Scale Expanding Cosmos Theory II – Cosmic Drag

C. Johan Masreliez
Redmond, WA 98052
USA
Email: jmasreliez@estfound.org

In a previous article the author introduced the Scale Expanding Cosmos (SEC) theory and showed that this new theory could resolve several problems with the Standard Cosmological Model. This new theory better agrees with observational data, for example the number count test, the angular size test, the surface brightness test and the supernovae Ia observations. In addition it provides a simple explanation to the Pioneer anomaly. The SEC theory predicts new and testable cosmological features among them cosmic (velocity) drag, which is the subject of this paper. I will show that currently there is substantial evidence for cosmic drag and suggest how this new and unexpected aspect of the universe may be confirmed by observations in the solar system.

Key words: Cosmic drag, galaxy formation, angular momentum problem, planetary ephemerides, planetary acceleration

1. Introduction

In the first paper of this series the author introduced a new cosmological theory, the Scale Expanding Cosmos (SEC) theory and showed how this theory might resolve several longstanding problems with the Standard Cosmological Model (SCM) based on the big bang. In this paper I will investigate a new feature predicted by the SEC theory – cosmic drag. Cosmic drag would cause relative velocities of freely moving objects to diminish with time and angular momenta of rotating system to dissipate. This paper discusses how cosmic drag could explain the formation and shape of spiral galaxies. Evidence for cosmic drag in the solar system, which would cause the planets to spiral toward the Sun, is presented and why this phenomenon has not been detected previously is discussed. The paper concludes with suggesting how cosmic drag might be verified by observations in the solar system.

2. Two cosmic drag relations

Appendix 1 of Masreliez, 2004 and in Masreliez, 1999 give the following expression for the velocity of a particle freely moving on a geodesic:

$$\beta = \frac{\beta_0 \cdot e^{-t/T}}{\sqrt{1-\beta_0^2+\beta_0^2 \cdot e^{-2t/T}}} \tag{2.1}$$

β is the normalized velocity v/c.

If the velocity initially equals the speed of light so that $\beta_0=1$ it follows that $\beta=1$ for all times. A photon therefore always moves at the speed of light. On the other hand, if the initial velocity is less than the speed of light, it will decrease with time. In particular if $\beta_0<<1$:

$$\begin{aligned} \beta &= \beta_0 \cdot e^{-t/T} \\ \dot{\beta} &= -\beta / T \end{aligned} \tag{2.2}$$

This is what causes Cosmic Drag in the SEC. Thus, the speed of light remains constant in the SEC, which implies that the Lorentz transformation holds. However, all inertial coordinate systems are no longer equivalent; there is a preferred cosmological reference system, see Masreliez, 1999.

The corresponding expression for angular motion is:

$$r^2 \cdot \dot{\theta}^2 = \frac{r_0^4 \cdot \dot{\theta}_0^{\ 2} \cdot (1 - \dot{r}^2) \cdot e^{-2t/T}}{r^2 \cdot [1 - \dot{r}_0^{\ 2} - (r_0 \cdot \dot{\theta}_0)^2] + r^4{}_0 \cdot \dot{\theta}_0^{\ 2} \cdot e^{-2t/T}} \tag{2.3}$$

This may be derived from the SEC geodesic by setting φ=0. For velocities much lower than the speed of light we have:

$$r^2 \cdot \dot{\theta} = r_0^{\ 2} \cdot \dot{\theta}_0 \cdot e^{-t/T} \tag{2.4}$$

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

If cosmic drag exists it will have observable consequences, which makes the SEC theory falsifiable. Cosmic drag explains the motion of matter in spiral galaxies and predicts that the planets slowly spiral toward the Sun with accelerating angular velocities. Optical observations in the solar system since the introduction of atomic time have now detected this acceleration as discussed in Masreliez, 1999.

This will be discussed in sections 4 and 5.

3. Cosmic drag generates a cosmological reference frame

Einstein's Special Relativity Theory does not recognize a preferred cosmological reference frame; all inertial frames are equivalent.

Furthermore, GR extends this equivalence between coordinate frames to all frames related by continuous variable transformations. This implies that there is no preferred cosmological reference frame in the SCM. Yet, the observed small relative velocities of galaxies, which on the average are well below one percent of the speed of light, and the cosmic microwave radiation dipole, which shows that the local group moves relative to the CMB, suggests that a cosmological reference frame does exist. Such a reference frame also is needed to explain the phenomenon of inertia and non-local aspects of Quantum Mechanics.

In the SEC theory cosmic drag generates a cosmological reference frame, since relative velocities of freely moving objects and angular momenta of rotating systems diminish over time, eventually converging to a common rest frame. Unlike Mach's reference frame, in which there is no mechanism that reduces relative velocities, cosmic drag diminishes relative motion and induces a cosmological reference frame in the SEC. This means that all inertial systems are not equivalent; there is a preferred cosmological rest frame toward which all motions converge. The new physics that makes this possible is the interesting property that the speed of light is not influenced by cosmic drag (although light is redshifted), while all relative motion slower than the speed of light diminish over time.

The cosmological reference frame is generated by "bootstrapping"; an observer in a freely moving galaxy sees its velocity relative to any other galaxy decrease exponentially, with a time constant equal to the Hubble time. Since this is true for all galaxies, all galaxies would eventually come to relative rest, if there were no other forces. This frame of relative rest defines the reference frame, which in the SEC it is induced by relative motion.

The existence of a rest frame makes it possible to define gravitational field energy. This is impossible in the SCM where there is no unique reference frame, since gravitational field energy depends on the chosen coordinates. In the SCM Schwarzschild exterior solution satisfies Einstein's GR equations with an energy-momentum tensor for which all components disappear. That a solution exists with zero energy-momentum tensor is strange, since it implies that the gravitational field energy disappears regardless of the chosen coordinate system, which conflicts with the understanding that the gravitational field energy should be negative. This conundrum, which has been discussed at length over the years (see for example Miser, Thorne and Wheeler), disappears in the SEC, where no solution to the GR equations corresponding to Schwarzschild's exterior solution exists. This means that the presence of matter necessarily must modify the energy-momentum tensor for vacuum and generate gravitational field energy, which is well defined in the cosmological reference frame. This will be further discussed in the third paper of this series.

