MACHINERY OF EXPANSION OF THE UNIVERSE

Charles B. Leffert

Email: Leffert.charles9@gmail.com

ABSTRACT

The success of quantum theory shows that the Universe is much more complicated than most have supposed. How did our universe get started? What is energy? What is gravity? The late Richard Feynman in Volume 1 of his "Lectures on Physics" said that no one had come up with the machinery of either energy or gravity. However the machinery of both has been presented by the author in recent issues of this viXar archive and other publications. For the machinery of the expansion of the universe, a complete spatial condensation theory, with no free parameters, has been under development for the past 25 years. In that development, one important contact has been made with quantum theory; the expansion theory predicts exactly the same value of vacuum energy as quantum theory, a factor of 10^{123} greater than Einstein's mass energy, Mc^2. The new concepts, such as a fourth spatial dimension, and our ordinary space of three spatial dimensions as the surface of a four-dimensional ball, indicate that there are even more complexities needed to accomplish unification with quantum theory. Present physics uses a symmetric time and yet we know that from our subjective concepts of past-present-future that there is also an "Arrow" of time. This conundrum was solved by two different productions of space operating under two different times. Our universe started under the first radiation-dominated era with the arrow of time producing four-dimensional space. Then as radiation cooled and four-dimensional space continued, geometric production of our three-dimensional space with symmetric time increased in the matter-dominated era. Some additional plots of important parameters are presented as well as a new agreement with measurements of passive separation of galaxies. But in general the aim of this paper is to alert the reader to the background vision of a greater epi-universe as the source of quantum interaction with the present mass of matter and the vision of how our universe came to be.

PRELIMINARIES

A new model of the universe has been derived [1]. The new complete theory has no free parameters such as lambda or dark energy to adjust to fit measurements. All astronomical measurements so far presented are well- fit by its predictions. The new decelerating universe has three fixed parameters of content density : radiation, matter and dark mass which allow slight adjustment but otherwise the new theory is either correct or is to be discarded.

The geometry of many present models of our universe are selected from the three k-options of the Friedmann solutions of Einstein's field equations [2]. These are all rejected here because there can be only one solution. The k = 1 closed solution places all the three-dimensional (3-D) space into a closed sphere floating in an empty space. Sufficient enclosed mass can cause gravity to collapse such a structure as Einstein discovered on his first try at cosmology. Also photons in such a closed space are forced to follow null geodesic light cones where two space-like points outside the light cones cannot be visited by the same photon.

Now add a fourth spatial dimension (4-D) and a 4-D spatial ball and place our 3-D universe on its surface. That produces an altogether different 3-D universe. Now any two points in its surface can be visited by a single photon on the great circle connecting those points.

Much has been learned about our universe in recent years including its age, ~13.5 Gy, the Hubble constant, $H_0 \simeq 2.22x10^{-18} s^{-1}$ and its size, ~ $R_0 \simeq c/H_0 \approx 4400\ Mpc$, early nucleosynthesis of light elements, cosmic microwave background (CMB) and further confirmation of relativity theory. However there are also some major cosmologies problems that one might hope to solve with a new model. Those major problems include: (1) No beginning for cosmological models, including Big Bang (BB) model; (2) No source of energy for early inflation to explain large-scale uniformity; (3) Enormous quantum theory prediction of vacuum energy ($\approx 10^{200}$ ergs), a factor of $\approx 10^{123}$ greater than Einstein's mass energy, Mc^2; (4) No one has yet found the source of the arrow of time for "past-present-future" concepts; (5) Most present models of our 3-D universe correctly use Ro/R = (1 +z), but have a "future problem" where "time" gets distorted in the future $(-1 \le z \le 0)$; (6) In Volume 1 of his "Lectures on Physics" [3], Richard Feynman emphasized that no one has given the machinery of either energy or gravity; (7) Present physics has defined a concept of comoving coordinates for commoving observers who move along with the Hubble flow. Comoving bodies are assigned their present value that does not change with time. Such coordinates may be useful for sources of radiation that tend to move with the Hubble flow, but certainly not useful for the radiation itself since the photons of interest always move opposite the Hubble flow; (8) and finally, since neither lambda nor dark energy will be included as contents, the new theory must show the costly physical error of their use in recent SNIa exploding star models.

