow a measured time interval in a moving frame to differ due to its different scale.

Here I will propose that the pace of time is a cosmological property of all existence, and that it is the same everywhere across the universe regardless of motion.

On the other hand, the duration of a time interval like a second may change in a relative sense. Thus I will assume that there is a universal, cosmologically induced, pacesetter for all existence mirrored by the reading of atomic clocks; I propose that atomic clocks remain synchronized regardless of motion. This will be further elaborated.

Setting x=0 in Voigt's Transformation (VI.4) we get t'=t. This means that elapsed times as indicated by the number of expired seconds in each frame agree. Let's call this number N. Locally all clocks record the same number N regardless of their relative motions. And, if the clock at x=0 in the SF agrees with a clock in the MF it will agree with all clocks in the MF because these clocks are synchronized. We may say that that N represents an absolute location in the temporal evolution of the cosmos.

On the other hand, when treating the VT as a coordinate transformation of GR we find a line-element by which the scale in the MF is contracted so that $dt'=(1/\gamma)dt$. These two different interpretations of the VT correspond to two aspects of time, its pace and its apparent duration. GR deals with the durations of seconds rather than with the elapsed time N. This means that although the progression number N is the same, time intervals may appear to be different if the scale of spacetime differs. This is what may happen when observing a moving frame where time appears to run slower; the number of seconds is always the same but a time interval in a moving frame may appear to be shorter due to scale contraction. If we don't realize this we may wrongly interpret the shorter duration as being caused by a slower progression of time during motion.

However, current physics does not distinguish between these two aspects of time; in fact, GR ignores the pace of time, merely comparing the relative durations of spacetime intervals. GR compares coordinate increments by taking into account their relative, different, metrics. Thus GR deals with the concept of relative durations, but not with the pace of time. Therefore GR cannot model the progression of time or model motion as a dynamic process. An additional degree of freedom (dimension) is needed corresponding to the pace of time, which in the thinking presented here corresponds to the cosmological scale expansion process.

Clearly we need to take into account both the pace of time and the relative durations of time intervals when modeling motion. In doing this we will find that time may progress at the same pace everywhere, but that time intervals in moving frames may appear to be shorter. This is true regardless of which frame is selected as being the SF. This situation cannot be captured by any 4D coordinate transformation since it also involves the dynamic relative scales of frames.

Here someone may object that time dilation is a fact that has been confirmed by numerous experiments, so how can clocks still run at the same pace? The answer is that in the past we have not taken into account the possibility of a fifth dimension in the form of a relative dynamic spacetime scale that allows co-existence of different four-dimensional spacetimes. An object in motion has its own co-moving local spacetime and experiences other objects in relative motion as a projection onto this local spacetime. This means that the observed properties of a moving object is apparent and not "real".

As we will see this includes the observed velocity.

True and apparent velocity

The introduction of these two aspects of time helps resolve the contradictory treatment of time in SR.

Consider the figure below.

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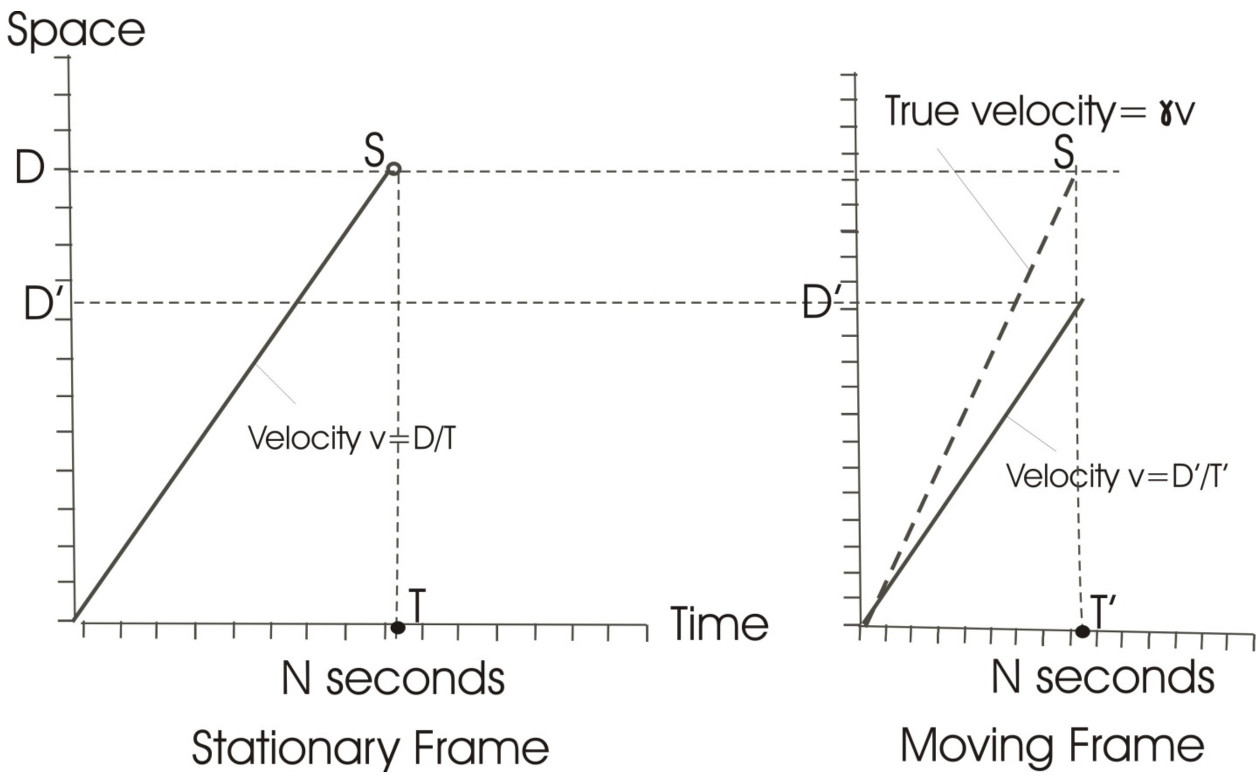

Figure 19: True and apparent velocity

The coordinate system on the left illustrates motion as it may be visualized in the stationary frame, while the right hand side shows motion in a moving frame where the scale is relatively contracted. If during the time T an object has moved the distance D in the SF we may set v=D/T. Similarly we also have v=D'/T' since both D' and T' are contracted versions of D and T.

However, if motion in the MF takes place at velocity v an observer in the SF would see the distance D' when observing this motion rather than D, and conclude that the distance traveled is shorter than D by the factor 1/γ. In order to actually observe the distance D the velocity in the MF must be larger than v by the factor γ.

This leads to the following conclusion:

An object that appears to move at velocity v is actually moving with a true velocity γv.

Note that this velocity is the "relativistic" velocity of SR, and that due to the different scales the true relative velocity is not v but γv. This difference between the real and perceived velocity is caused by the "speed of light" c, which is a constant that relates time and space in the four-dimensional spacetime geometry of GR.

Since we are not used to the idea that motion causes relative scale contraction it is tempting to think of motion in the stationary frame. However, this is a mental mistake since there can be *no motion of points in the local geometry* of a reference frame. Furthermore, if motion implies scale-contraction it rules out using the local metrics for the moving object as seen from the stationary frame. In other words, as soon as there is motion the object ceases to exist in the local stationary frame.

This makes it clear that 4D coordinate transformation cannot model motion.

Therefore, the VT might be seen as representing the "projection" of the moving geometry onto the local frame. Although this point of view at first may seem strange it will become clear when taking into account an additional scale dimension that allows co-existence of different four-dimensional spacetimes.

Motion causes moving frames to exist in different 4D manifolds.

An additional dimension beyond the four spacetime dimensions

By this reasoning we arrive at the somewhat surprising, and perhaps unsettling, proposition that an additional dynamic degree of freedom of fundamental importance may exist beyond those of space and time, and that this "new" degree of freedom might be the scale of spacetime. We may think of it as an additional, independent, "dimension" beyond the four spacetime dimensions. We already saw that modeling the progression of time demands this additional dimension.

Every inertial frame would then be associated with a separate, and local, 4D spacetime geometry, while other inertial frames would be associated with their own local 4D geometries. Accelerating from one velocity to another would mean that although the local Minkowskian geometries remain the same, they differ in a relative sense via the scale dimension. Motion would then in general involve transitioning in the scale of spacetime as well as in the four spacetime dimensions. Like the arrow in Zeno's arrow paradox, a moving object always remains at rest in its local spacetime geometry.

During acceleration a moving observer would experience contracted frames in the past and would consequently also experience a gravitational-type force directed backwards toward to these past locations. *This is the inertial force.*

This would obviously be something completely new to science, but this new perspective should not be ignored, because it could open the door to a new and better understanding of our world.

We noted that the VT implies that the temporal coordinate is the same for both the stationary frame and the moving frame. However, an observer in the SF will see distances shorter in the MF and will therefore be traveling farther in the MF in a given time than indicated by the velocity v in the VT. Because of the metrical scale-contraction the velocity v used in the VT is not the actual velocity experienced by a traveler in terms of distance per second.

Since the LT and the VT yield scale equivalent Minkowskian line-elements with the same identical GR field equations they are, according to GR, physically equivalent. It may therefore seem that it would not matter which representation we chose. However, the additional postulate that the progression of time should be the same in all inertial frames favors the VT and results in a different interpretation of several observed phenomena.

It also explains the origin of inertia.

Visualizing the additional scale-dimension

The scale perspective of inertial frames is symmetric and only depends on the relative velocity. This is illustrated in Figure 20 by considering one-dimensional spaces imbedded in a two-dimensions.

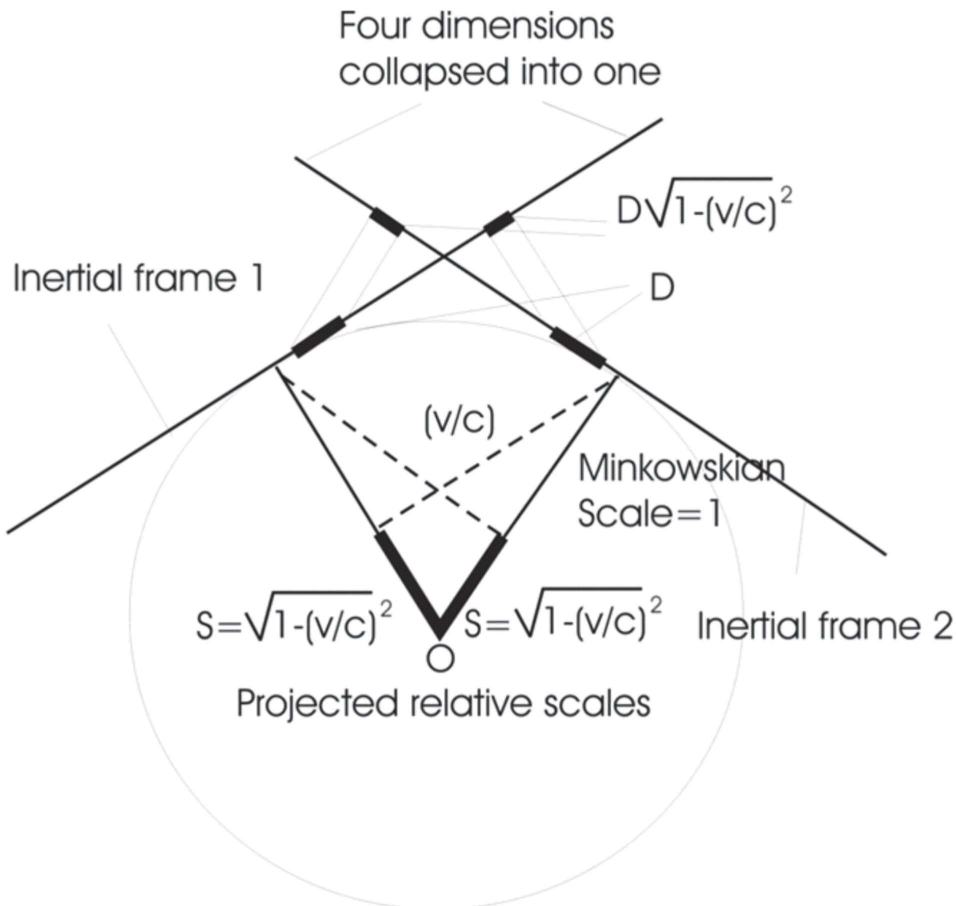

Figure 20: Illustrating an additional dimension

In the figure the four dimensions of spacetime are collapsed into a single dimension – a line. The page is two dimensional and thus adds one dimension. The two straight lines correspond to two different 4D manifolds. Similarly a fifth dimension would allow different 4D spacetimes to coexist, modeling different inertial frames as represented by the two 1D lines in the figure. Acceleration causes transition between these frames of different relative scales, which might be the origin of Inertia. In the figure this is illustrated by different orientations of the lines. In other words, different 4D spacetimes may co-exist imbedded in a 5D manifold. The figure also shows how an increment in a 1D (or 4D) space is projected onto a different co-existing space, the projection being smaller by the square root of the inertial scale factor. This models time dilation and length contraction in SR.

Furthermore, from this illustration it is clear that the projection of motion along one of the lines is moving slower on the other line. When the two lines become close to perpendicular, motion on one line may become arbitrary fast while its projection on the other line may remain quite slow. This is also the case in 4D when the velocity approaches c, in fact the projected motion in time stops completely at the velocity v=c when the lines are perpendicular. In SR this corresponds to time-dilation and length-contraction proportional to the inertial scale factor, which approaches zero when the v approaches c.

A "one dimensional observer" on the line may never directly experience the second dimension, just like we, living in a 4D world, don't directly experience the 5th scale-dimension.

A few interesting consequences of relative scale contraction

If the scale of spacetime were to contract in a relative sense during acceleration it would have observational consequences very similar to what SR predicts, which might explain why SR currently is believed to be absolutely correct. However, the interpretations using SR's relativistic time rather than a dynamic spacetime scale would differ.

First: If the scale contracts so that distances and time intervals appear shorter when in motion, an observed velocity v in the stationary frame would, as already mentioned, not be the true velocity. The SF observer sees distances contracted in the MF but uses her own temporal reference in measuring the velocity, which means that the observed motion, as judged from the SF, appears to be faster. Because of the length contraction the true velocity is γv rather than v in terms of distance covered per second.

A thought experiment may help clarifying the situation. Consider flying very fast above the surface of a planet. If the velocity causes apparent relative scale contraction, distances between mile posts on the surface would appear shorter and as a consequence we can cover a larger distance per second. In other word, we fly faster than indicated by the velocity v.