4. Spiral galaxy formation

In the SEC galaxies could be very old objects, perhaps tenths or even hundreds of billion years old. They must be dynamic objects sustained by some steady state process, since matter continuously is falling toward the galaxy core due to cosmic drag. Matter might be ejected from a galaxy core from time to time in order to keep the matter inside the central bulge constant on the average. This could be the role of the Active Galactic Nuclei (AGNs). In the SEC context this process is not unreasonable, since black holes cannot form. Preliminary investigations indicate that the formation of black holes is prevented in the SEC. This will also be discussed in the third paper of this series.

Cosmic drag could explain the spiral shape of galaxies since the angular momentum of slowly rotating systems diminishes exponentially with time in the SEC universe. Stars moving on geodesics will describe spiral paths toward the galaxy core, and since they are freely falling, gravitation pulls them into galaxy arms. This would explain the well-defined spiral arm structure and the thin galaxy discs.

I will assume that galaxies retain their shape and their internal geometry over very long time intervals. Otherwise we would see a large variety of geometries rather than just a few.

Therefore, this discussion is based on the following postulate:

> *The matter flow toward a galaxy's core is constant and is the same at all radii.*

If this were not the case, matter could accumulate within separate regions in a galaxy and the geometry and matter distribution would change with time. *I will show that this simple postulate implies that in general the velocity curves are flat.*

Let $A(r)$ be an area enclosing the core, for example a spherical surface centered at the core and $v(r,t)$ be the radial velocity of the mass flow. The mass flow through the surface at distance r is then given by:

$$\text{Mass flow} = \rho(r,t)\cdot A(r)\cdot v(r,t) = \text{constant} \tag{4.1}$$

Consider a particle that moves from the outer region in a galaxy toward the center starting at $t=0$ with $r=r_0$. The mass in the volume $r(t)<r< r_0$ is given by:

$$M(r(t) < r < r_0) = -\int_{r_0}^{r} \rho \cdot A \cdot dx =$$

$$-\int_{r_0}^{r} \frac{\text{constant}}{v} dx = \text{constant} \int_{o}^{t} dt = \text{constant} \cdot t \tag{4.2}$$

If there is no mass inside r_0 this implies:

$$M(r > r(t)) = \text{constant} \cdot t \tag{4.3}$$

This defines the mass distribution as a function of fall time. Furthermore, assume that there is a central bulge with mass M_b confined to $r<r_b$. The mass inside radius r but outside the bulge is given by:

$$M(r) = M_b + (M(r_0) - M_b)(1 - \frac{t}{T_c}) \tag{4.4}$$

This linear relation defines the galaxy mass distribution that is required for steady state flow conditions in the outer regions. T_c controls the linear slope. In classical physics the radial motion is given by the differential equation:

$$\ddot{r} = -(\frac{G \cdot M(r)}{r^2} - \frac{J^2}{r^3}) \tag{4.5}$$

$$J = v_t \cdot r$$

where J is the normalized angular momentum and v_t the tangential velocity. In the SEC universe this equation is modified by cosmic drag, which reduces the radial acceleration and diminishes the angular momentum:

$$J = J_0 \cdot e^{-t/T} \tag{4.6}$$

The radial motion now satisfies:

$$\ddot{r} = -\frac{\dot{r}}{T} - \left(\frac{G \cdot M(r)}{r^2} - \frac{J^2}{r^3}\right) = -\frac{\dot{r}}{T} - \left(\frac{G \cdot M(r)}{r^2} - \frac{J_0{}^2 e^{-2t/T}}{r^3}\right) \quad (4.7)$$

In a typical galaxy the first term is much smaller than each of the two terms inside the parenthesis. Qualitative aspects of the motion may therefore be investigated by simply setting the parenthesis equal to zero:

$$\frac{G \cdot M(r)}{r^2} - \frac{J_0{}^2 \cdot e^{-2t/T}}{r^3} \approx 0 \quad (4.8)$$

or:

$$\left[\frac{M_b}{M(r_0)} + \left(1 - \frac{M_b}{M(r_0)}\right)\left(1 - \frac{t}{T_c}\right)\right] - \frac{r_0 \cdot e^{-2t/T}}{r} \approx 0 \quad (4.9)$$

Here we have made use of the initial condition $GM(r_0)=J_0^2/r_0$. As a function of time the radius satisfies:

$$r(t) = \frac{r_0 \cdot e^{-2t/T}}{M_f(t)} \quad (4.10)$$

where:

$$M_f(t) = \left[\frac{M_b}{M(r_0)} + \left(1 - \frac{M_b}{M(r_0)}\right)\left(1 - \frac{t}{T_c}\right)\right] \quad (4.11)$$

The tangential velocity assuming an essentially circular orbit is given by:

$$v_t(t)=\sqrt{\frac{GM(t)}{r}}=\sqrt{GM(r_0)}\cdot\sqrt{\frac{M_f}{r}}=\sqrt{\frac{GM(r_0)}{r_0}\frac{M_f}{e^{-t/T}}}= \\ =v_t(0)\cdot\frac{M_f}{e^{-t/T}} \tag{4.12}$$

Together with the radial relation this defines the rotation curve. The angular position may be found from:

$$r\cdot v_r=r^2\cdot\dot{\theta}=J_0\cdot e^{-t/T} \tag{4.13}$$

$$\dot{\theta}=\frac{J_0\cdot e^{-t/T}}{r^2}\propto e^{3t/T}\cdot M_f^2 \tag{4.14}$$

These simple expressions may be used to get a qualitative idea of the motions of stars and cool gas in a typical spiral galaxy. They also define the spiral shape. We find that the rotation curves generally are flat if less than one third of the mass is confined to the bulge.