POSSIBILITIES

Some have said that cosmology is not a good discipline to work out new space-time theories. It seems to this author that the cosmological problems listed above are needed to inspire the new concepts to build the correct space-time theory. Our present physics, including relativity, is based on a symmetric time, so there is no hope of deriving the arrow of time from present physics. A fourth spatial dimension with our 3-D universe on the surface of a 4-D ball has already been mentioned. In order to avoid the symmetric time of present 3-D physics, a process is needed to produce the expansion of 3-D space which does not directly produce 3-D space. A unidirectional spatial condensation (SC) process will be attempted that produces 4-D spatial particles, which in turn is the cause of the production of 3-D space. This SC-process will solve a number of other problems, but it immediately introduces another problem (9); From what and how is 4-D space being produced? Somehow quantum theory must answer some of these problems. The mathematical structures of N-spheres [4] may be helpful (N = 3), where the volumetric time rate, shown by over-dot ($\dot{x} = dx/dt$), is proportional to the surface area.

Table 1·

Volume	$V_3 = 2\pi^2 R^3$	$V_4 = 1/2\ \pi^2\ R^4 = 1/4\, V_3 R$	(1)
Rate	$\dot{V}_3 = 6\pi^2 R^2 \dot{R}$	$\dot{V}_4 = 2\pi^2 R^3 \dot{R} = V_3 \dot{R} = 4 V_4 H$	(2)

Eventually it is hoped to derive a mathematical law for the expansion, but what information or building blocks are now available? Note that the universe does not know the size of the units we have chosen for our measurements of space, time and mass. So the physical constant of gravity , G, and velocity of light, c , were of limited use until Max Planck discovered his Planck constant, h [5], and the formation of Planck's natural units(subscript p),

Table 2

Length	$l_p = 1.616x10^{-33}$ cm	$N_r = r/l_p$	(3)
Time	$t_p = 5.391x10^{-44}$ s	$N_t = t/t_p$	(4)
Mass	$m_p = 2.177x10^{-5}$ g	$N_M = M/m_p$	(5)
Planck Constant	$\hbar = 1.055x10^{-27} cm^2 g\, s^{-1}$	$\hbar = h/2\pi$),	(6)
Expansion Redshift	z	(1 + z) = R_0/R	(7)

Dimensionless grouping of parameters are a favorite of Nature. Going the last step to numbers N in Table 2 is very useful even though such numbers become very large. Nature can certainly count. As example, the Schwarzschild radius of a non-rotating black hole, $r_s = 2GM/c^2$ and $G = c^2 l_p / m_p$ reduce the black hole to $N_{rs} = 2N_M$.

With Tables 1 and 2, sufficient information is now available to make the first estimate of the rate of production of 4-D space. From Equation 2 , $\dot{V}_4 = 1.47x10^{96}\ cm^4 s^{-1}$ and using Equation 3, $\dot{N}_4 = 2.16x10^{227}$ 4-D particles per second. If now $\dot{N}_4$ is multiplied by Planck's constant, one gets the vacuum energy of $E_4 = 2.3x10^{200}$ ergs in agreement with the predicted energy of quantum theory. But one gets more, the very definition of "Energy" follows,

$$E_{SC} \equiv \dot{N}_4 \hbar \qquad (8)$$

As indicated by problem (3) above, Einstein's $E = Mc^2$ cannot account for the quantum vacuum energy, but the new SC-energy can account for Einstein's energy. Can Equation 2 be re-written to better explain the new physics? $\dot{V}_4 = 1/4\left(2\pi^2 R^3\right)\dot{R} = \left(1/4\ \right)V_3\dot{R}$ and using Equation 3 gives,

$\dot{N}_4 = \left(1/4\right)N_3\dot{N}_R$. The 4-D cells inside the 4-D ball are not reproducing, the SC-production is all on the exposed surface cells. In the early universe $\dot{R}/c$ is enormous, but no internal cell of the radius is moving, again it is only the R-cell at the surface that receives a new cell every t_p s.

New Gravity

The new source for the expansion of our universe has worked out well. Before continuing with the development of expansion theory, are there any other problems that the expansion source can solve? What about Newton's problem of the machinery of attraction? It is almost unbelievable that a simple two-step translation can change Newton's gravitational "pull-force" to a gravitational "push-force".