This adjustment of our perspective would have the following interesting consequences:

- The "speed of light", c, would become and *observational limit* to how fast an object may be seen to move, but would not constrain how far it might travel in a given time. It would be possible to travel farther than a light-year in a year! (This is also true in SR due to time dilation). This new interpretation would have the following additional consequences:

- Since an object seen as moving at velocity v will move at a "true velocity" $v'=\gamma v$ its momentum would be $p=mv'$ in agreement with SR and classical physics. Its mass would not increase, but instead its true velocity would be higher than the observed velocity v. The observed "increase in mass" would then be caused by a higher velocity rather than an increased "relativistic" mass.

$$p = m \cdot v = \text{"relativistic mass"} \cdot v = (\gamma m_0) \cdot v = m_0 \cdot (\gamma v) = m_0 \cdot \text{"true velocity"}$$

This would explain the apparent relativistic increase in mass as being due to a higher true velocity and not due to some mysterious, unexplainable, mechanism that causes mass to increase.

- A traveler moving on a circular route, as considered by Einstein, would not be younger upon returning, but would simply arrive back earlier than estimated from its observed velocity v. There would be no difference in elapsed times between observers, because clocks always run at the same pace, which would resolve the Twin Paradox once and for all.

- The Newtonian pre-relativistic concept of simultaneity would make its comeback; atomic clocks may be used to define cosmological simultaneity as given by the same readings on these clocks. This would obsolete the use of light signals for clock synchronization.

- By SR it is possible to travel farther in a given time than is indicated by the velocity v, since the pace of time slows down during motion. The result would be the same with the new interpretation, since the velocity increases by the same factor as time slows down by SR.

- The fraction of muons that survive the passage through the earth's atmosphere would be greater than expected simply due to their higher velocities and shorter transit times.

- In a Synchrotron the electrons may travel at 99.99999 percent of the speed of light. They radiate at frequencies that match their rotation frequency. However, since their true velocities are a factor γ larger than observed, the radiated frequencies are a factor γ higher than the frequencies of the applied accelerating, rotating, field.

The progression of time and absolute time

Relative scale adjustment of four-dimensional spacetime during acceleration admits a common pace of time for all moving objects while allowing temporal durations to be different in a relative sense. Thus (the progression of) time may remain the same in all inertial frames while time still may appear to run at a slower pace in moving frames. However, the "slowing pace of time" of moving clocks is merely an apparent phenomenon caused by a diminished relative scale of spacetime. As already mentioned this resolves the most serious and widely debated challenge to special relativity – the Twin Paradox.

The introduction of the metrical scale as an additional dynamic aspect of existence allows clear differentiation between local spacetime geometry in a stationary frame and the relative spacetime geometry in a moving frame, which in the past were thought to be identically the same. Now we realize that moving frames appear scale-contracted.

An additional degree of freedom for motion in the form of a dynamic scale of four-dimensional spacetime is implied by the cosmological expansion, which may act simultaneously across the cosmos. This novel scale expansion process could explain the progression of time as being a physical process "beyond space and time", i.e. it is a dynamic physical process that does not change the four-dimensional geometry as expressed by the line-element of GR. This explains why the progression of time always has been so mysterious; we all realize that it somehow involves "motion in time" rather than motion in space, but cannot visualize what this temporal motion might be. The dynamic scale expansion of spacetime could be what makes time pass.

This "new" and previously unknown aspect of the world would of cause be of immense importance and it seems strange that it has not been recognized earlier. However, it may soon become obvious to us all.

The cosmological expansion with its steadily increasing scale acts simultaneously (non-locally) unconstrained by the “speed of light“ c. In principle this also provides a vehicle of synchronizing clocks cosmologically and thus obsoletes the need to synchronize clocks via light signals as is done by SR.

Newton's absolute time makes its comeback!

The photon as a particle

The nature of a photon has always been mysterious, it also puzzled Einstein. Here is a quote:

All the fifty years of conscious brooding have brought me no closer to answer the question, "What are light quanta?" Of course today every rascal thinks he knows the answer, but he is deluding himself.

Albert Einstein Dürrenmat, p.35

Theodor Kaluza and Oskar Klein declared light a “distortion through 5-dimensional space”, a clear “*Anschauung*”, that is, a hypothetical perception without any basis in known physics.

The new explanation of motion developed above may perhaps also shed some light (no pun intended) on the photon, if this particle instead of moving at the speed c were to move at an *observed* velocity v, slightly is less than but extremely close to c. Assume a very tiny virtual rest mass for the photon m_0. Its momentum would then be close to $\gamma m_0 c$ (using its relativistic velocity) and its energy close to $E=\gamma m_0 c^2=pc$ like it is in SR.

Almost all the energy of a photon would then be kinetic.

This would mean that all photons actually move at true velocities exceeding c, and that the “speed of light” c is not the actual velocity of photons but rather a constant of nature that relates time to space. The small size of the photon is now explained by scale contraction. And, like in SR there is additional contraction in the direction of motion, which would explain the oscillating electromagnetic field perpendicular to its motion.

This makes it possible to visualize a photon as a particle with a metrical field modulation similar to the deBroglie matter-wave. In Chapter V of this monograph we saw that the deBroglie matter wave might be explained as being modulation of the metrical scale of spacetime, which in the VT (and LT) is given by the term:

$$\omega v x / c^2 \approx \omega_0 \gamma x / c \qquad \text{(VI.12)}$$

With a deBroglie wavelength x=λ, the time t_m between the arrival of two consecutive deBroglie "wave crests" satisfies:

$$\omega_0 \gamma v x / c^2 \approx \omega_0 \gamma x / c \approx \omega_0 \gamma \cdot \lambda / c = \omega_0 \gamma \cdot t_m = 2\pi \qquad \text{(VI.13)}$$

On the other hand the period t_c of the Compton oscillation, which is associated with rest mass, is given by:

$$\omega_0 \gamma t_c = 2\pi \qquad \text{(VI.14)}$$

Thus for a photon $t_m = t_c$, and the periods of these two waves, one being due to the temporal Compton oscillation and the other one due to the spatial deBroglie matter-wave modulation, coincide.

It therefore appears as if the photon has only one wave instead of two waves of different origin – the deBroglie wave and the Compton wave. This would explain its dual aspects of wave and particle.

We also saw that the deBroglie wave may be identical to the quantum wave that guides particles in for example the double slit experiment. This may also be true for the photon, which in this aspect may behave just like ordinary particles. Therefore it is possible that a photon is a special kind of particle with non-zero rest mass, although it is very, very, tiny.

Richard Feynman said this:

There is one simplification at least. Electrons behave ... in exactly the same way as photons; they are both screwy, but in exactly in the same way...

We may inverse this comment and say that photons are particles that behave in exactly the same way as electrons!

Thus, it appears that the photon may be explained as being a particle that behaves just like any other particle. However, it should be noted that this ontological explanation for the photon requires relative scale contraction during motion.

Therefore this explanation is not consistent with SR, which may explain Einstein's frustration.

Is Special Relativity "right"?

Asking if SR is right is similar to asking if the epicycles were right. If we only take into account their ability to model the planetary motions as they appear on the night sky we might argue that they did and excellent job in a positivistic sense. But, if we want to find out why the planets move as they do we would not consider the epicycles to be right.

Similarly, the fact that SR agrees with our observations may makes us believe that this theory is absolutely right, but if we would like to find an ontological explanation to why time runs slower in motion, or if we want to find the origin of the phenomenon of Inertia, SR cannot be the last word.

If we adopt Voigt's transformation rather than Lorentz's it would mean that the observed scale of spacetime is contracted in a relative sense for frames in motion, but that this apparent scale contraction does not influence the local conditions in each frame.

This interpretation has three major advantages:

1. It resolves the Twin Paradox by recognizing that frames in relative motion are in different spacetime manifolds.
2. It allows a common temporal reference (absolute cosmological time).
3. It explains the inertial force

It resolves the Twin Paradox since the diminished scale in a moving frame allows an observed clock to run slower without influencing its local pace in the moving frame.

It allows a common temporal reference because moving frames are related via Voigt's transformation rather than Lorentz's.

And, it explains inertia as being a curved spacetime phenomenon induced by the dynamic spacetime scale.

However, it has one "drawback" if you believe that the world may be described by standard physics because it implies that the relative perspective between moving frames involves an additional aspect in the form of a dynamic spacetime scale. Hence, it is no longer sufficient to model relative motion merely via changing locations in four-dimensional spacetime; the additional scale-dimension must also be taken into account.

Perhaps you wonder how SR has survived all the scrutiny over the hundred years since 1905. The reason might be that Einstein's derivation is perfectly logical and correct as long as the world is four-dimensional. Therefore, mathematical minds analyzing it have not found anything wrong with it. However, the additional scale dimension opens up a new world.

The scientist is now confronted with the choice of either believing the math and Einstein and just accept inconsistencies, or acknowledge that something is not quite right with SR, as Herbert Dingle did.

Final comments on Motion, Inertia, Special Relativity

When Einstein introduced Special Relativity in 1905 the Lorentz Transformation had already been proposed by Henrik Lorentz and Henri Poincaré, which helped pave the way for his theory. By the Principle of Relativity the pace of time should locally be the same in all inertial frames, yet according to the SR theory it differs in moving frames. This is an inconsistency that from the very beginning has been at the center of controversy. Obviously, a theory that claims that the time is the same in all inertial frames (due to the Principle of Relativity), but also claims that it is different in moving frames cannot be quite right.

The new theory proposed here eliminates this problem by introducing an additional aspect of existence in the form of a relative scale of inertial frames, which makes it possible to clearly differentiate between the spacetime geometries of local and relative observers. All inertial observers may experience the same pace of time in their own local inertial frames, but see time (apparently) run slower in moving frames due to their scale difference. By this development the scale of spacetime becomes an additional "dimension" beyond the four spacetime dimensions, and we might rightly wonder if this additional complication really is warranted.

There are at least three weighty considerations in support of this new aspect of existence:

First: It would explain the inertial force as being due to induced spacetime curvature caused by a changing relative scale during acceleration.

Second: It would make possible the existence of a common cosmological pace of time; *Newton's absolute time could make its come-back.*

Third: It would eliminate the speed of light as an ultimate velocity constraint for space travel.

These advantages are substantial and should justify further investigation of the "new" scale dimension. We know that the absence of a common pace of time is in conflict with non-local influences in quantum theory, and that it puts into question uniform cosmological aging. Clearly, the speed of light, c, cannot be a universal velocity constraint for influences. And imposing a theoretical constraint on how far we may travel in given time seems unreasonable. (In this context it is amusing to note that the cherished "warp speed" of Science Fiction may find its justification in new physics, since all acceleration contracts, or "warps", the metrical scale of spacetime in a relative sense.)

The SR theory is the best we can do if our existence actually were confined to the four dimensions of space and time. But, this might not be the case; at least one additional "dimension" may exist in the form of a dynamic scale, a possibility that should not be overlooked. It may open up new avenues of research, which could lead to deeper understanding.

A dynamic spacetime scale could enter physics as an additional degree of freedom beyond the four dimensions of space and time.

The main objective of this chapter on motion is to put forward this possibility, trusting that it will be subjected to unbiased scrutiny.

Chapter VII: Summary of this monograph

The main objective of science is to help us grasp the world in the context of what we believe is known and well understood. This is why mathematics plays such an important role in physics. Mathematics is a very structured language based on what is considered known beyond any reasonable doubt, for example 2+2=4. So, if we can explain our world using this language it seems that such explanations must be correct.

However, this is not necessarily the case.

The problem with this approach is that Nature may not be restricted to using the building blocks we use in formulating our mathematical theories. In other words, the information based on a set of axioms may not be the same as the information based on a different set of axioms.

The SEC model is an example of this. Adding the fifth scale-dimension to the previous four dimensions of time and space allows a new and fundamentally different understanding of the world that better agrees with our observations. The additional mathematics resulting from adding this new dimension explains a number of previously unexplainable aspects ranging from the previously mysterious creation of the world from nothingness to Dark Energy and Dark Matter, which both turn out to be artifacts of restricted mathematics. In other words, Dark Energy and Dark Matter no longer exist as previously imagined.

Thus it appears that the main problem with the current thinking is that it ignores the possibility that the scale of existence may change with time. This is why the progression of time always has been enigmatic. Time may progress by changing the scale of existence!

By the new thinking proposed in this monograph we step out of a four-dimensional world into a richer five-dimensional world that better agrees with how we experience our world.

The line of reasoning presented in this monograph gradually evolved over a twenty year period while single-mindedly probing the limits of our current understanding. During this extended effort it became clear that an interesting possibility may have been overlooked in the past, suggesting that an additional degree of freedom for motion might exist in the form of a dynamic scale of four-dimensional spacetime. At first this may be hard to accept, because this idea is new and unfamiliar. It challenges several preconceptions deeply rooted in our world-view and in the very foundation of modern science.

This work challenges both the seasoned reader and the layman, who both may be unprepared for these new ideas. Yet, the progression of time has always been mysterious to us and subjected to much speculation; it is the most keenly experienced aspect of our existence, yet its origin has in the past remained unknown.

Obviously, if we cannot explain the passage of time there is no hope to ever understand the universe.

The finding that cosmological scale expansion of both space and time may explain what is causing the progression of time should be of great interest to us all.

This work has been one of love with many highlights and moments of awe and joy when discovering something new and unexpected. Some specialists may consider the development of this monograph too "simpleminded", or that it is pushing the limits of what presently is considered acceptable. However, Copernicus' idea of a moving Earth was also very simpleminded compared to the 80 or more epicycles of the Ptolemaic model, and it also pushed the limits of acceptability.

Let me just recall a few highlights during the development of this new world-view.

- In 1993 an idea occurred to me: That there is no predetermined scale of existence. Worlds of different scales should appear identical to their inhabitants. This claim is supported by GR since its field equations are identical for spacetimes of different scale.
- *Cosmological scale-equivalence became a fundamental postulate for the SEC model*.
- This suggested that the cosmological scale of spacetime might expand and that this is the nature of the cosmological expansion.
- The ancient Greek philosopher Parmenides argued that something cannot be created out of nothingness, therefore the universe must exist perpetually.
- If existence is perpetual, the scale of the cosmos should expand geometrically (exponentially) since all epochs then would become scale-equivalent with identical

spacetime geometries in GR. And, since the cosmos currently is assumed to be about 14 billion years old (the Hubble Time), the time constant for this exponential cosmological scale expansion ought to be the Hubble Time.

- *This suggested the Minkowskian line-element with an exponentially increasing scale as the SEC line-element.*
- This would imply that the cosmos would seem to be 14 billion years old regardless of epoch.
- *The Hubble Time becomes a cosmological* ***constant*** *that has nothing to do with the age of the universe.*
- This would also eliminate the troublesome creation event, which is the major problem with the SCM's Big Bang model.
- Einstein's critical density appears in the energy-momentum tensor for the SEC line-element as its temporal component, and the three spatial components appear as part of his Cosmological Constant. This would explain both the Dark Energy and the "accelerating expansion" as being a direct consequence of the cosmological scale-expansion. Thus the Dark Energy might be curved spacetime energy rather than some exotic, unknown, particles.
- The distance-redshift relation for the SEC line-element and the corresponding apparent luminosity relation allow testing the SEC using astronomical observations at cosmological distances. The SEC model excellently agrees with three different cosmological tests; the number count test, the angular size test and the surface brightness test.
- *The SCM model fails all of them.*
- Furthermore, the SEC model also agrees with the supernovae 1a observations without having to speculate on Dark Energy or a Cosmological Constant.
- However, since the scale increases for the four-dimensional SEC line-element of GR it would imply that the geometry of the universe changes with time. This violates scale-equivalence and perpetual existence by which the world geometry should always remain the same independent of time.