The mass M in (4.4) reaches M_b at $t=T_c$. Should this occur for some $r(T_c)=r_c>r_b$, the assumption could be made that the mass remains equal to M_b in the region $r_b<r<r_c$. The mass distribution in a galaxy is in this way partitioned into three disjoint regions, the central bulge $r<r_b$, a transition region $r_b<r<r_c$ and an outer region $r_c<r<r_0$. In the transition region there is no matter, but the mass density could increase sharply at the beginning of the outer region at $r=r_c$. This would correspond to a dip in the rotation curve at some radial distance outside the bulge followed by an increasing velocity beyond this region - a feature often seen in rotation curves. Lower mass density in a transition region can also be seen in many spiral galaxies where a circular region with lower luminosity often surrounds the bulge. Figures 1 and 2, which were derived using the relations above, illustrate these generic features.

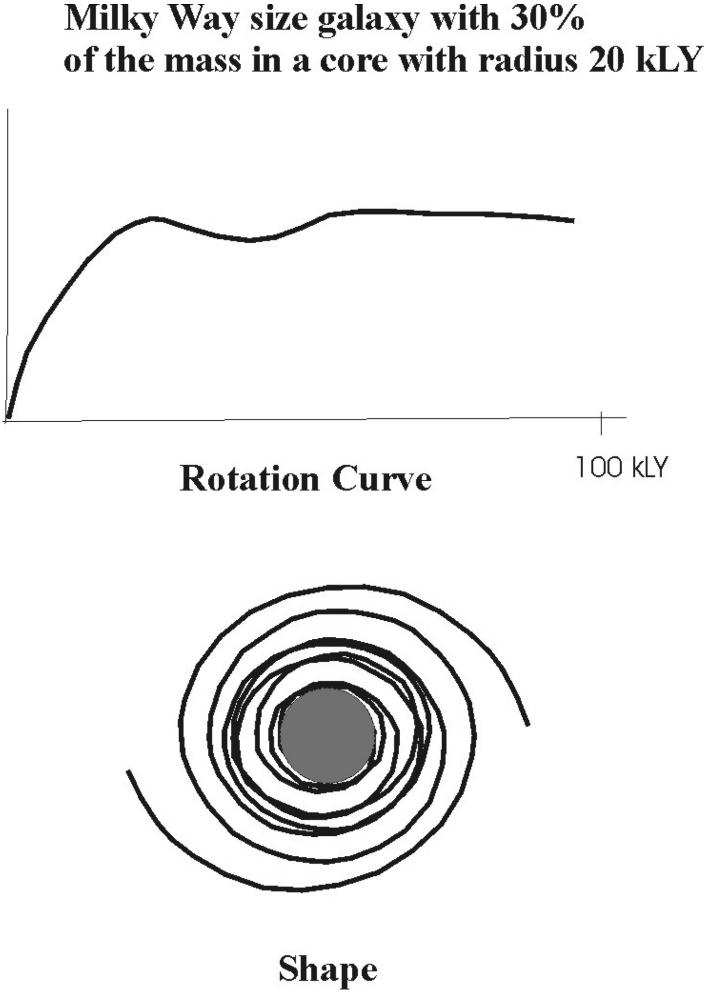

Figure 1: Example of rotation curve, and spiral shape based on constant mass flow.

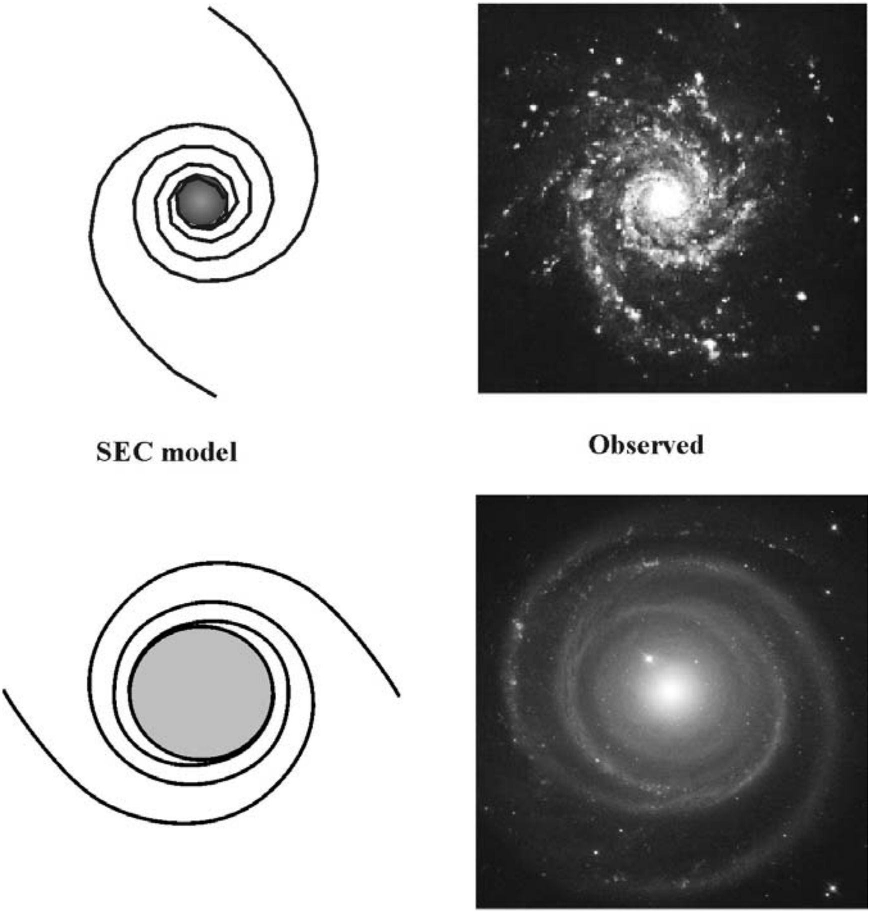

Figure 2: Examples of spiral galaxy shapes

Note that with this explanation the flat rotation curves does not require a spherical dark matter halo. The hidden matter could be cool gas primarily confined to the galaxy arms, which might extend far beyond the visible star forming regions.