In the new gravitational model, a mass M in our 3-D space causes a significant dimple of the surface of the 4-D ball because it is also bombarded by these condensing M-D spatial particles from epi-space. At a distance r outside the center of mass of M, mass M causes a local curvature of 3-D space, such that, relative to the radius R of the universe at r, the normal to the 3-D surface at r makes an angle theta, θ , such that the bombarding acceleration a_4 produces a_3 = $a_4 \sin\left(\theta\right)$.

The next step is to replace mass M by its equivalent black hole of mass M and set $\sin\left(\theta\right)$ to unity at the Schwarzschild radius, $r_s = 2GM/c^2$, of the black hole. That produces separate equations for a_4 and $\sin(\theta)$. Their product, $a_4 \sin(\theta)$, gives the same answer as Newton's equation.

$$a_4 = -\left(c^2/4l_p\right)\left(m_p/M\right) = -1.3922x10^{53}\left(m_p/M\right), cm/s^2 \quad (9)$$

$$\sin(\theta) = \left(2l_p/m_p\right)^2\left(M/r\right)^2 = 2.204x10^{-56}\left(M/r\right)^2, rad \quad (10)$$

For acceleration a_3 of -981 cm/s^2 at the surface of the Earth, $a_4 \sin(\theta)$ gives exactly the same value but in terms of the strong source of gravity, a_4 = 1.071x10^{20} cm/s^2, a factor of ~10^{20} times a_3, the component we measure here on Earth. The epi-bombardment of the entire surface of the universe, increases the internal pressure of the 4-D ball and counters its tendency to locally curve 3-D space, so $\sin(\theta)$ was only 1.932x10^{-18} rad. There is no need for quantum gravity. Gravity is global, not a quantum machine. The quantum machine is the source of the bombarding epi-space particles.

Upgrading Machinery

In the Early 90's astronomers found excess mass in the rotation curves of spiral galaxies and they called it a variant "dark matter" because it only interacted gravitationally with baryon matter. Very high collisional experiments have failed to find such 3-D particles. Also such excess mass will not fit into the new SC model since it scales as R^{-3} with the expansion. Instead with production of 4-D particles, it is called a variant 4-D particle of "dark mass" that scales with the expansion as R^{-2} and its density decreases with the expansion as it must.

Review of past Big Bang models show that the Hubble parameter H with units of inverse time, plays a major role; some cosmologists even call inverse H as time. An attempt will be made to derive the law of expansion in terms of time t instead of H. Dimensionless grouping of parameters will be sought and some assembled. Some are already suggested by their Planck units such as $G\rho t^2 = \left(l_p^2 l_p / t_p^2 m_p\right)\left(m_p / l_p^3\right) t_p^2 = 1$. Another, tH =1, will surely appear.

Law of Expansion

The difficult part of the derivation is to compose a simple space-time statement of the key parameters of the expansion that is correct over all time and it must be in the dimensionless language of the universe. The basic fixed parameters are shown in Table 3. Both space and time vary as our universe is dominated in turn by radiation, matter and finally dark mass. So we start with partial derivatives, $\partial/\partial R$, of the expression for the total density in Table 4.

Table 3

1. Age	t_0 = 13.5 Gy
2. Hubble constant	H_0 = 68.6 (km/s)/Mpc
3 Size	R_0 = 4388 Mpc:
4. Present radiation density	ρ_{r0} = 0.94x10^{-33} g/cm^{-3}
5. Present matter density	ρ_{m0} = 2.72x10^{-31} g/cm^{-3}
6. Present x-stuff density	ρ_{X0} = 2.191x10^{-30} g/cm^{-3}
7. Radiation Scale Factor	R^{-4}
8. Matter Scale Factor	R^{-3}
9. X-stuff Scale factor	R^{-2}