Therefore the four-dimensional spacetime of GR cannot model the SEC.

- This apparent disadvantage of the SEC model may be formally overcome by assuming that the cosmological scale may change incrementally while reproducing the four-dimensional spacetime geometry at increasing scales in a stepwise fashion. This is the process of Discrete Incremental Scale Transition (DIST)**,** which conserves the 4D world geometry by scale-equivalence.
- A dynamic scale of spacetime would then enter physics as a new fundamental degree of freedom, suggesting a five-dimensional cosmos model in GR.
- This also suggests that Theodor Kaluza's five-dimensional GR, whereby he derived Maxwell's equations, actually may have been our first hint of a more complete five-dimensional world.
- The incremental DIST process also suggests a connection with Quantum Mechanics via the oscillating spacetime scale modeled by the DIST process. David Bohm's version of QM may be derived from GR if the metrics of the Minkowskian line-element were to oscillate at the Compton frequency!
- *This merges QM with GR, and suggests the QM wave functions are modulation of the scale of spacetime!*
- Since the time of Newton the origin of the inertial force appearing in his second law of motion has been mysterious. With an *Inertial Scale Factor* applied to the Minkowskian line-element the inertial force may be explained as being a curved spacetime phenomenon akin to gravitation:

  $$\text{Inertial Scale Factor} = \sqrt{1-(v/c)^2}$$

  With the square of this scale-factor applied to the Minkowskian line-element all accelerating motions will take place on geodesics of GR!
- *This suggests that inertial frames of Special Relativity might be in different manifolds of GR separated by relative scale.*
- This would revise Special Relativity without altering its observational aspects while offering an explanation to inertia. It would also indisputably resolve the Twin Paradox, since the time observed in a moving frame may appear to differ from the local time because of its relative scale difference.
- *Furthermore, it would allow an absolute cosmological time.*

All these findings are of course new and may perhaps seem a bit hard to digest, but if at least a few of them turn out to have merit they will revolutionize science. Newton's first law of motion and his law of gravitation would be invalidated on cosmological scales of space and time. It would also revise Special Relativity and merge GR with QM.

The cosmos might be a thermodynamically open system in which energy induced by a slowing pace of time unendingly flows to its expanding space while keeping the net energy zero. This is made possible by a cosmological scale expansion that conserves the geometry of the four-dimensional spacetime.

The progression of time, which mirrors this cosmological scale expansion, and is keenly felt by all living beings, assumes its rightful place as being the foremost of all physical processes.

In retrospect it is interesting to note that Newton could not answer what might carry gravitational influences across empty space. He left this question open. And, Faraday suggested that some kind of "field" carries the magnetic force and made metal filings line up on a paper above a magnet. This field idea gained further momentum from Maxwell's equations that described electromagnetic actions.

General Relativity suggested a possible explanation for gravitational influences, and the term "gravitational field" was coined. However, GR also offered an explanation to the nature of this field; it was caused by "spacetime curvature", i. e. by coordinate metrics that change with location. The electromagnetic field and the gravitational field became separate and different entities that acted in a background of space and time.

Then Theodor Kaluza showed that Maxwell's equations were a consequence of a certain five-dimensional version of GR. However, people, including Einstein himself, could not understand how this derivation of Maxwell's equation from GR was possible. Kaluza's finding further developed by Oskar Klein became known as the "Kaluza-Klein miracle". It appears that nobody understood the deeper significance of this development, which may have been our first indication that the world has more dimensions than just the four of spacetime.

Quantum Theory further complicated this world-view by adding field-like wave functions with unusual properties, since they were believed to represent probability densities rather than something "physical", and acted non-locally.

Now it seems that this rather confusing scenario is about to change. It is possible that nothing else exists than the four dimensions of spacetime together with the scale of spacetime acting as a dynamic fifth dimension. There is no "substance" or any tiny "fundamental particle" at the very core of material existence. It is possible that the world is nothing but dynamic hyperspace geometry energized by the progression of time. All "fields" and all matter may be modulations of the metrical properties of this 5D hyperspace.

During the twentieth century we lost the ancient vision of a world of unmatched simplicity, self-sustained in perpetual existence, a world without beginning or end, in favor of a world created some 14 billion years ago, which is doomed to perish in the future.

However, we may now return to the belief in a world without limits in space or time, a world of meaning and unlimited possibilities in which we all can feel at home.

There is no greatness where there is no simplicity, goodness and truth.

Leo Tolstoy

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APPENDICES

Appendix I: Deriving the free geodesic in the SEC and Cosmic Drag

The General Relativity geodesic relations are given by:

$$\frac{d^2 x_\alpha}{ds^2} + \Gamma^\alpha_{\mu\nu} \cdot \frac{dx_\mu}{ds}\frac{dx_\nu}{ds} = 0 \qquad \text{(A1.1)}$$

Consider the SEC line-element:

$$ds^2 = e^{2t/T}(dt^2 - dr^2 - r^2 d\theta^2 - r^2 \sin^2(\theta) d\varphi^2) \qquad \text{(AI.2)}$$

The Christoffel symbols $\Gamma^\alpha_{\mu\nu}$ are:

$$\begin{array}{llll}
\Gamma^0_{00} = 1/T; & \Gamma^0_{11} = 1/T; & \Gamma^0_{22} = r^2/T; & \Gamma^0_{33} = r^2 \cdot \sin^2(\theta)/T \\
\Gamma^1_{01} = \Gamma^1_{10} = 1/T & \Gamma^1_{22} = -r & & \Gamma^1_{33} == r\sin^2(\theta) \\
\Gamma^2_{02} = \Gamma^2_{20} = 1/T & \Gamma^2_{12} = \Gamma^2_{21} = 1/r & & \Gamma^2_{33} = -\sin(\theta)\cos(\theta) \\
\Gamma^3_{03} = \Gamma^3_{30} = 1/T & \Gamma^3_{13} = \Gamma^3_{31} = 1/r & & \Gamma^3_{23} = \Gamma^3_{32} = \cos(\theta)/\sin(\theta)
\end{array} \qquad \text{(A1.3)}$$

All other Christoffel symbols are zero. The geodesic equations are:

$$\frac{d^2 t}{ds^2} = -\frac{1}{T}[(\frac{dt}{ds})^2 + (\frac{dr}{ds})^2 + r^2 \cdot (\frac{d\theta}{ds})^2 + r^2 \cdot \sin^2(\theta) \cdot (\frac{d\varphi}{ds})^2] \qquad \text{(A1.4)}$$

$$\frac{d^2r}{ds^2} = -\frac{2}{T}(\frac{dt}{ds})(\frac{dr}{ds}) \ + r\cdot(\frac{d\theta}{ds})^2 + r\cdot\sin^2(\theta)\cdot(\frac{d\varphi}{ds})^2 \qquad \text{(A1.5)}$$

$$\frac{d^2\theta}{ds^2} = -\frac{2}{T}(\frac{dt}{ds})(\frac{d\theta}{ds}) \ -\frac{2}{r}\cdot(\frac{d\theta}{ds})(\frac{dr}{ds}) + \sin(\theta)\cdot\cos(\theta)\cdot(\frac{d\varphi}{ds}) \qquad \text{(A1.6)}$$

$$\frac{d^2\varphi}{ds^2} = -\frac{2}{T}(\frac{dt}{ds})(\frac{d\varphi}{ds}) \ -\frac{2}{r}\cdot(\frac{d\varphi}{ds})(\frac{dr}{ds}) - 2\cdot\frac{\cos(\theta)}{\sin(\theta)}\cdot(\frac{d\varphi}{ds})(\frac{d\theta}{ds}) \qquad \text{(A1.7)}$$

The first terms on the right hand side model a new physical phenomenon – "Cosmic Drag".

For the radial geodesic with $d\Theta=d\varphi=0$ relation (AI.5) becomes:

$$\frac{d^2r}{ds^2} = -\frac{2}{T}\frac{dr}{ds}\frac{dt}{ds} \qquad \text{(AI.8)}$$

Integrating with K as an integration constant:

$$\frac{dr}{ds} = K\cdot e^{-2t/T} \quad \text{(AI.9)}$$

Setting $\beta=(dr/dt)/c$ we get from the line-element:

$$\frac{ds}{dt} = e^{t/T}\sqrt{1-\beta^2} \qquad \text{(AI.10)}$$

From this and (AI.9) we have:

$$\frac{dr}{ds} = \frac{dr}{dt}\frac{dt}{ds} = \frac{\beta}{\sqrt{1-\beta^2}}e^{-t/T} = K\cdot e^{-2/T} \text{ (AI.11)}$$

Where K is given by:

$$K = \frac{\beta_0}{\sqrt{1-\beta_0{}^2}} \quad \text{(AI.12)}$$

Solving for β:

$$\beta = \frac{\beta_0\cdot e^{-t/T}}{\sqrt{1-\beta_0^2+\beta_0^2\cdot e^{-2t/T}}} \qquad \text{(A1.13)}$$

β is the velocity of a free particle on a geodesic in the SEC.

Note also that:

$$\frac{\beta}{\sqrt{1-\beta^2}} = \frac{\beta_0}{\sqrt{1-\beta_0^2}}e^{-t/T} \qquad \text{(AI.14)}$$

The "relativistic velocity" decreases exponentially with time in the SEC.

If the velocity of a particle initially equals the speed of light, it will always remain the speed of light:

$\beta_0 = 1 \rightarrow \beta = 1$ for all t. (AI.15)

However, for small velocities this becomes:

$$\beta << 1 \rightarrow \beta \approx \beta_0 e^{-t/T} \rightarrow v \approx v_0 \cdot e^{-t/T} \qquad \text{(A1.16)}$$

This is the cosmic drag relation by which relative velocities of freely moving objects diminish over time. According to (AI.14) this relation also holds for relativistic velocities.

Similarly we find by setting $d\varphi=0$ in (A1.6) that the angular momentum decreases with time in the SEC. Proceeding as above we get:

$$r^2 \cdot \dot{\theta}^2 = \frac{r_0^4 \cdot \dot{\theta}_0^2 \cdot (1-\dot{r}^2) \cdot e^{-2t/T}}{r^2 \cdot [1-\dot{r}_0^2-(r_0 \cdot \dot{\theta}_0)^2] + r^4{}_0 \cdot \dot{\theta}_0^2 \cdot e^{-2t/T}} \qquad \text{(A1.17)}$$

For velocities much smaller than the speed of light this becomes:

$$r^2 \cdot \dot{\theta} = r_0^2 \cdot \dot{\theta}_0 \cdot e^{-t/T} \qquad \text{(AI.18)}$$

Angular momentums decrease exponentially over time in the SEC.

The length of a geodesic, L_r, for a freely moving particle with non-zero rest mass is finite and may be obtained by integrating (A1.13) from zero to infinity:

$$L_r = T \cdot \ln\left(\sqrt{\frac{1+\beta_0}{1-\beta_0}}\right) \qquad \text{(A1.19)}$$

According to relation (II.13) in the main text:

$$L_r = T \cdot \ln(1+z) \qquad \text{(A1.21)}$$

Therefore:

$$z+1 = \sqrt{\frac{1+\beta_0}{1-\beta_0}} \qquad \text{(AI.20)}$$

Thus the cosmological redshift after the source has come to complete rest equals its initial Doppler shift! It may be shown that the redshift remains the same while changing from Doppler shift to cosmological redshift.

In Minkowskian spacetime this motion would correspond to constant velocity (except for the loss of signal strength with increasing distance). This also shows that the expanding space absorbs kinetic energy in the SEC while four-dimensionally keeping the net energy constant via the slowing progression of time.

Appendix II: Ephemeris Time and Universal Time

Ephemeris Time (ET) is based on the motion of the Earth around the Sun while Universal Time (UT) is based on the rotation of the Earth. UT is essentially the same as solar time. ET drifts positive at an accelerating rate and will in one century advance by about 30 seconds relative to UT. This difference between ET and UT is usually explained as being caused by a slowing rotation of the Earth caused by tidal braking action due to gravitational influences from the Moon and the Sun.

However, with the SEC theory there could be another explanation since this theory predicts that the angular motion of the Earth around the Sun accelerates in proportion to exp(t/T) with t=atomic time and that the rotation of the Earth slows down in proportion to exp(-t/T). The difference between ET and UT could therefore be interpreted as being at least partly caused by cosmic drag.

The Sun's acceleration due to cosmic drag causes ephemeris time to accelerate relative to atomic time. For small time intervals t<<T we have:

$$(ET - AT)_{sun} = T_{eph} - t \approx t + \frac{\Delta t^2}{2T} - t = \frac{\Delta t^2}{2T} \quad \text{(AII.1)}$$

The spin-down of the Earth also contributes by:

$$(UT - AT)_{\text{Earth}} = -\frac{\Delta t^2}{2T} \quad \text{(AII.2)}$$

Together this gives:

$$\left(ET - UT\right)_{\text{Cosmic Drag}} = \frac{\Delta t^2}{T} \quad \text{(AII.3)}$$

With T=14 billion year this difference becomes 21 seconds per century and with T=10 billion years 30 seconds/cy.

In addition the Earth's rotation might slow down due to tidal friction, which could account for the remaining difference between this estimate and the actually observed 30 seconds/cy.

This suggests that the difference between ET and UT mainly could be due to cosmic drag rather than tidal friction.

Appendix III: Deriving Quantum Mechanics from General Relativity

In this appendix Quantum Mechanics (QM) is used instead of QT to denote the theory based on the Schrödinger equation (and Heisenberg's matrix approach).

The fact that the link between GR and QM has been missing ever since the beginning of the development of quantum theory suggests that this connection perhaps cannot be found within the four-dimensional spacetime of GR. However, this is not true because the derivation below is made using standard GR. In other words, the derivation does not use knowledge beyond current physics except in one respect; *it assumes that the metrical scale of spacetime for a particle oscillates.*

Although an inhabitant in the SEC may not locally experience the scale-expansion on a macroscopic level, the DIST process suggests that the scale of spacetime may oscillate, and this possibility became the starting point for this investigation. As we will see it leads to a link between GR and QM.

It requires the following three assumptions:

A1: The 4D scale of a particle confined to a small volume oscillates at the Compton frequency.

A2. The spacetime of a particle in motion may be modeled by the Minkowskian line-element modulated by an oscillating scale at the Compton frequency.

A3. The linear part of the Ricci scalar of GR for this oscillating line-element disappears.

These three assumptions allow QM to be derived from GR.