A wide variety of rotation curves may be modeled by the above derived relations. Figure 3 shows examples of observed rotation curves from Sofue and Rubin, 2001. Four of these curves were selected in order to test if they could be modeled by relations (4.10) and (4.12).

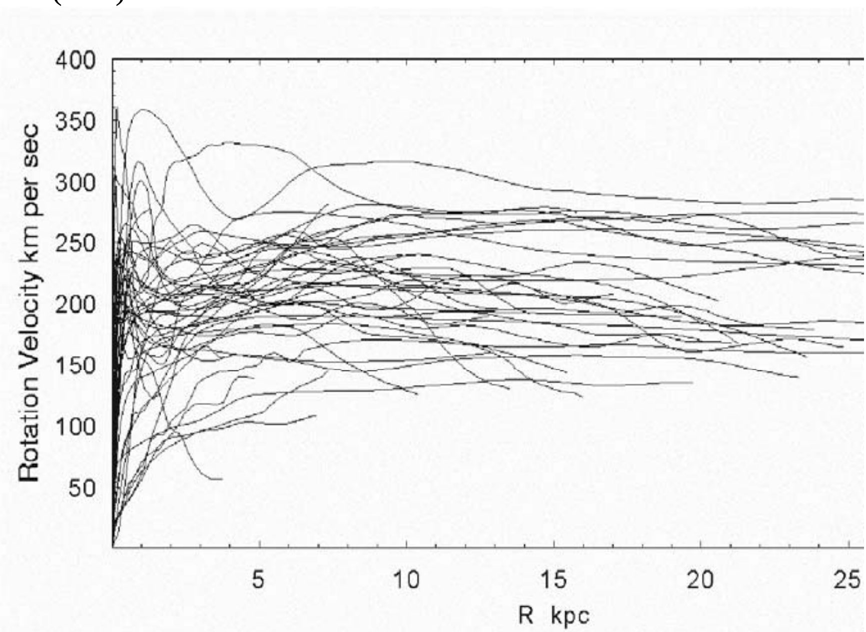

Fig 3. Typical rotation curves.
(From Sofue and Rubin, 2001)

Figure 4: Four observed and modeled rotation curves.

As shown in Figure 4 it was possible to closely model three of the four selected curves by adjusting three parameters: the core mass fraction, the core radius and the time constant Tc. Reasonably good agreement could also be obtained with the fourth rotation curve, which has an unusually sharp peak at a small radial distance. This suggests that cosmic drag and the constant mass flow postulate might control galaxy formation and sustain their shapes.

If this is the case, a mechanism must exist that prevents matter from accumulating at the center of the galaxy core. It is likely that such a mechanism exists in the SEC and this will be the topic of my next paper. Here I will only mention two facts:

1 The event horizon is a true singularity in the SEC; it is a spherical surface with infinite spacetime curvature.
2. A freely falling particle cannot penetrate the event horizon.

This suggests that something extraordinary occurs when the mass density approaches that of a black hole. This might explain the AGN jets and their sometimes intense radiation.

Appendix 2 proposes that the CMB radiation might be thermalized radiation primarily from AGN activities.

5. Planetary accelerations

Diminishing angular momentum should cause the planets to slowly spiral toward the Sun. I will show in an upcoming paper that Newton's law of gravitation is modified in the SEC so that the gravitational potential is changed by a factor of order $(r/T)^2$:

$$P = \frac{GM}{r} \cdot (1 + O(r/T)^2) \tag{5.1}$$

The difference between this potential and the Post-Newtonian potential is of order 10^{-28} in the solar system. This is negligible, which means that Kepler's third law holds:

$$r^3 \cdot \omega^2 = \text{Constant} \tag{5.2}$$

Combining this law with the cosmic drag angular momentum relation (2.4) gives the planetary accelerations:

$$\text{Angular velocity: } \frac{d\omega}{dt} = \frac{3\omega}{T} \rightarrow \omega = \omega_0 \cdot e^{3t/T} \qquad (5.2)$$

$$\text{Radial position: } \frac{dr}{dt} = -\frac{2r}{T} \rightarrow r = r_0 \cdot e^{-2t/T} \tag{5.3}$$

$$\text{Tangential velocity: } \frac{dv}{dt} = \frac{v}{T} \rightarrow v = v_0 \cdot e^{t/T} \tag{5.4}$$

Thus, according to the SEC theory the planets spiral toward the Sun with accelerating tangential and angular velocities while their distances from the Sun decrease steadily. The angular (secular) acceleration of the Earth is about 2.8 arcsec/century^2 and the orbital radius currently decreases by about 20 meters per year assuming T=14 billion years.

6. Observational evidence for cosmic drag

After having discovered that the SEC model implies cosmic drag, the question becomes if there exists observational evidence for this phenomenon.

Many pulsars spin down at rates close to the SEC theory's prediction. If a millisecond pulsar were to be slowed down by some other mean, for example friction, it would dissipate heat comparable to the Sun's energy output. The spin-down of pulsars cannot be explained by standard physics but is predicted by the SEC theory (see further Masreliez, 1999).

Noting these preliminary pieces of evidence for cosmic drag it seems possible that the planets might spiral toward the Sun while accelerating. In fact, it appears that accelerating angular motions of the planets already might have been detected. Recently several independent investigators have reported discrepancies between the optical observations and the planetary ephemerides. The discussions by Yao & Smith (1988, 1991, 1993), Krasinsky et. al. (1993), Standish & Williams (1990), Seidelman et al. (1985, 1986), Seidelman (1992), Kolesnik (1995, 1996) and Poppe et. al. (1999) indicate that residuals of right ascensions of the Sun show a nearly

1″/cy negative linear drift before 1960 and an equivalent positive drift after that date.