Table 4

$$\rho = \rho_{r0}\left(R_0/R\right)^4 + \rho_{m0}\left(R_0/R\right)^3 + \rho_{x0}\left(R_0/R\right)^2 \qquad (4.1)$$

$$\rho' = \partial\rho/\partial R = -2\,\rho_2/R\,, \qquad (4.2)$$

$$\rho_2 = 2\rho_r + (3/2)\,\rho_m + \rho_x\,. \qquad (4.3)$$

$$\rho'' = \partial^2\rho/\partial R^2 = -2\,\rho_3/R \qquad (4.4$$

$$\rho_3 = 4\rho_r + (9/4)\,\rho_m + \rho_x \qquad (4.5)$$

Ignoring composures that failed, start with the BB-expression for the critical density but re-interpret ρ as the total density and solve for H^2. Next, multiply just the right side by $4\left(\rho/\rho_2\right)^2$ and take the positive root to get,

$$H = \dot{R}/R = \left(32\pi G/3\right)^{1/2}\left(\rho/\rho_2\right)\rho^{1/2} \qquad (11\ )$$

One can verify that $\left(32\pi G\rho/3\right)^{1/2} = 1/t$ is a solution that on substitution gives,

$$tH = \rho/\rho_2\,. \qquad \left[1/2 \le tH \le 1\right] \qquad (13\ )$$

Squaring the solution gives for the "Law of the Expansion",

$$G\rho t^2 = \kappa = 3/32\pi\,. \qquad (14\ )$$

This new law must also hold for the present, ρ_0 and t_0, and combining the two equations gives a final equation for asymmetric time. The "Arrow of Time" has been found!

$$t = t_0\left(\rho_0/\rho\right)^{1/2}. \qquad (15)$$

Now we have the heart of the model. This is a great step forward. The value of the sixth fixed parameter, ρ_{x0} or Ω_{x0}, was not known, but now it can be calculated from the new law by difference. The total present density, ρ_0 = $\kappa/\left(Gt_0^2\right)$, so simply subtract, $\rho_{r0}+\rho_{m0}$, to get,

$$\rho_{x0} = \kappa/\left(Gt_0\right) - \rho_{r0} - \rho_{m0}. \qquad (16)$$

Using the BB-critical density, ρ_c = $3H^2/8\pi G$, Dimensionless densities are: Ω_{r0} = 0.00011, Ω_{m0} = 0.03075, and Ω_{X0} = 0.24771, Ω_0 =0.279. Note $\Omega_{m0}+\Omega_{x0}$, = 0.28, is in good agreement with WMAP measurements [6]. Other important equations can now be derived,

$$H(z) = H_0\left(\rho_{20}\Big/\rho_0^{3/2}\right)\left(\rho^{3/2}(z)\Big/\rho_2(z)\right) \qquad (17)$$

$$t(z) = t_0\rho_0^{1/2}x\left[\rho_{r0}(1+z)^4+\rho_{m0}(1+z)^3+\rho_{x0}(1+z)^2\right]^{-1/2} \qquad (18)$$

$$\dot{R}/c = (R/ct)(\rho/\rho_2) \qquad [10^{24}\geq \dot{R}/c \geq 1] \qquad (19)$$

$$q = -R\ddot{R}/\dot{R}^2 = \left(-1+\left(3-2\left(\rho\rho_3/\rho_2^2\right)\right)/tH\right) \qquad [1\geq q\geq 0] \qquad (20)$$

Progress has been made with the space-time of the new theory, but there is more to learn before adding photon behavior to the expanding universe.

The symbols for the present age and size of our universe are t_0 and R_0, respectively. Some cosmologists process them as constants of the universe. That could be a good approximation for the period of the "present plus or minus a century or two", but certainly not for the billions of years scale of the universe. Instead, for a different age, t_0', or size, R_0', of our universe, use a factor of change F (or f), as, R_0' = F R_0, and it turns out that the new redshift is,

$$z' = F(1+z)-1. \qquad (21)$$

Internal Expansion

From Equations (2), $\dot{V}_4$ expands the 4-D ball and geometry expands our 3-D universe, via $\dot{V}_3$. Next, move inside V_3 and consider the expansion of our ordinary 3-D space from a selected point, the origin z = 0, in Figure 1 on the surface of the Earth. The point is the present entrance to a telescope pointing in a fixed direction in the sky. Selection of this origin divides all of the photons in the universe into two groups; (1) those that could enter the telescope represented by the solid spiral curve, v = Hr – c, from positive space; and (2) all other photons. Although a telescope cannot measure CMB, some are also entering the telescope. Also shown in negative distance, are the photons, v = -(Hr + c), that just missed the Earth. The distance from z = 0 back along the curve to a emitting source is called the emission distance, ED. At reception the source is at RD = (1+z)ED. For photon energy loss, one must indeed integrate the equation,