Consider the Minkowskian line-element with c=1 modulated by a dynamic scale:

$$ds^2 = e^{2g(t,x,y,z)}\left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(AIII.1)}$$

Let us assume that the function g(·) may be factored into a spatial and an oscillating temporal part:

$$ds^2 = e^{\mathrm{Re}\left(2C\cdot h(x,y,z)\right)\cdot e^{-i\omega t}}\left(dt^2 - dx^2 - dy^2 - dz^2\right) \text{ (AIII.2)}$$

The use of a complex exponent is to be interpreted as the real part, for example *exp(-iωt)* means *cos(ωt)* and *i ·exp(-iωt)* means *sin(ωt)*. The reason we can do this is that all relations derived in the following are linear so that their real and imaginary parts may be separated. The complex exponential also simplifies the derivation and leads to results familiar from QM.

In the following the label Re( ) is omitted.

Since the following derivation formally uses standard differential methods in 4D spacetime I will use the Lorentz transformation instead of Voigt's transformation (combined with scale adjustments), because SR with its Lorentz transformation is the best we can do in four dimensions. Also, this will demonstrate that a link between GR and QM exists even with currently known physics.

With these preliminaries let us first consider motion of a spatially confined volume modeled by the line-element (AIII.2). With constant velocity v in the x-direction the Lorentz transformation is with c=1:

$$\begin{aligned} x &= \gamma\left(x'-vt'\right) \\ t &= \gamma\left(t'-vx'\right) \\ \gamma &= \frac{1}{\sqrt{1-v^2}} \end{aligned} \qquad \text{(AIII.3)}$$

The modulating part of the exponent in the metric then becomes:

$$2Ce^{-i\omega t} \rightarrow 2Ce^{i\gamma\omega(vx'-t')} \qquad \text{(AIII.4)}$$

If the modulation is confined to a particle, the spatial modulation in (AIII.4) is reminiscent of the quantum mechanical wave function of a moving particle with wave number:

$$k = \gamma\omega v \qquad \text{(AIII.5)}$$

Thus, motion of a spatial volume with oscillating metrics has the effect of spatially modulating the phase of this oscillation.

Furthermore, every particle is associated with scale excitation at the relativistic Compton frequency given by:

$$\begin{aligned} m &= \mathrm{h}\gamma\omega = \mathrm{h}\varpi \\ \varpi &@\gamma\omega = 2\pi f \end{aligned} \qquad \text{(AIII.6)}$$

Since c=1 this relation is the familiar E=mc^2=hf where f is the relativistic Compton frequency.

The relationship between the momentum and the wave number is:

$$p = \mathrm{h}k = mv \qquad \text{(AIII.7)}$$

According to (AIII.4) motion would cause the Compton oscillation to become “phase modulated” and create a spatial wave in the metrical scale of spacetime, *exp(ikx)*.

Thus, if Compton oscillation in the scale of spacetime is associated with every particle this oscillation will during motion be accompanied by a metrical “matter-wave”. This would provide support for de Broglie’s two-wave idea. There is one “particle-wave” that could be the Compton oscillation associated with a particles motion in time, the other could be the deBroglie matter-wave associated with its motion in space. Both these quantum mechanical waves would then be modulations of the metrical scale of spacetime.

With this interpretation the quantum mechanical matter-wave is a relativistic phenomenon; it is a spatial wave in the metrical scale of spacetime induced by motion. Since the wave number of the matter-wave depends on the very high Compton frequency corresponding to a particle’s matter energy, this small relativistic effect becomes significant even at relatively low velocities.

This interpretation would resolve the wave-particle duality since these two aspects are inseparable; *the matter-wave is a direct consequence of the Compton oscillation and of a particle’s motion.*

The previously mysterious fact that a particle behaves both as a wave and a particle, might find its natural explanation. Traditionally we think of a “particle” as something material and indivisible, but this might be wrong. Particles could be nothing but standing wave oscillations in the spacetime metrics that are sustained by the cosmological scale-expansion. Motion in time (and scale) might induce their Compton oscillation. This new understanding would also obsolete Bohr’s Principle of Complementarity by providing an ontological explanation to the dual wave/particle nature.

Bohm and his followers have shown that a consistent quantum mechanical theory may be derived based on just three conditions:

C1. There exists a function, ψ (of unspecified ontology), which satisfies Schrödinger's wave equation.

C2. A particle’s momentum $\boldsymbol{p}$ satisfies the relation:

$$\boldsymbol{p} = \hbar \cdot Im \frac{\nabla \psi}{\psi} \qquad \text{(AIII.8)}$$

Im stands for the imaginary part. *This expression is often referred to as the deBroglie/Bohm “pilot function”.*

C3. The motion is subjected to random disturbance.

A link between GR and QM will now be established by demonstrating that these three conditions may be derived from GR if the metrical scale oscillates. I will first show that the pilot function may be derived from the geodesic relation of GR.

Consider the scaled Minkowskian line element with a general dynamic scale function ϕ:

$$ds^2 = \phi^2\left(t,x,y,z\right)\cdot\left(dt^2 - dx^2 - dy^2 - dz^2\right) \quad \text{(AIII.9)}$$

I will first show how the deBroglie/Bohm pilot-wave may be derived from the geodesic of GR. The geodesic equation of GR is:

$$\frac{d^2x^\mu}{ds^2} + \Gamma^\mu_{\nu\lambda}\frac{dx^\nu}{ds}\frac{dx^\lambda}{ds} = 0 \qquad \text{(AIII.10)}$$

For the x-coordinate this relation becomes with indices given by x^0=t, x^1=x, x^2=y and x^3=z:

$$\begin{aligned}\frac{d^2x}{ds^2} &= -\Gamma^1_{00}\left(\frac{dt}{ds}\right)^2 - \Gamma^1_{11}\left(\frac{dx}{ds}\right)^2 - \Gamma^1_{22}\left(\frac{dy}{ds}\right)^2 - \\ &-\Gamma^1_{33}\left(\frac{dz}{ds}\right)^2 - 2\Gamma^1_{10}\left(\frac{dt}{ds}\right)\left(\frac{dx}{ds}\right) - 2\Gamma^1_{12}\left(\frac{dx}{ds}\right)\left(\frac{dy}{ds}\right) - 2\Gamma^1_{13}\left(\frac{dx}{ds}\right)\left(\frac{dz}{ds}\right) = \\ &= -\Gamma^1_{00}\left(\frac{dt}{ds}\right)^2 + \Gamma^1_{11}\left(\frac{dx}{ds}\right)^2 - \Gamma^1_{22}\left(\frac{dy}{ds}\right)^2 - \\ &-\Gamma^1_{33}\left(\frac{dz}{ds}\right)^2 - 2\left(\frac{dx}{ds}\right)\left[\Gamma^1_{10}\left(\frac{dt}{ds}\right) + \Gamma^1_{11}\left(\frac{dx}{ds}\right) + \Gamma^1_{12}\left(\frac{dy}{ds}\right) + \Gamma^1_{13}\left(\frac{dz}{ds}\right)\right]\end{aligned} \quad \text{(AIII.11)}$$

We have:

$$\begin{aligned}\frac{d^2x}{ds^2} &= \frac{d}{ds}\left(\frac{dx}{dt}\frac{dt}{ds}\right) = \left[\frac{d}{dt}\left(\frac{dx}{dt}\frac{dt}{ds}\right)\right]\left(\frac{dt}{ds}\right) = \\ &\left(\frac{d^2x}{dt^2}\right)\left(\frac{dt}{ds}\right)^2 + \left(\frac{dx}{dt}\right)\left[\frac{d}{dt}\left(\frac{dt}{ds}\right)\right]\left(\frac{dt}{ds}\right)\end{aligned} \quad \text{(AIII.12)}$$

From the line element (AIII.9):

$$\frac{dt}{ds} = \frac{1}{\phi\sqrt{1-v^2}};\ \text{where } v = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2} \text{ and } \dot{x} = \frac{dx}{dt} \qquad \text{(AIII.13)}$$

The bracket factor in the last term of (AIII.4) therefore is:

$$\frac{d}{dt}\left(\frac{dt}{ds}\right) = -\frac{\dot{\phi}}{\phi^2\sqrt{1-v^2}} + \frac{v\cdot\dot{v}}{\phi\left(1-v^2\right)^{3/2}} = \left[-\frac{\dot{\phi}}{\phi} + \frac{v\cdot\dot{v}}{\left(1-v^2\right)^2}\right]\left(\frac{dt}{ds}\right) \qquad \text{(AIII.14)}$$

$$\dot{\phi} = \frac{d\phi}{dt}$$

We may get rid of the dependence on *s* by dividing all terms in the geodesic by $(dt/ds)^2$. Rewriting the last term of (AIII.12) by using (AIII.14):

$$\dot{x}\left[\frac{d}{dt}\left(\frac{dt}{ds}\right)\right]\left(\frac{dt}{ds}\right) = \left[-\frac{\dot{x}\dot{\phi}}{\phi} + \frac{\dot{x}v\dot{v}}{\left(1-v^2\right)}\right]\left(\frac{dt}{ds}\right)^2 \qquad \text{(AIII.15)}$$

The geodesic relation may now be written:

$$\left[\ddot{x} - \frac{\dot{x}\dot{\phi}}{\phi} + \frac{\dot{x}v\dot{v}}{\left(1-v^2\right)}\right]\left(\frac{dt}{ds}\right)^2 = \text{Right hand side of (AIII.11)} \qquad \text{(AIII.16)}$$

The right hand side may also be written:

$$-\begin{bmatrix}\Gamma^1_{00} - \Gamma^1_{11}\dot{x}^2 + \Gamma^1_{22}\dot{y}^2 + \Gamma^1_{33}\dot{z}^2 \\ +2\dot{x}\left\{\Gamma^1_{10} + \Gamma^1_{11}\dot{x} + \Gamma^1_{12}\dot{y} + \Gamma^1_{13}\dot{z}\right\}\end{bmatrix}\left(\frac{dt}{ds}\right)^2 \qquad \text{(AIII.17)}$$

The Christoffel symbols are:

$$\begin{aligned}&\Gamma^1_{00} = \Gamma^1_{11} = -\Gamma^1_{22} = -\Gamma^1_{33} = \frac{1}{\phi}\frac{\partial\phi}{\partial x} \\ &\Gamma^1_{12} = \frac{1}{\phi}\frac{\partial\phi}{\partial y}; \quad \Gamma^1_{13} = \frac{1}{\phi}\frac{\partial\phi}{\partial z}; \quad \Gamma^1_{10} = \frac{1}{\phi}\frac{\partial\phi}{\partial t}\end{aligned} \qquad \text{(AIII.18)}$$

Substituting this into the bracket of (AIII.17):

$$-\frac{1}{\phi}\begin{bmatrix} \dfrac{\partial\phi}{\partial x} - \dfrac{\partial\phi}{\partial x}\left(\dot x^2+\dot y^2+\dot z^2\right) \\ +2\dot x\left(\dfrac{\partial\phi}{dt}+\dfrac{\partial\phi}{\partial x}\dot x+\dfrac{\partial\phi}{\partial y}\dot y+\dfrac{\partial\phi}{\partial z}\dot z\right)\end{bmatrix} = -\frac{1}{\phi}\left[\frac{\partial\phi}{\partial x}\left(1-v^2\right)+2\dot x\dot\phi\right] \quad \text{(AIII.19)}$$

Together with (AIII.16) we get:

$$\ddot x + \frac{\dot x v\dot v}{\left(1-v^2\right)} = -\frac{1}{\phi}\left[\frac{\partial\phi}{\partial x}\left(1-v^2\right)+\dot x\dot\phi\right] \quad \text{(AIII.20a)}$$

Similarly for the other two components:

$$\ddot y + \frac{\dot y v\dot v}{\left(1-v^2\right)} = -\frac{1}{\phi}\left[\frac{\partial\phi}{\partial y}\left(1-v^2\right)+\dot y\dot\phi\right] \quad \text{(AIII.20b)}$$

$$\ddot z + \frac{\dot z v\dot v}{\left(1-v^2\right)} = -\frac{1}{\phi}\left[\frac{\partial\phi}{\partial z}\left(1-v^2\right)+\dot z\dot\phi\right] \quad \text{(AIII.20c)}$$

Combining these we get in vector notations:

$$\begin{gathered}\mathbf{v} = \left(\dot x, \dot y, \dot z\right) \\ \dot{\mathbf{v}} + \frac{\mathbf{v}\cdot v\dot v}{\left(1-v^2\right)} = -\frac{1}{\phi}\left[\nabla\phi\left(1-v^2\right)+\dot\phi\mathbf{v}\right]\end{gathered} \quad \text{(AIII.21a)}$$

Reintroducing c:

$$\dot{\mathbf{v}} + \frac{\mathbf{v}\cdot v\dot v}{\left(c^2-v^2\right)} = -\frac{1}{\phi}\left[\nabla\phi\left(c^2-v^2\right)+\dot\phi\mathbf{v}\right] \quad \text{(AIII.21b)}$$

Now consider the scale function and c=1:

$$\phi = e^{C\cdot h\cdot\exp^{-i\omega t}} \quad \text{(AIII.22)}$$

We get:

$$\dot{\mathbf{v}} + \frac{\mathbf{v}\cdot v\dot{\mathbf{v}}}{\left(1-v^2\right)} = -C\cdot h\cdot e^{-i\omega t}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\left(\frac{\dot{h}}{h}-i\omega\right)\mathbf{v}\right] \quad \text{(AIII.23)}$$

The very rapid modulation of the phase with changing velocity, -$\omega\boldsymbol{v}$, which is implied by the imaginary term within the bracket, disappears if:

$$\omega\mathbf{v} = \mathrm{Im}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}\mathbf{v}\right] \qquad \text{(AIII.24)}$$

Finally since $m = \omega\hbar$:

$$m\mathbf{v} = \mathbf{p} = \hbar\cdot\mathrm{Im}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}\mathbf{v}\right] \qquad \text{(AIII.25a)}$$

This is the relativistic version of the deBroglie-Bohm pilot wave function.

The last term in the bracket is very small if v<<c and we get then get the usual deBroglie-Bohm pilot wave function:

$$m\mathbf{v} = \mathbf{p} \approx \hbar\cdot\mathrm{Im}\left[\frac{\nabla h}{h}\right] \qquad \text{(AIII.25b)}$$

We also have:

$$\dot{\mathbf{v}} + \frac{\mathbf{v}\cdot v\dot{\mathbf{v}}}{\left(1-v^2\right)} = -C\cdot h\cdot e^{-i\omega t}\cdot\mathrm{Re}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}\cdot\mathbf{v}\right] \qquad \text{(AIII.26)}$$

According to the last relation there is random acceleration excitation.