A paper by Yuri Kolesnik (Kolesnik, 1996) reports on positive drift of the planets relative to their ephemerides based on optical observations covering thirty years with atomic time. This study uses data from many observatories around the world, and all observatories independently detect the planetary drifts. In personal communication Kolesnik agreed that the noted discrepancies very well might be accelerations and thus quadratic with time. Table I shows Kolesnik's semi-accelerations (the second order coefficient) estimated from his observations compared to the SEC theory's predictions if the Hubble time is fourteen billion years.

Table I: Planetary semi-accelerations with T=14 billion years

Planet	Predicted by the SEC (arcsec/century^2)	Observed (arcsec/century^2)
Mercury	5.77	8.6 ± 3.0
Venus	2.26	1.9 ± 0.5
Earth	1.39	1.4 ± 0.2

The good agreement between the predicted and the observed accelerations based on thirty years of optical observations with atomic time is strong evidence in favour of the SEC. Recently Kolesnik has analyzed 240,000 optical observations from 1750-2000. Estimated angular accelerations based on these observations have been published in a joint paper with the author (*Astronomical Journal, August 2004)*. There is agreement with the SEC theory predictions.

One might perhaps wonder why these planetary accelerations, have not been detected earlier. In fact, they were discovered a long time ago by several independent investigators, perhaps most prominently Spencer Jones (1939). At the time of the Spencer Jones investigation, time-keeping in astronomy still used Universal Time (UT), which is based on the rotation of the Earth. The detected accelerations may therefore also be explained by a decelerating pace of UT due to decelerating rotation of the Earth (perhaps caused by tidal friction) rather than by an accelerating motion of the Earth around the Sun. The rate of deceleration of the Earth's rotation that would correspond to the observed acceleration of the Sun's motion can be estimated. Correcting UT for this estimated spin-down rate of the Earth and eliminating short-term fluctuations gives "Ephemeris Time (ET)" by which the motion of the Earth and the planets are uniform on the average. However, it also creates an unresolved discrepancy between the spin-down rate of the Earth's rotation and the motion of the Moon, which are related by conservation of angular momentum, (Masreliez, 1999). This problem has been thoroughly investigated by for example Newton (1985) and Dicke (1966) but no good explanation has yet been found.

However, the planetary drifts Kolesnik and several other investigators have detected are based on accurate modern optical observations and they use atomic time. Therefore, these drifts are unquestionably real.

Today we are facing a curious situation; the drifts detected by optical observations are not apparent when constructing the modern ephemerides. These ephemerides are fitted primarily to radar ranging data between the Earth and the three other inner planets and laser ranging to the Moon. Jet Propulsion Laboratory (JPL) has found that the measured ranges can be fitted excellently to Newtonian ephemerides with relativistic corrections (Post-Newtonian) using a traditional approach by which the temporal argument implicitly is derived in the ephemeris construction process (Standish, 1998). It is commonly believed that this good fit to the ranging data confirms that the planetary orbits are Post-Newtonian with the implicit assumption that the ephemeris time, ET, is proportional to Atomic Time, AT.

However, this is not necessarily the case. A good fit does not guarantee that the ephemerides actually are Newtonian in a cosmological reference frame that is not Minkowskian. It is possible that a perfect Post-Newtonian fit might be obtained when the ephemeris construction process determines the time base, since this approach automatically might select a local Minkowskian system in which Newton's law of gravitation applies. If spacetime is curved locally, as is the case with the SEC model, a local Minkowskian system may always be found. But, the temporal coordinate of this local Minkowskian coordinate representation could accelerate relative to atomic time, see Appendix 1. This would allow perfect ranging data agreement with the Post-Newtonian ephemerides, since the law of gravitation differs by merely an order $(r/T)^2$, where T is the Hubble distance, between the two coordinate representations, which as we saw is in the order of 10^{-28}. In spite of excellent fit to the Post-Newtonian ephemerides optical observations will deviate from the ephemerides, thus explaining the mysterious discrepancy (Masreliez, "Optical observations and ranging").

Therefore, ranging data cannot *without atomic time* verify whether or not Newton's law (with its relativistic corrections) applies in the cosmological reference system. Newtonian ephemerides in a local Minkowskian system might not be Newtonian in a cosmological coordinate system with curved spacetime. Investigating the consequence of this hypothesis, assuming that the SEC theory is correct, we find that the Moon's distance from the Earth changes more slowly than estimated and that the Moon very well could have formed at the same time as the Earth.

Although modern ephemerides primarily are based on very accurate range measurements to the nearby planets, the ephemerides for the outer planets still use optical observations and Very Long Baseline Interferometry (VLBI). However, the low angular velocities of the outer planets hide their accelerations, which, if detected, easily could be interpreted as being due to observational errors or modeling inadequacies.

Making use of all the available ranging data since the inception of the planetary ranging program some thirty years ago might make it possible to check whether the coordinate time of the ephemerides accelerates relative to atomic time. The temporal acceleration of the time base derived from ranging predicted by the SEC theory is 1/T corresponding to 2-3 seconds quadratic drift relative to AT in fifty years. However, the JPL approach of fitting the ephemeris time as closely as possible to a time-base proportional to AT would reduce this discrepancy by at least a factor eight making it very difficult to detect. The Earth moves at a speed of 30 km/sec so the position discrepancy due to the timing error amounts to merely 3-4 km in 30 years. This is of the same size as the ranging uncertainties.

In spite of being very small, planetary acceleration could account for the drifts detected by optical observations, since planetary secular accelerations are amplified by a factor three due to changing radial distance, see relation (5.2).

The circumstance that the secular planetary accelerations due to cosmic drag are proportional to the motions explains how they could have been misinterpreted as being caused by a decelerating universal time. The semi-acceleration of the Sun (i.e. the Earth's motion in its orbit), deduced by Spencer Jones from solar eclipses, is 1.23 arcsec/cy^2, which comparing with Table 1 suggests that this acceleration primarily could be due to the SEC theory's cosmic drag and not to slowing rotation of the Earth. This could explain the discrepancy between optical observations and the ephemerides and resolve the mismatch between the angular momentum of the Earth and the motion of the Moon.