$$v_c = dr/dt = Hr - c \qquad (22)$$

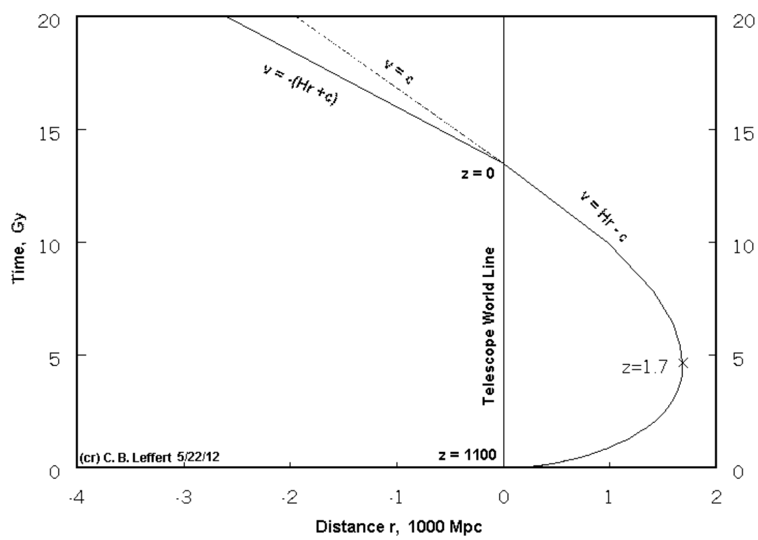

Figure 1 Space-time trajectory of photons to the telescope. Both z=1100 CMB, and z=10 star sources are near (0,0) and with their photons only a small distance from the world line, but are moving away. Photons that miss the Earth change velocity to, v = -(Hr + c) and are shown at negative r. Only at r = 0, z=0 does net v_c = -c; a very costly trajectory in photon energy.

The photons we measure are, and always were, moving against the Hubble flow. The scientific community has not yet awakened to the physics of Figure 1, even with a number of publications [1-References] and direct warnings [7, 8, 9]. The cost in thousands of wasted scientific man-hours searching for non-existent lambda and dark energy has been enormous and it continues today.

Photon Delay (PD) Effect

The expansion rate of one new 4-D spatial particle produced on every exposed 4-D spatial particle on the surface of the 4-D ball had to start with the first such 4-D particle that was produced in the mother Epi-universe. So the beginning $\dot{R}/c \approx 10^{24}$ was enormous as Equation (19) and Figure 1 show. In our surface universe, photons move in all 3-D directions. They move at velocity v = c relative to the local space. But relative to a distant point, origin, that distance is increasing so fast, it moves the photons and their embedding space, further away. Not until the Hubble parameter decreases in time to H < |c|/r can the photons begin to decrease the distance to the telescope. This Photon Delay (PD) effect must be evaluated by integrating the differential Equation (22). Direct integration, neglecting radiation, was accomplished, and numerical integration is shown in Figure 2. The PD-effect is sufficiently large that no photon has yet circumnavigated our 3-D universe.