Example: We saw that for motion in the x-direction we have:

$$h = e^{i\varpi xv};$$

$$mv = p = \hbar\cdot\mathrm{Im}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}v\right] = \hbar\cdot\left[\varpi v\left(1-v^2\right)+\varpi\frac{dx}{dt}\cdot v^2\right] = \hbar\varpi v = mv \qquad \text{(AIII.27)}$$

If the complex function h(x,y,z), which modulates the Compton oscillation, is proportional to the quantum mechanical wave function ψ, relation (AIII.25) *is the de Broglie/Bohm momentum relation, i.e. the "pilot function"[Bohm, 1952].* ***Therefore the pilot function may be derived from GR's geodesic relation.***

The two relations (AIII.25) and (AIII.26) speak volumes about the ontological nature of QM. If the metrical scale of a particle oscillates it will be subjected to cyclic disturbance that depends on the spatial scale function *h* that modulates the oscillation. And, the particle tends to move in the direction of increasing magnitudes for *h*. Also, this motion will disappear when the slope of *h* disappears, i. e. where ∇ h disappears. The particle converges toward peaks of the wave function.

This provides an ontological explanation to the deBroglie-Bohm's guiding function; it may be derived directly from the geodesic equation of GR if the spacetime of a particle oscillates at the Compton frequency. Thus, the previously mysterious "guiding action" without any applied force finds its physical explanation if a particle always is accompanied (and sustained) by oscillation of the spacetime metrical scale at the Compton frequency.

This fulfills conditions C2 and C3 with $h=\psi$.

The Schrödinger equation may also be derived from GR based on the assumption A4 the Ricci scalar for the line-element should disappear. This assumption is reasonable since it is satisfied if the energy-momentum tensor for vacuum disappears. (I will in this derivation ignore the small contribution from cosmological expansion.) A necessary (but not sufficient) condition for the Ricci scalar to disappear is a wave equation for the function *g* of (AIII.1) [Masreliez, 2005a]:

$$\Delta\big(g(t,x,y,z)\big)-\frac{\partial^2}{\partial t^2}\big(g(t,x,y,z)\big)=0 \qquad \text{(AIII.28)}$$

Here Δ is the Laplace operator. Consider the g-function:

$$g=C\cdot h\big(x,y,z\big)\cdot e^{-i(\omega+E/\mathrm{h})t}\cdot e^{i\varpi\left(\int(1+V/m)\mathbf{ds}\cdot\mathbf{n}\right.} \qquad \text{(AIII.29)}$$

As before the temporal oscillation is at the Compton frequency, and that this oscillation is confined to a small spatial volume.

The corresponding line-element is:

$$ds^2 = \exp\left[2\cdot C\cdot h\left(x,y,z\right)\cdot e^{-i\left(\omega+E/\hbar\right)t}\cdot e^{i\varpi\left(\oint\left(1+V/m\right)\mathbf{ds}\cdot\mathbf{n}\right)}\right]\left(dt^2-dx^2-dy^2-dz^2\right) \qquad \text{(AIII.30)}$$

In the line integral ***ds*** is a path increment vector and ***n*** a unity velocity vector corresponding to motion at the speed of light. This form may seem contrived but leads to the Schrödinger equation. Let's analyze it.

The energy E is assumed to be constant and may be seen as giving a frequency adjustment to the Compton oscillation, while the potential function $V(x,y,z)$ adjusts the phase of the deBroglie matter-wave. We will assume both these influences are much smaller than the mass energy:

$$\begin{aligned} E &<< \hbar\varpi = m \\ V &<< m \end{aligned} \qquad \text{(AIII.31)}$$

The line integral corresponds to the deBroglie matter-wave; **ds·n** corresponds to the product x·v in (AIII.4). The line element (AIII.30) therefore models motion that is influenced by a variations of the Compton frequency given by E and phase modulations of the deBroglie mater-wave given by V.

Replacing the line integral with a sum of segments indexed by i and assuming that the vectors $\mathbf{n_i}$ on these segments are constant:

$$I(x,y,z) = \oint\left(1+V/m\right)\cdot\mathbf{ds}\cdot\mathbf{n} = \sum_{x_0,y_0,z_0}^{x,y,z}\left(1+V/m\right)\left(\Delta x_i n_{xi} + \Delta y_i n_{yi} + \Delta z_i n_{zi}\right) \qquad \text{(AIII.32)}$$

If the intervals are small, differentiation of this sum with respect to x may be approximated by the contribution from the last term in the sum:

$$\frac{\partial I}{\partial x} \approx \frac{\Delta I(x,y,z)}{\Delta x} \approx \left(1+V/m\right)n_{xi} \qquad \text{(AIII.33)}$$

After a second differentiation of the exponent in the integral and adding the contributions from y and z we get the term:

$$\left(1+V/m\right)^2\left(n_x^2+n_y^2+n_z^2\right) = \left(1+V/m\right)^2 \qquad \text{(AIII.34)}$$

We therefore find, after carrying out the differentiations in (AIII.28) that the Ricci scalar disappears if the following two relations hold:

Terms not containing $\mathbf{n}_i$:

$$\nabla^2 h - \varpi^2\left[\left(1+\frac{V}{m}\right)^2 - \left(1+\frac{E}{\hbar\varpi}\right)^2\right]h = 0 \qquad \text{(AIII.35)}$$

Terms containing **$\mathbf{n_i}$**:

$$\varpi\left[2(1+\frac{V}{m})\cdot\frac{\nabla h}{h}+\frac{\nabla V}{m}\right]\cdot\mathbf{n}_i=0 \qquad \text{(AIII.36)}$$

Using (AIII.31) we have:

$$\left[1+\frac{V}{m}\right]^2=1+\frac{2V}{m}+\left(\frac{V}{m}\right)^2\approx 1+2\frac{V}{m} \quad \text{(AIII.37)}$$

$$\left[1+\frac{E}{\varpi\hbar}\right]^2=1+2\frac{E}{m}+\left(\frac{E}{m}\right)^2\approx 1+2\frac{E}{m} \qquad \text{(AIII.38)}$$

Substituting these in (AIII.32) we get the Schrödinger equation:

$$-\frac{\hbar^2}{2m}\nabla^2 h+\left(V-E\right)\cdot h=0 \qquad \text{(AIII.39)}$$

This derivation may easily be generalized to the situation where the wave function h also depends on time. We then get the additional terms:

$$\begin{aligned}&2i\left(\varpi+\frac{E}{\hbar}\right)\frac{\partial h}{\partial t}-\frac{\partial^2 h}{\partial t^2}\approx 2i\varpi\frac{\partial h}{\partial t}\\&-\frac{\hbar^2}{2m}\left(2i\varpi\frac{\partial h}{\partial t}\right)=-i\hbar\frac{\partial h}{\partial t}\end{aligned} \qquad \text{(AIII.40)}$$

Moving this term to the right hand side of (AIII.36)

$$-\frac{\hbar^2}{2m}\nabla^2 h+\left(V-E\right)\cdot h=i\hbar\frac{\partial h}{\partial t} \qquad \text{(AIII.41)}$$

This is the time dependent Schrödinger equation.

A similar derivation of the Schrödinger equation for the electromagnetic field may be found in [Masreliez, 2005].

The relation (AIII.32) does not depend on the velocity vectors n_i.

The Schrödinger equation applies regardless of a particle's motion.

Furthermore, if relation (AIII.3) is satisfied for n_i it is also satisfied for $-n_i$. Therefore, the Schrödinger equation applies even for a particle "at rest" subjected to back and forth motion. In other words, the mere presence of an oscillating volume (particle) at some location creates a response from its environment given by the wave functions of QM, which could be modulations of the metrics of spacetime. This may influence the subsequent motion of the particle, and since this influence takes place via the metrics it could be non-local, allowing instantaneous influences independent of separation distance.

In other words, Schrödinger equation does not model motion but models resonance conditions in the metrics of spacetime that depend on geometry, energies, and fields.

This development shows that if the scale of spacetime oscillates at the Compton frequency the Schrödinger equation is a necessary condition for the disappearance of the Ricci scalar of GR. The finding that the deBroglie-Bohm pilot function and the Schrödinger equation both may be derived from GR and that there also is random influence implies that Bohm's conditions C1, C2 and C3 are all satisfied.

In other words, QM may be derived from GR.

Furthermore, it suggests that the quantum mechanical wave functions may have physical meaning; they could correspond to modulation of the Compton oscillation of the scale of spacetime.

This would allow us to merge GR and QM into a single more complete theory, ending their century-long estrangement. The probabilistic interpretation of QM could then be abandoned in favor of new physics based on dynamic spacetime metrics. The behavior of the quantum world would no longer be something mysterious and probabilistic but would be a consequence of influences via the dynamic scale of spacetime exited by the cosmological scale expansion.

This implies a direct link between the QM and the SEC model.

Although you may appreciate this ontological explanation to quantum mechanics it must be admitted that it currently does not address several aspects of the quantum world, for example "spin", and it may therefore be ignored by mainstream experts who in the spirit of the Copenhagen school consider any ontological explanation unnecessary or even undesirable. But, like the epicycles of the past described the motions of the planets without giving any answer to the question "why", the currently popular purely mathematical, and probabilistic, approach to quantum theory (including string theory) may not contribute as much to our understanding of the world as even a simplistic ontological explanation will. When Copernicus presented his moving Earth model it did not model the motions of the planets with the same accuracy as the epicycles. However, it still became the preferred explanation because of its simplicity. The connection between QM and the SEC model might provide us with a deeper understanding of the world.

Einstein was right; God does not play dice.

Appendix IV: Speculation on the Nature of Motion

How does a particle move? Does it jump incrementally or does it change its dimensions and move like an inchworm? It turns out that Appendix III together with the explanation to the inertial force may offer a possible ontological explanation.

Consider again the 5D hyperspace line element:

$$ds^2 = u^2(dt^2 - dx^2 - dy^2 - dz^2) - (T \cdot du)^2 \quad \text{(AIV.1)}$$

We may think of the 4D SEC cosmos as moving in this 5D hyperspace space on a null-geodesic with the fifth dimension, u, playing the role of "time". This line-element has two terms. The last term disappears if u is constant and the 5D line-element then collapses into the line-element for scale-equivalent 4D spacetime. On the other hand, motion in the 4D spacetime at the speed of light will cause the first term to disappear allowing motion purely in the fifth dimension, which may model scale transition. Spatial motion at the speed of light implies that time stands still in 4D spacetime, which makes the scale transition appear instantaneous.

This suggests that the incremental scale transition of the DIST process might be associated with motion in 4D spacetime at the speed of light.

Chapter VI on motion suggests that the spacetime scale for an accelerating particle contracts by the inertial factor $1\text{-}v^2$, and that relative to a co-accelerating observer this scale is incrementally "reset" via the DIST process to keep the line-element locally Minkowskian.

Consider the hyperspace line-element:

$$ds^2 = u^2 \cdot (1 - v^2)(dt^2 - dx^2 - dy^2 - dz^2) - (T \cdot du)^2 \quad \text{(AIV.2)}$$

We may think of acceleration as occurring in two steps:

In the first step the scale contracts continuously via the inertial scale factor while the scale u remains constant *u=1 and du=0*. In this first step the world is 4D spacetime since the last term in (AIV.2) disappears. This step may be modeled by GR.

In the second step there is spatial transition at the speed of light while the scale adjusts $u \Rightarrow 1/(1-v^2)$ thus “resetting” the 4D scale to one. In this second step, which corresponds to the discrete scale transition in the DIST process, the first term equals zero and the motion is solely in scale.

We find that motion may take place by alternately switching between motion in spacetime and motion in the fifth scale-dimension.

This somewhat speculative ontological explanation would imply that all motion takes place via transitions both in 4D spacetime and in five-dimensional hyperspace. The reader familiar with Richard Feynman’s checkerboard approach to quantum theory may sense a connection here since he showed that random walks in space and time at the speed of light leads to Dirac’s famous equation for the electron.

http://en.wikipedia.org/wiki/Feynman_checkerboard

When deriving the Schrödinger equation in appendix III an increment of the line-integral (AIII.32) was expressed as the scalar product of a displacement vector, **ds**, and a unit velocity vector, **n**, which corresponds to motion at the speed of light. Dividing this line-element into number of short segments each modeling motion at the speed of light allowed the Schrödinger equation to be derived from GR.

However, with the 5D line-element (AIV.2) we now find that incremental motion at the speed of light may be associated with changes in the fifth dimension that resets the dynamic scale and models the discrete scale adjustment of the DIST process. As we saw this scale adjustment appears to be instantaneous to an observer. It is therefore possible that particles always move in tiny rapid steps at the speed of light combined with simultaneous scale adjustments, and that the velocity we observe macroscopically merely is the projection of all these numerous increments in the direction of motion. The DIST loop may coincide with the Compton oscillation, supporting the proposition that the Compton oscillation, which is associated with all particles, takes place in the scale of spacetime.

Since a displacement at the speed of light occurs instantaneously, the particle may be seen as being at two different locations in 4D spacetime at the same time. And, if the spatial displacement of each of these increments is comparable to the wavelength of the Compton oscillation it would be consistent with Heisenberg's uncertainty relation. This suggests the intriguing possibility that processes may exist in a 5D the universe that involves influences beyond 4D spacetime.

Chess is a game that plays out in two dimensions. However, moving a piece makes use of the third dimension. Similarly the geometry of the world is four-dimensional but motion in this 4D world may take place via a fifth dimension. In 4D spacetime motion may seem mysterious since it involves instantaneous quantum jumps but in 5D hyperspace it becomes understandable because a seemingly "instantaneous" change in location may take place via motion in the fifth dimension. It appears that the fifth dimension is not merely a piece of nice mathematics but might be as real as any of the four dimensions of spacetime.

This explanation may seem a bit speculative, but we cannot move beyond known physics without some speculation.

Appendix V: Deriving the inertial scale factor

Consider the scaled Minkowskian line element with c=1:

$$ds^2 = \phi^2\left(x,y,z\right)\cdot\left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(AV.1)}$$

Proceeding as in Appendix III we derive (AIII.21) from the geodesic relation for the line-element above:

Multiplying this with the velocity **v** and noting that since ϕ is not a function of t:

$$\nabla\phi\cdot\boldsymbol{v} = \dot{\phi} \qquad \text{(AV.3)}$$

(AV.2) becomes:

$$v\dot{v} + \frac{v^3\dot{v}}{\left(1-v^2\right)} = -\frac{1}{\phi}\left[\dot{\phi}\left(1-v^2\right) + \dot{\phi}v^2\right] = -\frac{\dot{\phi}}{\phi}$$

$$\frac{v\dot{v}}{\left(1-v^2\right)} = -\frac{\dot{\phi}}{\phi} \qquad \text{(AV.4)}$$

This is relation is *identically* satisfied by the *inertial metric*:

$$\phi = \text{constant} \cdot \sqrt{1 - v^2} \qquad \text{(AV.5)}$$

Substituting the inertial metric into (AV.2):

$$\dot{v} = v \cdot \nabla v \qquad \text{(AV.6)}$$

Therefore the geodesic acceleration for the inertial line element satisfies:

$$\boldsymbol{a} = \dot{v} = grad\left(\frac{v^2}{2}\right) = \nabla\left(\frac{v^2}{2}\right) \qquad \text{(AV.7)}$$

This relation always holds for acceleration in any coordinate representation since the gradient vector is covariant. This geodesic acceleration equals the gradient of the *inertial field potential* $v^2/2$.