There is at least one study in which the planetary ephemerides are constructed based on atomic time rather than on a timebase fitted to the observations. This is the study by Oesterwinter and Cohen (1972), which concludes that the old ET based on planetary angular motions, drift relative to AT by about 7 seconds in 50 years. This agrees well with relation (5.2) above, which with T=14 billion years gives a corresponding quadratic temporal drift of 7.5 seconds on 50 years assuming that the drift is caused by a slowing progression of Universal Time.

Also, very early analyses of measured radar ranges by two different teams, one American and one Russian, report positive planetary tangential accelerations based on numerical integrations. Reasenberg & Shapiro (1978) derived positive tangential accelerations of Mercury and Venus based on about 15 years of range measurements. Krasinsky et. al. (1986) also gave positive accelerations derived from radar observations in the interval 1961-1982. These results are consistent with the SEC theory. With T=14 billion years the predicted normalized tangential acceleration is $(dv/dt)/v = 1/T = 0.71 \cdot 10^{-10}$/year.

Note that the old ET, which is based on the planetary motions, differs from the temporal argument in the modern ephemerides. The old ET is determined so that the average planetary angular motion is constant relative to the stellar background and therefore corrects for the angular acceleration (5.2). On the other hand, the JPL ephemerides are determined so that the tangential accelerations disappear on the average and corrects for (5.4); the radial motions can be ignored. These two time bases are not the same and they both differ from Atomic Time, which could explain observational inconsistencies.

Summarizing, planetary acceleration as predicted by the SEC theory has recently been detected by several independent studies and will soon be confirmed beyond any reasonable doubt (if they exist) since the position discrepancies increase quadratically with time.

7. Summary

Cosmic drag predicted by the SEC theory would "induce" a cosmological reference frame and thus resolve a fundamental enigma, which has been debated since the time of Newton and Leibnitz. The existence of inertia (Newton's spinning bucket experiment) indicates that a reference frame exists, but physics does not recognize such a frame. Rather than postulating an absolute reference frame as was done by Newton or associate it with very distant stars (galaxies) as was done by Mach, the SEC reference frame is *self-induced* by diminishing relative motion between galaxies in a feedback process whereby relative motion determines a reference frame toward which all motion converge.

Cosmic drag would explain the formation of galaxies and suggest a steady state process that could sustain them over very long time periods. If there is cosmic drag, matter is continuously falling toward the galaxy core in spiral geodesic trajectories. Even a very weak gravitational field could gather freely falling matter into well defined galaxy arms and the gradually diminishing angular momentum would resolve the perplexing angular momentum problem in the formation of galaxies. In this scenario galaxies are very old dynamic objects that could remain stable over long time periods. This implies that there must be some mechanism that ejects matter from the galaxy core when the mass density there becomes too high. Today we know that every galaxy seems to harbour a very dense core and that many galaxies have active nuclei (AGNs). One could speculate that these enigmatic objects might intermittently eject matter from the core as evidenced by the AGN jets.

Based on this assumption and assuming steady state conditions, the mass flow toward the core must be the same at all radial distances. This simple postulate will together with the SEC theory's cosmic drag explain the shape of spiral galaxies and their flat rotation curves. This model also explains several typical features of rotation curves.

Comic drag should also influence the motions of the planets in our solar system; it should cause them to spiral toward the Sun with accelerating angular motions. It is not difficult to understand why such angular acceleration has not been detected in the past. Before introducing atomic time into astronomy in the mid 1950s, the most accurate available time reference was based on planetary motion. Universal Time was based on the rotation of the Earth and Ephemeris Time on the motion of the Earth around the Sun. By defining time this way any acceleration of the planets will disappear *by definition*. Even after introducing Atomic Time 1955, the old method of constructing planetary ephemerides was continued, since this procedure was well established and no deviation from Newtonian motion ever had been found. The possibility that spacetime might be locally curved like in the SEC theory, which would invalidate the traditional approach, might never have been considered; there was no reason to suspect it before Atomic Time was introduced.

However, according to the SEC theory the planets accelerate, which will cause their positions to drift relative to their traditional ephemerides if Atomic Time is used when timing optical observations. This drift has been detected and confirmed by several independent investigators and the estimated accelerations agree with the SEC theory's predictions within estimation uncertainties. This could be verified by future optical observations, since the planetary discrepancies increase quadratically with time. Together with the Pioneer anomaly discussed in Masreliez, 2004, this would give us two ways of verifying of the SEC theory using observations in the solar system.

References:

Anderson J. et. al., 2002, "Study of the anomalous acceleration of Pioneer 10 and 11", *Phys. Rev.* ***D65*** *082004*

Bohm D., 1952, "A suggested interpretation of quantum theory in terms of "hidden" variables, I and II", *Phys. Rev.* ***85****, 166-193*

Bohm D., 1993, "Causal Interpretation of Quantum Mechanics." *Cambridge University Press, New York, 598 pp.*

Bondi H. and Gold T., 1948, *M.N.R.A.S,.* ***108****, No. 3*

Bouwens R., Broadhurst T. and Silk J., 1998: *ApJ* ***505****, 556-578*

Bouwens R., Broadhurst T. and Silk J., 1998: *ApJ* ***505****, 579-589*

Browne P. F., 1995, *"de Sitter Cosmology Reinterpreted", Apeiron, July*

Browne P. F., 1995, *"The cosmological views of Nernst; an appraisal", Apeiron, July*

Canuto V., Adams, P.J., Hsieh, S.H. and Tsiang F., 1977: *Phys. Rev. D,* ***16****, 1643*

Dicke R.H.: 1966,"The Secular Acceleration of the Earth's Rotation and Cosmology", *The Earth-Moon System, Plenum Press. pp. 98-164.*

Dirac, P.A.M, 1973: *Proc. Roy. Soc. London A 333,403*

Djorgovski S. and Spinrad H., 1981, *ApJ* ***251****, 417*

Einstein A.: 1917, "Cosmological Considerations on the General Theory of Relativity", *Trans. from: Sitzungsberichte der Preussischen Akad. d . Wissenschaften*

Friedmann A. Z.: 1922, *Phys.* ***10****, 377*

Goldhaber G. et. al. 2001, Timescale Stretch Parametrization of Type Ia Supernovae B-band Light-curves. *The Astrophysical Journal,* ***558****, 359*

Holland P., 1993, "The Quantum Theory of Motion. An Account of the de Broglie-Bohm Causal Interpretation of Quantum Mechanics." *Cambridge University Press, New York, **598** pp.*

Hoyle F., 1948, *M.N.R.A.S, **108**, No. 5*

Hoyle F. and Narlikar J.V., 1962, *Proc. Roy. Soc., **A270**, 334*

Hubble E., 1929*, Proc. Nat. Acad, Sci. (USA) **15**,168*

Keel, 2002, *http://www.astr.ua.edu/keel/agn/*

Kolesnik Y. B., 1995*, A&A **294**, 876*

Kolesnik Y.B., 1996*, in Dynamics, Ephemerides and Astrometry of the Solar System, S. Ferraz-Mello et.al. eds., Reidel, Dordrecht, p.477*

Kolesnik, Y. B., 2000, *Proceedings of the IAU 2000*

Krasinsky G. A., Pitjeva E.V., Sveshnikov M.L., Chunayeva L.I.,1993, *Cel. Mec. Dyn. Astron. **55**, 1*

LaViolette P.A.: 1986*, ApJl 301, 544-553*

Lemaître G.:1927*, Ann. Soc. Sci. Bruxelles **47A**, 49*

Lubin L. and Sandage A.*, 2001, astro-ph/0102213*

Lubin L. and Sandage A.*, 2001, astro-ph/0102214*

Lubin L. and Sandage A.*, 2001, astro-ph/0106563*

Lubin L. and Sandage A.*, 2001, astro-ph/0106566*

Maeder, A., 1977: *A&A. **65**, 337-343*

Masreliez C.J., 1999, "The Scale Expanding Cosmos Theory", *Ap&SS **266**, Issue 3, 399-447*

Masreliez, 2001, *"The Expanding Space time theory"*, www.estfound.org

Masreliez 2003, *"Optical observations and ranging"" ,* www.estfound.org

Masreliez 2003, *"Accelerating universe or tired light?",* www.estfound.org

Masreliez 2002, *"Explaining the Pioneer 10 acceleration anomaly", www.estfound.org*

Masreliez 2001, *"Gravitation in the Expanding Spacetime",* www.estfound.org

Masreliez 2002, *"A link between General Relativity and Quantum Mechanics", www.estfound.org*

Masreliez C.J, 2004, *"The Scale Expanding Cosmos Theory I- An Introduction ", Apeiron July, 11, p 99-133*

Metcalfe N. et. al.: 1995, *M.N.R.A.S. 273, 257-276*

Miser C. W., Thorne K. S. and Wheeler. J. A. 1970, *W. H. Freeman and Company*

Nelson E., 1979, "Connection between Brownian motion and quantum mechanics", *Lecture notes in Physics, vol.100, Springer, Berlin*

Nernst, 1937, *Z. für Physik* ***106****, 663*

Newton R.R.: 1985, "The Moon's Acceleration and its Physical Origins", *Vol.1&2, John Hopkin's University Press, 1984.*

Nottale L., 1993, "Fractal Space-Time and Microphysic", *World Scientific Publishing Co.*

Oesterwinter C., Cohen C.J., 1972, *Cel. Mech. 5, 317*

Perlmutter, S. et. al., 1995, *ApJ,* ***440,*** *41*

Perlmutter, S. et. al., 1997, *ApJ,* ***483****, 565*

Perlmutter, S, et. al., 1999, *ApJ,* ***517****, 565*

Perlmutter, S, 2003, *Physics Today, April (53-58)*

Poppe P. S. R., Leister N., Laclare F., Delmas C., 1999, *AJ* ***116****, 2574*

Reasenberg R.D., Shapiro I.I., 1978, in On the Measurement of Cosmological Variation Of the Gravitational Constant, *L. Halpern, Ed., Gainesville, University Press of Florida, p.71*

Riess et.al., 1996, *ApJ,* ***473,*** *88-109*

Riess, A. et. al.., 1997, *AJ,* ***114****, 722*

Riess, A. et. el., 1998, *AJ,* ***116****, 1009*

Riess, A. G. et al., 1999, *AJ,* ***118****, (2668-2674)*

Riess, A. G. et al., 2001, *astro-ph/0104455*

Slipher V. M., 1914, *17th Meeting of the A.A.S.*

Schmidt B. et.al., 1998, *ApJ, 507, 46*

Seidelman P. K., Santoro E. J., Pulkkinen K. F. 1985, *in Szebenhey V., Balazs B. (eds) Dynamical Astronomy, Austin, Texas, p. 55*

Seidelman P. K., Santoro E. J., Pulkkinen K. F. 1986, *in Kovalevsky J. and Brumberg V. A. (eds.) Relativity in Celestial Mechanics and Astrometry, Kluwer, Dordrecht, p. 99*

Seidelman P. K., 1992, Ferraz-Mello S. et al. *(eds.) Chaos, Resonance and Collective Dynamical Phenomena in the Solar System, Kluwer, Dordrecht, p. 49*

Sofue. Y and Rubin V., *2001, ARAA* ***39****, 137-174*

Spencer Jones:1939, *M.N.R.A.S.* ***99****,541*

Standish E. M. 1998, "Time scales in JPL and CfA Ephemerides",

A&A, ***336****, p. 381-384*

Standish E.M., Williams J.G., 1990, *in Lieske J.H. and Abalakin V.K. (eds.) Inertial Coordinate System on the Sky , Kluwer, Dordrecht, p.173*