The *inertial line* element becomes:

$$ds^2 = \left(1 - v^2\right) \cdot \left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(AV.8)}$$

The acceleration in (AV.7) is caused by an applied force *F*. We have from (AV.7):

$$E = \int F \cdot ds = \int ma \cdot ds = \int m\nabla\left(\frac{v^2}{2}\right) \cdot ds = \left(\frac{mv^2}{2}\right) \qquad \text{(AV.9)}$$

The derivation in this appendix shows that the acceleration in (AV.7) is gravitational in nature, and that it is a consequence of the inertial line-element (AV.8). Kinetic energy is induced by spacetime curvature caused by the inertial metric (AV.5).

Ultimately kinetic energy, as well as inertia, is due to hyperspace curvature, which alters the local 4D spacetime in 5D hyperspace.

As an example consider rotational motion with fixed radius of the Minkowskian frame modeled by:

$$x = r\cos(\omega t);\; y = r\sin(\omega t))$$

$$\dot{x} = -r\omega\sin(\omega t) = -\omega y; \qquad \dot{y} = r\omega\cos(\omega t) = \omega x$$

$$v^2 = \dot{x}^2 + \dot{y}^2 = \omega^2\left(y^2 + x^2\right)$$

We get:

$$a_x = \frac{\omega^2}{2}\frac{\partial\left(y^2 + x^2\right)}{\partial x} = \omega^2 x; \quad a_y = \omega^2 y \qquad \text{(AV.10)}$$

$$|a| = \sqrt{a_x^{\,2} + a_y^{\,2}} = \omega^2 r = \text{centrifugal acceleration}$$

Spherical or cylindrical coordinates immediately yield:

$$a_r = \frac{1}{2}\frac{\partial v^2}{\partial r} = \frac{1}{2}\frac{\partial\left(\omega r\right)^2}{\partial r} = \omega^2 r \qquad \text{(AV.11)}$$

Thus, with the inertial scale metric (reintroducing c) $1\text{-}(v/c)^2$ the centrifugal acceleration equals the geodesic acceleration. This demonstrates how circular motion of an inertially scaled Minkowskian frame generates a gravitational-type inertial force. And, as was shown in the text, the inertial metric is a relative phenomenon that applies to all line-elements for objects in relative motion. Therefore all motions make use of the fifth scale-dimension!

This is new physics.

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APPENDICES

Appendix I: Deriving the free geodesic in the SEC and Cosmic Drag

The General Relativity geodesic relations are given by:

$$\frac{d^2x_\alpha}{ds^2} + \Gamma^\alpha_{\mu\nu} \cdot \frac{dx_\mu}{ds}\frac{dx_\nu}{ds} = 0 \qquad \text{(A1.1)}$$

Consider the SEC line-element:

$$ds^2 = e^{2t/T}(dt^2 - dr^2 - r^2 d\theta^2 - r^2\sin^2(\theta)d\varphi^2) \qquad \text{(AI.2)}$$

The Christoffel symbols $\Gamma^\alpha_{\mu\nu}$ are:

$$\begin{array}{llll} \Gamma^0_{00} = 1/T; & \Gamma^0_{11} = 1/T; & \Gamma^0_{22} = r^2/T; & \Gamma^0_{33} = r^2\cdot\sin^2(\theta)/T \\ \Gamma^1_{01} = \Gamma^1_{10} = 1/T & & \Gamma^1_{22} = -r & \Gamma^1_{33} == r\sin^2(\theta) \\ \Gamma^2_{02} = \Gamma^2_{20} = 1/T & & \Gamma^2_{12} = \Gamma^2_{21} = 1/r & \Gamma^2_{33} = -\sin(\theta)\cos(\theta) \\ \Gamma^3_{03} = \Gamma^3_{30} = 1/T & & \Gamma^3_{13} = \Gamma^3_{31} = 1/r & \Gamma^3_{23} = \Gamma^3_{32} = \cos(\theta)/\sin(\theta) \end{array} \qquad \text{(A1.3)}$$

All other Christoffel symbols are zero. The geodesic equations are:

$$\frac{d^2t}{ds^2} = -\frac{1}{T}[(\frac{dt}{ds})^2 + (\frac{dr}{ds})^2 + r^2\cdot(\frac{d\theta}{ds})^2 + r^2\cdot\sin^2(\theta)\cdot(\frac{d\varphi}{ds})^2] \qquad \text{(A1.4)}$$

$$\frac{d^2r}{ds^2} = -\frac{2}{T}(\frac{dt}{ds})(\frac{dr}{ds}) + r\cdot(\frac{d\theta}{ds})^2 + r\cdot\sin^2(\theta)\cdot(\frac{d\varphi}{ds})^2 \qquad \text{(A1.5)}$$

$$\frac{d^2\theta}{ds^2} = -\frac{2}{T}(\frac{dt}{ds})(\frac{d\theta}{ds}) - \frac{2}{r}\cdot(\frac{d\theta}{ds})(\frac{dr}{ds}) + \sin(\theta)\cdot\cos(\theta)\cdot(\frac{d\varphi}{ds}) \qquad \text{(A1.6)}$$

$$\frac{d^2\varphi}{ds^2} = -\frac{2}{T}(\frac{dt}{ds})(\frac{d\varphi}{ds}) \ -\frac{2}{r}\cdot(\frac{d\varphi}{ds})(\frac{dr}{ds}) - 2\cdot\frac{\cos(\theta)}{\sin(\theta)}\cdot(\frac{d\varphi}{ds})(\frac{d\theta}{ds}) \qquad \text{(A1.7)}$$

The first terms on the right hand side model a new physical phenomenon – "Cosmic Drag".

For the radial geodesic with $d\Theta=d\varphi=0$ relation (AI.5) becomes:

$$\frac{d^2r}{ds^2} = -\frac{2}{T}\frac{dr}{ds}\frac{dt}{ds} \qquad \text{(AI.8)}$$

Integrating with K as an integration constant:

$$\frac{dr}{ds} = K\cdot e^{-2t/T} \quad \text{(AI.9)}$$

Setting $\beta=(dr/dt)/c$ we get from the line-element:

$$\frac{ds}{dt} = e^{t/T}\sqrt{1-\beta^2} \qquad \text{(AI.10)}$$

From this and (AI.9) we have:

$$\frac{dr}{ds} = \frac{dr}{dt}\frac{dt}{ds} = \frac{\beta}{\sqrt{1-\beta^2}}e^{-t/T} = K\cdot e^{-2/T} \quad \text{(AI.11)}$$

Where K is given by:

$$K = \frac{\beta_0}{\sqrt{1-\beta_0^{\,2}}} \quad \text{(AI.12)}$$

Solving for β:

$$\beta = \frac{\beta_0\cdot e^{-t/T}}{\sqrt{1-\beta_0^2+\beta_0^2\cdot e^{-2t/T}}} \qquad \text{(A1.13)}$$

β is the velocity of a free particle on a geodesic in the SEC.

Note also that:

$$\frac{\beta}{\sqrt{1-\beta^2}} = \frac{\beta_0}{\sqrt{1-\beta_0^2}}e^{-t/T} \qquad \text{(AI.14)}$$

The "relativistic velocity" decreases exponentially with time in the SEC.

If the velocity of a particle initially equals the speed of light, it will always remain the speed of light:

$\beta_0 = 1 \rightarrow \beta = 1$ for all t. (AI.15)

However, for small velocities this becomes:

$$\beta << 1 \rightarrow \beta \approx \beta_0 e^{-t/T} \rightarrow v \approx v_0 \cdot e^{-t/T} \qquad \text{(A1.16)}$$

This is the cosmic drag relation by which relative velocities of freely moving objects diminish over time. According to (AI.14) this relation also holds for relativistic velocities.

Similarly we find by setting $d\varphi=0$ in (A1.6) that the angular momentum decreases with time in the SEC. Proceeding as above we get:

$$r^2 \cdot \dot{\theta}^2 = \frac{r_0^4 \cdot \dot{\theta}_0^2 \cdot (1-\dot{r}^2) \cdot e^{-2t/T}}{r^2 \cdot [1-\dot{r}_0^2 - (r_0 \cdot \dot{\theta}_0)^2] + r^4{}_0 \cdot \dot{\theta}_0^2 \cdot e^{-2t/T}} \qquad \text{(A1.17)}$$

For velocities much smaller than the speed of light this becomes:

$$r^2 \cdot \dot{\theta} = r_0^2 \cdot \dot{\theta}_0 \cdot e^{-t/T} \qquad \text{(AI.18)}$$

Angular momentums decrease exponentially over time in the SEC.

The length of a geodesic, L_r, for a freely moving particle with non-zero rest mass is finite and may be obtained by integrating (A1.13) from zero to infinity:

$$L_r = T \cdot \ln\left(\sqrt{\frac{1+\beta_0}{1-\beta_0}}\right) \qquad \text{(A1.19)}$$

According to relation (II.13) in the main text:

$$L_r = T \cdot \ln(1+z) \qquad \text{(A1.21)}$$

Therefore:

$$z+1 = \sqrt{\frac{1+\beta_0}{1-\beta_0}} \qquad \text{(AI.20)}$$

Thus the cosmological redshift after the source has come to complete rest equals its initial Doppler shift! It may be shown that the redshift remains the same while changing from Doppler shift to cosmological redshift.

In Minkowskian spacetime this motion would correspond to constant velocity (except for the loss of signal strength with increasing distance). This also shows that the expanding space absorbs kinetic energy in the SEC while four-dimensionally keeping the net energy constant via the slowing progression of time.

Appendix II: Ephemeris Time and Universal Time

Ephemeris Time (ET) is based on the motion of the Earth around the Sun while Universal Time (UT) is based on the rotation of the Earth. UT is essentially the same as solar time. ET drifts positive at an accelerating rate and will in one century advance by about 30 seconds relative to UT. This difference between ET and UT is usually explained as being caused by a slowing rotation of the Earth caused by tidal braking action due to gravitational influences from the Moon and the Sun.

However, with the SEC theory there could be another explanation since this theory predicts that the angular motion of the Earth around the Sun accelerates in proportion to exp(t/T) with t=atomic time and that the rotation of the Earth slows down in proportion to exp(-t/T). The difference between ET and UT could therefore be interpreted as being at least partly caused by cosmic drag.

The Sun's acceleration due to cosmic drag causes ephemeris time to accelerate relative to atomic time. For small time intervals t<<T we have:

$$(ET - AT)_{sun} = T_{eph} - t \approx t + \frac{\Delta t^2}{2T} - t = \frac{\Delta t^2}{2T} \qquad \text{(AII.1)}$$

The spin-down of the Earth also contributes by:

$$(UT - AT)_{\text{Earth}} = -\frac{\Delta t^2}{2T} \qquad \text{(AII.2)}$$

Together this gives:

$$\left(ET - UT\right)_{\text{Cosmic Drag}} = \frac{\Delta t^2}{T} \qquad \text{(AII.3)}$$

With T=14 billion year this difference becomes 21 seconds per century and with T=10 billion years 30 seconds/cy.

In addition the Earth's rotation might slow down due to tidal friction, which could account for the remaining difference between this estimate and the actually observed 30 seconds/cy.

This suggests that the difference between ET and UT mainly could be due to cosmic drag rather than tidal friction.

Appendix III: Deriving Quantum Mechanics from General Relativity

In this appendix Quantum Mechanics (QM) is used instead of QT to denote the theory based on the Schrödinger equation (and Heisenberg's matrix approach).

The fact that the link between GR and QM has been missing ever since the beginning of the development of quantum theory suggests that this connection perhaps cannot be found within the four-dimensional spacetime of GR. However, this is not true because the derivation below is made using standard GR. In other words, the derivation does not use knowledge beyond current physics except in one respect; *it assumes that the metrical scale of spacetime for a particle oscillates.*

Although an inhabitant in the SEC may not locally experience the scale-expansion on a macroscopic level, the DIST process suggests that the scale of spacetime may oscillate, and this possibility became the starting point for this investigation. As we will see it leads to a link between GR and QM. It requires the following three assumptions:

A1: The 4D scale of a particle confined to a small volume oscillates at the Compton frequency.

A2. The spacetime of a particle in motion may be modeled by the Minkowskian line-element modulated by an oscillating scale at the Compton frequency.

A3. The linear part of the Ricci scalar of GR for this oscillating line-element disappears.

These three assumptions allow QM to be derived from GR.

Consider the Minkowskian line-element with c=1 modulated by a dynamic scale:

$$ds^2 = e^{2g(t,x,y,z)}\left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(AIII.1)}$$

Let us assume that the function g(·) may be factored into a spatial and an oscillating temporal part:

$$ds^2 = e^{\mathrm{Re}\left(2C\cdot h(x,y,z)\right)\cdot e^{-i\omega t}}\left(dt^2 - dx^2 - dy^2 - dz^2\right) \quad \text{(AIII.2)}$$

The use of a complex exponent is to be interpreted as the real part, for example *exp(-iωt)* means *cos(ωt)* and *i ·exp(-iωt)* means *sin(ωt)*. The reason we can do this is that all relations derived in the following are linear so that their real and imaginary parts may be separated. The complex exponential also simplifies the derivation and leads to results familiar from QM.

In the following the label Re( ) is omitted.

Since the following derivation formally uses standard differential methods in 4D spacetime I will use the Lorentz transformation instead of Voigt's transformation (combined with scale adjustments), because SR with its Lorentz transformation is the best we can do in four dimensions. Also, this will demonstrate that a link between GR and QM exists even with currently known physics.

With these preliminaries let us first consider motion of a spatially confined volume modeled by the line-element (AIII.2). With constant velocity v in the x-direction the Lorentz transformation is with c=1:

$$\begin{aligned} x &= \gamma\left(x' - vt'\right) \\ t &= \gamma\left(t' - vx'\right) \qquad \text{(AIII.3)} \\ \gamma &= \frac{1}{\sqrt{1-v^2}} \end{aligned}$$

The modulating part of the exponent in the metric then becomes:

$$2Ce^{-i\omega t} \rightarrow 2Ce^{i\gamma\omega(vx'-t')} \qquad \text{(AIII.4)}$$

If the modulation is confined to a particle, the spatial modulation in (AIII.4) is reminiscent of the quantum mechanical wave function of a moving particle with wave number:

$$k = \gamma\omega v \qquad \text{(AIII.5)}$$

Thus, motion of a spatial volume with oscillating metrics has the effect of spatially modulating the phase of this oscillation.

Furthermore, every particle is associated with scale excitation at the relativistic Compton frequency given by:

$$\begin{aligned} m &= \mathrm{h}\gamma\omega = \mathrm{h}\varpi \\ \varpi &\cong \gamma\omega = 2\pi f \qquad \text{(AIII.6)} \end{aligned}$$

Since c=1 this relation is the familiar $E=mc^2=hf$ where f is the relativistic Compton frequency.

The relationship between the momentum and the wave number is:

$$p = \mathrm{h}k = mv \qquad \text{(AIII.7)}$$

According to (AIII.4) motion would cause the Compton oscillation to become "phase modulated" and create a spatial wave in the metrical scale of spacetime, *exp(ikx)*.

Thus, if Compton oscillation in the scale of spacetime is associated with every particle this oscillation will during motion be accompanied by a metrical "matter-wave". This would provide support for de Broglie's two-wave idea. There is one "particle-wave" that could be the Compton oscillation associated with a particles motion in time, the other could be the deBroglie matter-wave associated with its motion in space. Both these quantum mechanical waves would then be modulations of the metrical scale of spacetime.

With this interpretation the quantum mechanical matter-wave is a relativistic phenomenon; it is a spatial wave in the metrical scale of spacetime induced by motion. Since the wave number of the matter-wave depends on the very high Compton frequency corresponding to a particle's matter energy, this small relativistic effect becomes significant even at relatively low velocities.

This interpretation would resolve the wave-particle duality since these two aspects are inseparable; *the matter-wave is a direct consequence of the Compton oscillation and of a particle's motion.*

The previously mysterious fact that a particle behaves both as a wave and a particle, might find its natural explanation. Traditionally we think of a "particle" as something material and indivisible, but this might be wrong. Particles could be nothing but standing wave oscillations in the spacetime metrics that are sustained by the cosmological scale-expansion. Motion in time (and scale) might induce their Compton oscillation. This new understanding would also obsolete Bohr's Principle of Complementarity by providing an ontological explanation to the dual wave/particle nature.

Bohm and his followers have shown that a consistent quantum mechanical theory may be derived based on just three conditions:

C1. There exists a function, ψ (of unspecified ontology), which satisfies Schrödinger's wave equation.

C2. A particle's momentum $\boldsymbol{p}$ satisfies the relation:

$$\boldsymbol{p} = \mathrm{h} \cdot Im \frac{\nabla \psi}{\psi} \qquad \text{(AIII.8)}$$

Im stands for the imaginary part. *This expression is often referred to as the deBroglie/Bohm "pilot function".*

C3. The motion is subjected to random disturbance.

A link between GR and QM will now be established by demonstrating that these three conditions may be derived from GR if the metrical scale oscillates. I will first show that the pilot function may be derived from the geodesic relation of GR.

Consider the scaled Minkowskian line element with a general dynamic scale function ϕ:

$$ds^2 = \phi^2(t,x,y,z)\cdot\left(dt^2 - dx^2 - dy^2 - dz^2\right) \quad \text{(AIII.9)}$$

I will first show how the deBroglie/Bohm pilot-wave may be derived from the geodesic of GR. The geodesic equation of GR is:

$$\frac{d^2x^\mu}{ds^2} + \Gamma^\mu_{\nu\lambda}\frac{dx^\nu}{ds}\frac{dx^\lambda}{ds} = 0 \qquad \text{(AIII.10)}$$

For the x-coordinate this relation becomes with indices given by $x^0=t$, $x^1=x$, $x^2=y$ and $x^3=z$:

$$\begin{aligned}
\frac{d^2x}{ds^2} &= -\Gamma^1_{00}\left(\frac{dt}{ds}\right)^2 - \Gamma^1_{11}\left(\frac{dx}{ds}\right)^2 - \Gamma^1_{22}\left(\frac{dy}{ds}\right)^2 - \\
&-\Gamma^1_{33}\left(\frac{dz}{ds}\right)^2 - 2\Gamma^1_{10}\left(\frac{dt}{ds}\right)\left(\frac{dx}{ds}\right) - 2\Gamma^1_{12}\left(\frac{dx}{ds}\right)\left(\frac{dy}{ds}\right) - 2\Gamma^1_{13}\left(\frac{dx}{ds}\right)\left(\frac{dz}{ds}\right) = \\
&= -\Gamma^1_{00}\left(\frac{dt}{ds}\right)^2 + \Gamma^1_{11}\left(\frac{dx}{ds}\right)^2 - \Gamma^1_{22}\left(\frac{dy}{ds}\right)^2 - \\
&-\Gamma^1_{33}\left(\frac{dz}{ds}\right)^2 - 2\left(\frac{dx}{ds}\right)\left[\Gamma^1_{10}\left(\frac{dt}{ds}\right) + \Gamma^1_{11}\left(\frac{dx}{ds}\right) + \Gamma^1_{12}\left(\frac{dy}{ds}\right) + \Gamma^1_{13}\left(\frac{dz}{ds}\right)\right]
\end{aligned} \quad \text{(AIII.11)}$$

We have:

$$\begin{aligned}
\frac{d^2x}{ds^2} &= \frac{d}{ds}\left(\frac{dx}{dt}\frac{dt}{ds}\right) = \left[\frac{d}{dt}\left(\frac{dx}{dt}\frac{dt}{ds}\right)\right]\left(\frac{dt}{ds}\right) = \\
&\left(\frac{d^2x}{dt^2}\right)\left(\frac{dt}{ds}\right)^2 + \left(\frac{dx}{dt}\right)\left[\frac{d}{dt}\left(\frac{dt}{ds}\right)\right]\left(\frac{dt}{ds}\right)
\end{aligned} \quad \text{(AIII.12)}$$

From the line element (AIII.9):

$$\frac{dt}{ds} = \frac{1}{\phi\sqrt{1-v^2}}; \text{ where } v = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2} \text{ and } \dot{x} = \frac{dx}{dt} \qquad \text{(AIII.13)}$$

The bracket factor in the last term of (AIII.4) therefore is:

$$\frac{d}{dt}\left(\frac{dt}{ds}\right) = -\frac{\dot{\phi}}{\phi^2\sqrt{1-v^2}} + \frac{v\cdot\dot{v}}{\phi\left(1-v^2\right)^{3/2}} = \left[-\frac{\dot{\phi}}{\phi} + \frac{v\cdot\dot{v}}{\left(1-v^2\right)^2}\right]\left(\frac{dt}{ds}\right) \qquad \text{(AIII.14)}$$

$$\dot{\phi} = \frac{d\phi}{dt}$$

We may get rid of the dependence on s by dividing all terms in the geodesic by $(dt/ds)^2$. Rewriting the last term of (AIII.12) by using (AIII.14):

$$\dot{x}\left[\frac{d}{dt}\left(\frac{dt}{ds}\right)\right]\left(\frac{dt}{ds}\right) = \left[-\frac{\dot{x}\dot{\phi}}{\phi} + \frac{\dot{x}v\dot{v}}{\left(1-v^2\right)}\right]\left(\frac{dt}{ds}\right)^2 \qquad \text{(AIII.15)}$$

The geodesic relation may now be written:

$$\left[\ddot{x} - \frac{\dot{x}\dot{\phi}}{\phi} + \frac{\dot{x}v\dot{v}}{\left(1-v^2\right)}\right]\left(\frac{dt}{ds}\right)^2 = \text{Right hand side of (AIII.11)} \qquad \text{(AIII.16)}$$

The right hand side may also be written:

$$-\begin{bmatrix}\Gamma^1_{00} - \Gamma^1_{11}\dot{x}^2 + \Gamma^1_{22}\dot{y}^2 + \Gamma^1_{33}\dot{z}^2 \\ +2\dot{x}\left\{\Gamma^1_{10} + \Gamma^1_{11}\dot{x} + \Gamma^1_{12}\dot{y} + \Gamma^1_{13}\dot{z}\right\}\end{bmatrix}\left(\frac{dt}{ds}\right)^2 \qquad \text{(AIII.17)}$$

The Christoffel symbols are:

$$\begin{aligned}&\Gamma^1_{00} = \Gamma^1_{11} = -\Gamma^1_{22} = -\Gamma^1_{33} = \frac{1}{\phi}\frac{\partial\phi}{\partial x}\\ &\Gamma^1_{12} = \frac{1}{\phi}\frac{\partial\phi}{\partial y}; \quad \Gamma^1_{13} = \frac{1}{\phi}\frac{\partial\phi}{\partial z}; \quad \Gamma^1_{10} = \frac{1}{\phi}\frac{\partial\phi}{\partial t}\end{aligned} \qquad \text{(AIII.18)}$$

Substituting this into the bracket of (AIII.17):

$$-\frac{1}{\phi}\left[\begin{array}{l}\frac{\partial\phi}{\partial x}-\frac{\partial\phi}{\partial x}\left(\dot{x}^2+\dot{y}^2+\dot{z}^2\right)\\ +2\dot{x}\left(\frac{\partial\phi}{dt}+\frac{\partial\phi}{\partial x}\dot{x}+\frac{\partial\phi}{\partial y}\dot{y}+\frac{\partial\phi}{\partial z}\dot{z}\right)\end{array}\right]= \tag{AIII.19}$$

$$-\frac{1}{\phi}\left[\frac{\partial\phi}{\partial x}\left(1-v^2\right)+2\dot{x}\dot{\phi}\right]$$

Together with (AIII.16) we get:

$$\ddot{x}+\frac{\dot{x}v\dot{v}}{\left(1-v^2\right)}=-\frac{1}{\phi}\left[\frac{\partial\phi}{\partial x}\left(1-v^2\right)+\dot{x}\dot{\phi}\right] \tag{AIII.20a}$$

Similarly for the other two components:

$$\ddot{y}+\frac{\dot{y}v\dot{v}}{\left(1-v^2\right)}=-\frac{1}{\phi}\left[\frac{\partial\phi}{\partial y}\left(1-v^2\right)+\dot{y}\dot{\phi}\right] \tag{AIII.20b}$$

$$\ddot{z}+\frac{\dot{z}v\dot{v}}{\left(1-v^2\right)}=-\frac{1}{\phi}\left[\frac{\partial\phi}{\partial z}\left(1-v^2\right)+\dot{z}\dot{\phi}\right] \tag{AIII.20c}$$

Combining these we get in vector notations:

$$\begin{array}{l}\mathbf{v}=\left(\dot{x},\dot{y},\dot{z}\right)\\ \dot{\mathbf{v}}+\frac{\mathbf{v}\cdot v\dot{v}}{\left(1-v^2\right)}=-\frac{1}{\phi}\left[\nabla\phi\left(1-v^2\right)+\dot{\phi}\mathbf{v}\right]\end{array} \tag{AIII.21a}$$

Reintroducing c:

$$\dot{\mathbf{v}}+\frac{\mathbf{v}\cdot v\dot{v}}{\left(c^2-v^2\right)}=-\frac{1}{\phi}\left[\nabla\phi\left(c^2-v^2\right)+\dot{\phi}\mathbf{v}\right] \tag{AIII.21b}$$

Now consider the scale function and c=1:

$$\phi=e^{C\cdot h\cdot\exp^{-i\omega t}} \tag{AIII.22}$$

We get:

$$\dot{\mathbf{v}} + \frac{\mathbf{v}\cdot v\dot{v}}{\left(1-v^2\right)} = -C\cdot h\cdot e^{-i\omega t}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\left(\frac{\dot{h}}{h}-i\omega\right)\mathbf{v}\right] \quad \text{(AIII.23)}$$

The very rapid modulation of the phase with changing velocity, -$\omega\boldsymbol{v}$, which is implied by the imaginary term within the bracket, disappears if:

$$\omega\mathbf{v} = \text{Im}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}\mathbf{v}\right] \qquad \text{(AIII.24)}$$

Finally since $m = \omega\hbar$:

$$m\mathbf{v} = \mathbf{p} = \hbar\cdot\text{Im}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}\mathbf{v}\right] \qquad \text{(AIII.25a)}$$

This is the relativistic version of the deBroglie-Bohm pilot wave function.

The last term in the bracket is very small if v<<c and we get then get the usual deBroglie-Bohm pilot wave function:

$$m\mathbf{v} = \mathbf{p} \approx \hbar\cdot\text{Im}\left[\frac{\nabla h}{h}\right] \qquad \text{(AIII.25b)}$$

We also have:

$$\dot{\mathbf{v}} + \frac{\mathbf{v}\cdot v\dot{v}}{\left(1-v^2\right)} = -C\cdot h\cdot e^{-i\omega t}\cdot\text{Re}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}\cdot\mathbf{v}\right] \qquad \text{(AIII.26)}$$

According to the last relation there is random acceleration excitation.

Example: We saw that for motion in the x-direction we have:

$$h = e^{i\varpi xv};$$

$$mv = p = \hbar\cdot\text{Im}\left[\frac{\nabla h}{h}\left(1-v^2\right)+\frac{\dot{h}}{h}v\right] = \hbar\cdot\left[\varpi v\left(1-v^2\right)+\varpi\frac{dx}{dt}\cdot v^2\right] = \hbar\varpi v = mv \qquad \text{(AIII.27)}$$

If the complex function h(x,y,z), which modulates the Compton oscillation, is proportional to the quantum mechanical wave function ψ, relation (AIII.25) *is the de Broglie/Bohm momentum relation, i.e. the "pilot function"[Bohm, 1952].* ***Therefore the pilot function may be derived from GR's geodesic relation.***

The two relations (AIII.25) and (AIII.26) speak volumes about the ontological nature of QM. If the metrical scale of a particle oscillates it will be subjected to cyclic disturbance that depends on the spatial scale function *h* that modulates the oscillation. And, the particle tends to move in the direction of increasing magnitudes for *h*. Also, this motion will disappear when the slope of *h* disappears, i. e. where ∇h disappears. The particle converges toward peaks of the wave function.

This provides an ontological explanation to the deBroglie-Bohm's guiding function; it may be derived directly from the geodesic equation of GR if the spacetime of a particle oscillates at the Compton frequency. Thus, the previously mysterious "guiding action" without any applied force finds its physical explanation if a particle always is accompanied (and sustained) by oscillation of the spacetime metrical scale at the Compton frequency.

This fulfills conditions C2 and C3 with $h=\psi$.

The Schrödinger equation may also be derived from GR based on the assumption A4 the Ricci scalar for the line-element should disappear. This assumption is reasonable since it is satisfied if the energy-momentum tensor for vacuum disappears. (I will in this derivation ignore the small contribution from cosmological expansion.) A necessary (but not sufficient) condition for the Ricci scalar to disappear is a wave equation for the function *g* of (AIII.1) [Masreliez, 2005a]:

$$\Delta\left(g(t,x,y,z)\right)-\frac{\partial^2}{\partial t^2}\left(g(t,x,y,z)\right)=0 \qquad \text{(AIII.28)}$$

Here Δ is the Laplace operator. Consider the g-function:

$$g=C\cdot h\left(x,y,z\right)\cdot e^{-i(\omega+E/\text{h})t}\cdot e^{i\varpi\left(\int(1+V/m)\mathbf{ds}\cdot\mathbf{n}\right.} \qquad \text{(AIII.29)}$$

As before the temporal oscillation is at the Compton frequency, and that this oscillation is confined to a small spatial volume.

The corresponding line-element is:

$$ds^2 = \exp\left[2 \cdot C \cdot h(x, y, z) \cdot e^{-i(\omega + E/\hbar)t} \cdot e^{i\varpi\left(\int (1+V/m)\mathbf{ds}\cdot\mathbf{n}\right)}\right]\left(dt^2 - dx^2 - dy^2 - dz^2\right) \tag{AIII.30}$$

In the line integral ***ds*** is a path increment vector and ***n*** a unity velocity vector corresponding to motion at the speed of light. This form may seem contrived but leads to the Schrödinger equation. Let's analyze it.