Tolman R. C., 1930, *Proc. Nat. Acad. Sci.,* ***16****, 511*

Van Flandern, 2002, *"The Top 30 Problems with the Big Bang", Apeiron, April*

Weyl, H., 1921: *Raum-Zeit-Materie, Springer, see also Dover Ed., 1952*

Wright N., 2001, *web page: www.astro.ucla.edu/~wright/tiredlit.htm*

Yao Z-G., Smith C., 1988, in Débarbat S., Eddy J.A., Eichhorn H.K., Upgren A.R. (eds.) *Mapping the Sky, Kluwer, Dordrecht, p.501*

Yao Z-G., Smith C., 1991, *Ap&SS* ***177,*** *181*

Yao Z-G., Smith C., 1993, in Muller I.I. and Kolaczek B. (eds.) *Developments in Astrometry and Their Impact on Astrophysics and Geodynamics, Kluwer, Dordrecht, p.403*

Appendix 1. A locally Minkowskian coordinate system

Consider the variable transformation (Masreliez, 1999):

$$\begin{aligned} t' &= T\cdot\cosh(r/T)\cdot e^{t/T} \\ r' &= T\cdot\sinh(r/T)\cdot e^{t/T} \end{aligned} \tag{A1.1}$$

The SEC line element is transformed into:

$$ds^2 = dt'^2 - dr'^2 - (r\cdot e^{t/T})^2\cdot(d\theta^2 + \sin(\theta)^2\cdot d\varphi^2) \tag{A1.2}$$

where r and t are implicitly defined by (A1.1). For radial distances within the solar system $r << T$ it follows from (A1.1) that:

$$ds^2 = dt'^2 - dr'^2 - [r'\cdot(1+O(r/T)^2)]^2\cdot(d\theta^2 + \sin(\theta)^2\cdot d\varphi^2) \tag{A1.3}$$

The metrical coefficients of the line element (A1.3) differ from the Minkowski line element by a fraction $(r/T)^2$, which for the inner planets is of the order 10^{-28}.

I will show in my next paper in this series that gravitational potential in the SEC takes the form:

$$P = \frac{GM}{r}\left[1 + O\left(\frac{r}{T}\right)^2\right] \tag{A1.4}$$

For the inner planets there is no observable difference between Minkowskian spacetime and the line element (A1.2) since the total error from the transformation (A1.1) and the modified gravitational potential (A1.4) is of order $(r/T)^2$. Therefore, fitting the ranging data and time base to Post-Newtonian ephemerides will automatically select line element (A1.2) instead of the SEC line element. Perfect fit with Post-Newtonian orbits well within ranging accuracies will obtain, giving the impression that spacetime locally is Minkowskian. However, ephemeris time t' differs from atomic time t and the optical observations, which measure the planetary positions relative to the stellar background and use atomic time, detect planetary secular acceleration. Although the radial coordinates r and r' also differ, and this difference is smaller than the ranging uncertainties, it cannot be ignored since the diminishing radial distance contributes by $2w/T$ to the secular acceleration. The rest, which is w/T, comes from the tangential acceleration.

Appendix 2. AGN activities may explain the Cosmic Microwave Background

In the SEC universe Planck's black body spectrum is preserved during the cosmological expansion, which means that this spectrum automatically could arise from thermalization of existing electromagnetic radiation from various sources in the universe. On the other hand, the black body spectrum is not preserved in the SCM and the observed CMB spectrum cannot arise spontaneously. This has justified the assumption that the CMB initially was emitted as black body radiation at a very high temperature after the big bang and since then has cooled down with the spatial expansion.

If the CMB is electro-magnetic radiation in thermal equilibrium, whereby CMB energy lost due to tired light is replaced by energy radiated by various sources, we have:

$$(CMB\ energy\ density)/T = (Radiated\ power\ density)$$

I will show that AGN activity might account for the right hand side of this relation. Since matter in all galaxies flow toward the galaxy core, matter must in steady state be ejected from the cores and I will assume that the AGNs perform this function in the SEC universe. It can be shown that the galaxies structures we observe would be created if the mass flow rate toward the galaxy core were aM/T where M is the galaxy's mass and a is a fraction in the range 0.10-0.15 depending on the galaxy size.

With an average galaxy mass 10^{41} kg, the mass ejection rate per galaxy would be:

$$aM/T=2.5\ to\ 3.8\cdot 10^{22}\ kg/sec$$

If the fraction of this mass energy that is converted to electro-magnetic energy is p, the radiated power per galaxy is:

$$paMc^2/T=pc^2\cdot(2.5\ to\ 3.8)\cdot 10^{22}\ Watt=p(2.2\ to\ 3.3)\cdot 10^{39}\ W$$

This assumes continuous AGN radiation. Much higher power levels might be expected if AGN's release their energy in bursts. The estimated number is consistent with observed AGN intensities in the range 10^{38}-10^{42} W.

The average distance between galaxies is approximately 12 million light years so that the power density radiated by AGNs is estimated to be in the range:

$$1.3\ to\ 2.0\ p\ 10^{-30}\ W/m^3$$

assuming that an AGN becomes active in every galaxy from time to time.

On the other hand, due to tired light redshift the CMB loses energy at a rate (CMB energy density)/T, and since the CMB energy density is $4\ 10^{-14}$ J/m^3 we get:

$$(CMB\ energy\ density)/T = 10^{-31}\ W/m^3$$

Setting these expressions equal we find that the power added by AGN activity will match power lost by the CMB if *p=0.05-0.08.* Therefore, AGN activity might explain the CMB radiation if about 10% of a galaxy's mass is ejected by an AGN per Hubble time and 5 to 8% of this matter energy is converted into electro-magnetic energy. This brief analysis is based on the assumption that the AGNs dominate other radiation sources including the enigmatic gamma-ray bursts. The contribution from ordinary stars is estimated to be less than 10% of the AGN radiation.