The energy E is assumed to be constant and may be seen as giving a frequency adjustment to the Compton oscillation, while the potential function *V(x,y,z)* adjusts the phase of the deBroglie matter-wave. We will assume both these influences are much smaller than the mass energy:

$$\begin{aligned} &E << \hbar\varpi = m \\ &V << m \end{aligned} \qquad \text{(AIII.31)}$$

The line integral corresponds to the deBroglie matter-wave; **ds·n** corresponds to the product x·v in (AIII.4). The line element (AIII.30) therefore models motion that is influenced by a variations of the Compton frequency given by E and phase modulations of the deBroglie mater-wave given by V.

Replacing the line integral with a sum of segments indexed by i and assuming that the vectors $\mathbf{n_i}$ on these segments are constant:

$$I(x, y, z) = \int (1 + V/m) \cdot \mathbf{ds} \cdot \mathbf{n} = \sum_{x_0, y_0, z_0}^{x, y, z} (1 + V/m)\left(\Delta x_i n_{xi} + \Delta y_i n_{yi} + \Delta z_i n_{zi}\right) \tag{AIII.32}$$

If the intervals are small, differentiation of this sum with respect to x may be approximated by the contribution from the last term in the sum:

$$\frac{\partial I}{\partial x} \approx \frac{\Delta I(x, y, z)}{\Delta x} \approx (1 + V/m) n_{xi} \qquad \text{(AIII.33)}$$

After a second differentiation of the exponent in the integral and adding the contributions from y and z we get the term:

$$(1 + V/m)^2 \left(n_x^2 + n_y^2 + n_z^2\right) = (1 + V/m)^2 \qquad \text{(AIII.34)}$$

We therefore find, after carrying out the differentiations in (AIII.28) that the Ricci scalar disappears if the following two relations hold:

Terms not containing $\mathbf{n}_i$:

$$\nabla^2 h - \varpi^2 \left[\left(1 + \frac{V}{m}\right)^2 - \left(1 + \frac{E}{\hbar\varpi}\right)^2\right] h = 0 \qquad \text{(AIII.35)}$$

Terms containing **$\mathbf{n_i}$**:

$$\varpi\left[2(1+\frac{V}{m})\cdot\frac{\nabla h}{h}+\frac{\nabla \mathrm{V}}{m}\right]\cdot\mathbf{n}_i=0 \qquad \text{(AIII.36)}$$

Using (AIII.31) we have:

$$\left[1+\frac{V}{m}\right]^2=1+\frac{2V}{m}+\left(\frac{V}{m}\right)^2\approx 1+2\frac{V}{m} \quad \text{(AIII.37)}$$

$$\left[1+\frac{E}{\varpi \mathrm{h}}\right]^2=1+2\frac{E}{m}+\left(\frac{E}{m}\right)^2\approx 1+2\frac{E}{m} \qquad \text{(AIII.38)}$$

Substituting these in (AIII.32) we get the Schrödinger equation:

$$-\frac{\mathrm{h}^2}{2m}\nabla^2 h+\left(V-E\right)\cdot h=0 \qquad \text{(AIII.39)}$$

This derivation may easily be generalized to the situation where the wave function h also depends on time. We then get the additional terms:

$$2i\left(\varpi+\frac{E}{\mathrm{h}}\right)\frac{\partial h}{\partial t}-\frac{\partial^2 h}{\partial t^2}\approx 2i\varpi\frac{\partial h}{\partial t}$$

$$-\frac{\mathrm{h}^2}{2m}\left(2i\varpi\frac{\partial h}{\partial t}\right)=-i\mathrm{h}\frac{\partial h}{\partial t} \qquad \text{(AIII.40)}$$

Moving this term to the right hand side of (AIII.36)

$$-\frac{\mathrm{h}^2}{2m}\nabla^2 h+\left(V-E\right)\cdot h=i\mathrm{h}\frac{\partial h}{\partial t} \qquad \text{(AIII.41)}$$

This is the time dependent Schrödinger equation.

A similar derivation of the Schrödinger equation for the electromagnetic field may be found in [Masreliez, 2005].

The relation (AIII.32) does not depend on the velocity vectors n_i.

The Schrödinger equation applies regardless of a particle's motion.

Furthermore, if relation (AIII.3) is satisfied for n_i it is also satisfied for $-n_i$. Therefore, the Schrödinger equation applies even for a particle "at rest" subjected to back and forth motion. In other words, the mere presence of an oscillating volume (particle) at some location creates a response from its environment given by the wave functions of QM, which could be modulations of the metrics of spacetime. This may influence the subsequent motion of the particle, and since this influence takes place via the metrics it could be non-local, allowing instantaneous influences independent of separation distance.

In other words, Schrödinger equation does not model motion but models resonance conditions in the metrics of spacetime that depend on geometry, energies, and fields.

This development shows that if the scale of spacetime oscillates at the Compton frequency the Schrödinger equation is a necessary condition for the disappearance of the Ricci scalar of GR. The finding that the deBroglie-Bohm pilot function and the Schrödinger equation both may be derived from GR and that there also is random influence implies that Bohm's conditions C1, C2 and C3 are all satisfied.

In other words, QM may be derived from GR.

Furthermore, it suggests that the quantum mechanical wave functions may have physical meaning; they could correspond to modulation of the Compton oscillation of the scale of spacetime.

This would allow us to merge GR and QM into a single more complete theory, ending their century-long estrangement. The probabilistic interpretation of QM could then be abandoned in favor of new physics based on dynamic spacetime metrics. The behavior of the quantum world would no longer be something mysterious and probabilistic but would be a consequence of influences via the dynamic scale of spacetime exited by the cosmological scale expansion.

This implies a direct link between the QM and the SEC model.

Although you may appreciate this ontological explanation to quantum mechanics it must be admitted that it currently does not address several aspects of the quantum world, for example "spin", and it may therefore be ignored by mainstream experts who in the spirit of the Copenhagen school consider any ontological explanation unnecessary or even undesirable. But, like the epicycles of the past described the motions of the planets without giving any answer to the question "why", the currently popular purely mathematical, and probabilistic, approach to quantum theory (including string theory) may not contribute as much to our understanding of the world as even a simplistic ontological explanation will. When Copernicus presented his moving Earth model it did not model the motions of the planets with the same accuracy as the epicycles. However, it still became the preferred explanation because of its simplicity. The connection between QM and the SEC model might provide us with a deeper understanding of the world.

Einstein was right; God does not play dice.

Appendix IV: Speculation on the Nature of Motion

How does a particle move? Does it jump incrementally or does it change its dimensions and move like an inchworm? It turns out that Appendix III together with the explanation to the inertial force may offer a possible ontological explanation.

Consider again the 5D hyperspace line element:

$$ds^2 = u^2(dt^2 - dx^2 - dy^2 - dz^2) - (T \cdot du)^2 \quad \text{(AIV.1)}$$

We may think of the 4D SEC cosmos as moving in this 5D hyperspace space on a null-geodesic with the fifth dimension, *u*, playing the role of "time". This line-element has two terms. The last term disappears if *u* is constant and the 5D line-element then collapses into the line-element for scale-equivalent 4D spacetime. On the other hand, motion in the 4D spacetime at the speed of light will cause the first term to disappear allowing motion purely in the fifth dimension, which may model scale transition. Spatial motion at the speed of light implies that time stands still in 4D spacetime, which makes the scale transition appear instantaneous.

This suggests that the incremental scale transition of the DIST process might be associated with motion in 4D spacetime at the speed of light.

Chapter VI on motion suggests that the spacetime scale for an accelerating particle contracts by the inertial factor $1\text{-}v^2$, and that relative to a co-accelerating observer this scale is incrementally "reset" via the DIST process to keep the line-element locally Minkowskian.

Consider the hyperspace line-element:

$$ds^2 = u^2 \cdot (1 - v^2)(dt^2 - dx^2 - dy^2 - dz^2) - (T \cdot du)^2 \quad \text{(AIV.2)}$$

We may think of acceleration as occurring in two steps:

In the first step the scale contracts continuously via the inertial scale factor while the scale u remains constant *u=1 and du=0*. In this first step the world is 4D spacetime since the last term in (AIV.2) disappears. This step may be modeled by GR.

In the second step there is spatial transition at the speed of light while the scale adjusts $u \Rightarrow 1/(1-v^2)$ thus "resetting" the 4D scale to one. In this second step, which corresponds to the discrete scale transition in the DIST process, the first term equals zero and the motion is solely in scale.

We find that motion may take place by alternately switching between motion in spacetime and motion in the fifth scale-dimension.

This somewhat speculative ontological explanation would imply that all motion takes place via transitions both in 4D spacetime and in five-dimensional hyperspace. The reader familiar with Richard Feynman's checkerboard approach to quantum theory may sense a connection here since he showed that random walks in space and time at the speed of light leads to Dirac's famous equation for the electron.

http://en.wikipedia.org/wiki/Feynman_checkerboard

When deriving the Schrödinger equation in appendix III an increment of the line-integral (AIII.32) was expressed as the scalar product of a displacement vector, **ds**, and a unit velocity vector, **n**, which corresponds to motion at the speed of light. Dividing this line-element into number of short segments each modeling motion at the speed of light allowed the Schrödinger equation to be derived from GR.

However, with the 5D line-element (AIV.2) we now find that incremental motion at the speed of light may be associated with changes in the fifth dimension that resets the dynamic scale and models the discrete scale adjustment of the DIST process. As we saw this scale adjustment appears to be instantaneous to an observer. It is therefore possible that particles always move in tiny rapid steps at the speed of light combined with simultaneous scale adjustments, and that the velocity we observe macroscopically merely is the projection of all these numerous increments in the direction of motion. The DIST loop may coincide with the Compton oscillation, supporting the proposition that the Compton oscillation, which is associated with all particles, takes place in the scale of spacetime.

Since a displacement at the speed of light occurs instantaneously, the particle may be seen as being at two different locations in 4D spacetime at the same time. And, if the spatial displacement of each of these increments is comparable to the wavelength of the Compton oscillation it would be consistent with Heisenberg's uncertainty relation. This suggests the intriguing possibility that processes may exist in a 5D the universe that involves influences beyond 4D spacetime.

Chess is a game that plays out in two dimensions. However, moving a piece makes use of the third dimension. Similarly the geometry of the world is four-dimensional but motion in this 4D world may take place via a fifth dimension. In 4D spacetime motion may seem mysterious since it involves instantaneous quantum jumps but in 5D hyperspace it becomes understandable because a seemingly "instantaneous" change in location may take place via motion in the fifth dimension. It appears that the fifth dimension is not merely a piece of nice mathematics but might be as real as any of the four dimensions of spacetime.

This explanation may seem a bit speculative, but we cannot move beyond known physics without some speculation.

Appendix V: Deriving the inertial scale factor

Consider the scaled Minkowskian line element with c=1:

$$ds^2 = \phi^2\left(x,y,z\right)\cdot\left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(AV.1)}$$

Proceeding as in Appendix III we derive (AIII.21) from the geodesic relation for the line-element above:

Multiplying this with the velocity **v** and noting that since ϕ is not a function of t:

$$\nabla\phi\cdot\boldsymbol{v} = \dot{\phi} \qquad \text{(AV.3)}$$

(AV.2) becomes:

$$v\dot{v} + \frac{v^3\dot{v}}{\left(1-v^2\right)} = -\frac{1}{\phi}\left[\dot{\phi}\left(1-v^2\right) + \dot{\phi}v^2\right] = -\frac{\dot{\phi}}{\phi}$$

$$\frac{v\dot{v}}{\left(1-v^2\right)} = -\frac{\dot{\phi}}{\phi} \qquad \text{(AV.4)}$$

This is relation is *identically* satisfied by the *inertial metric*:

$$\phi = \text{constant} \cdot \sqrt{1 - v^2} \qquad \text{(AV.5)}$$

Substituting the inertial metric into (AV.2):

$$\dot{v} = v \cdot \nabla v \qquad \text{(AV.6)}$$

Therefore the geodesic acceleration for the inertial line element satisfies:

$$\boldsymbol{a} = \dot{v} = grad\left(\frac{v^2}{2}\right) = \nabla\left(\frac{v^2}{2}\right) \qquad \text{(AV.7)}$$

This relation always holds for acceleration in any coordinate representation since the gradient vector is covariant. This geodesic acceleration equals the gradient of the *inertial field potential* $v^2/2$.

The *inertial line* element becomes:

$$ds^2 = \left(1 - v^2\right) \cdot \left(dt^2 - dx^2 - dy^2 - dz^2\right) \qquad \text{(AV.8)}$$

The acceleration in (AV.7) is caused by an applied force *F.* We have from (AV.7):

$$E = \int F \cdot ds = \int ma \cdot ds = \int m\nabla\left(\frac{v^2}{2}\right) \cdot ds = \left(\frac{mv^2}{2}\right) \qquad \text{(AV.9)}$$

The derivation in this appendix shows that the acceleration in (AV.7) is gravitational in nature, and that it is a consequence of the inertial line-element (AV.8). Kinetic energy is induced by spacetime curvature caused by the inertial metric (AV.5).

Ultimately kinetic energy, as well as inertia, is due to hyperspace curvature, which alters the local 4D spacetime in 5D hyperspace.

As an example consider rotational motion with fixed radius of the Minkowskian frame modeled by:

$$x = r\cos\left(\omega t\right); \; y = r\sin\left(\omega t\right))$$

$$\dot{x} = -r\omega\sin\left(\omega t\right) = -\omega y; \qquad \dot{y} = r\omega\cos\left(\omega t\right) = \omega x$$

$$v^2 = \dot{x}^2 + \dot{y}^2 = \omega^2\left(y^2 + x^2\right)$$

We get:

$$a_x = \frac{\omega^2}{2}\frac{\partial\left(y^2 + x^2\right)}{\partial x} = \omega^2 x; \quad a_y = \omega^2 y \qquad \text{(AV.10)}$$

$$\left|a\right| = \sqrt{a_x{}^2 + a_y{}^2} = \omega^2 r = \text{centrifugal acceleration}$$

Spherical or cylindrical coordinates immediately yield:

$$a_r = \frac{1}{2}\frac{\partial v^2}{\partial r} = \frac{1}{2}\frac{\partial\left(\omega r\right)^2}{\partial r} = \omega^2 r \qquad \text{(AV.11)}$$

Thus, with the inertial scale metric (reintroducing c) $1-(v/c)^2$ the centrifugal acceleration equals the geodesic acceleration. This demonstrates how circular motion of an inertially scaled Minkowskian frame generates a gravitational-type inertial force. And, as was shown in the text, the inertial metric is a relative phenomenon that applies to all line-elements for objects in relative motion. Therefore all motions make use of the fifth scale-dimension!

This is new physics.