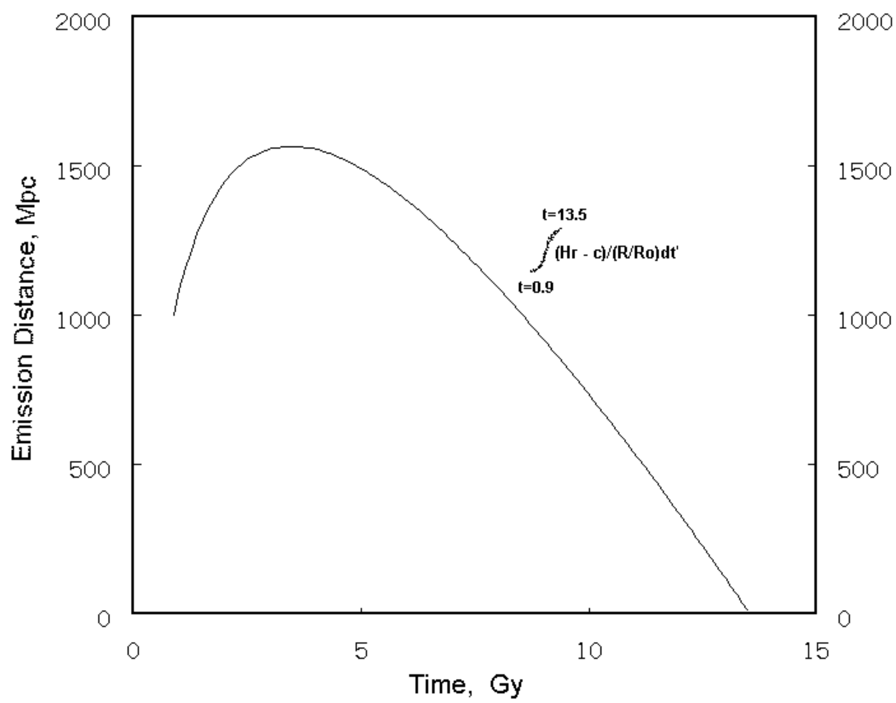

Figure 2 A packet of photons released at z = 10, t ~ 1 Gy, and ED = 1000 Mpc, made their way against the PD-effect, v_c =Hr – c, to arrive at the present. The run was repeated with the Hr term removed, the photons spiraled out to the present making about 30 orbits of the universe.

Had the packet been CMB photons, z ~ 1100, the photons would have made hundreds more very early orbits losing all pattern of the CMB.

To get a 4-D view from Epi-space of the trajectory of the photons, pass a plane through the center of the 4-D ball so that it includes the axis of the telescope as shown in Figure 3.

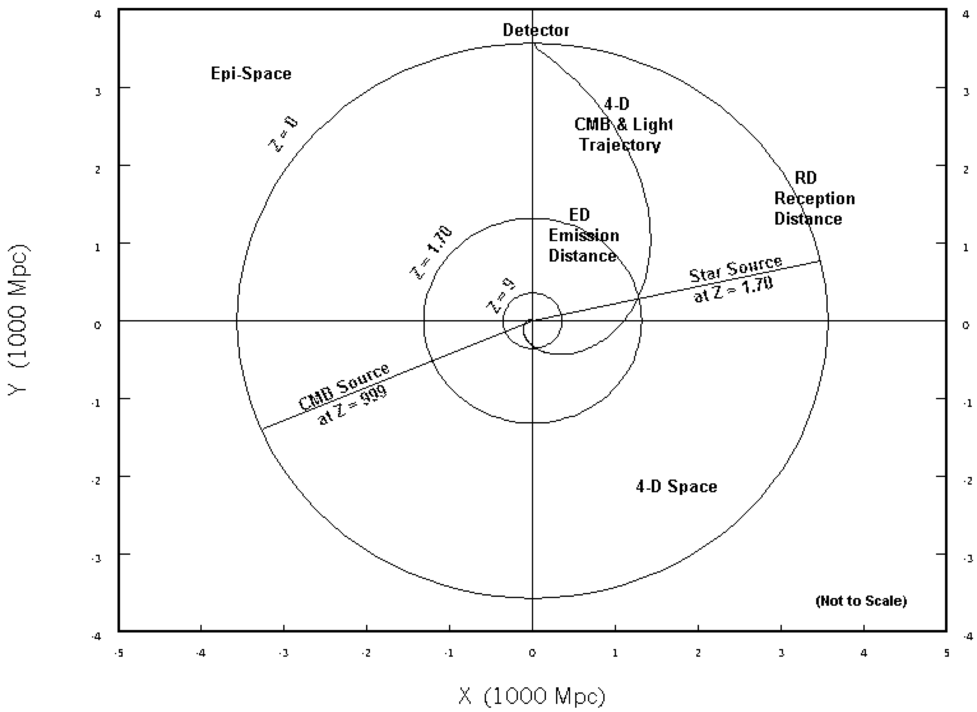

Figure 3 Our expanding 3-sphere universe viewed from epi-space. Photons travel on expanding circles, thus on the 4-D spiral generated by computer. The vertical radius is the world line of the telescope atoms. Note the arc length between is greatest at z = 1.7.

The magnitude scale m developed by astronomers for luminosity measurements is based on the luminosity of the Sun and is presented in most cosmology textbooks. However conversion of the measured energy flux of the photons to the luminosity distance d_L is another matter. For a static universe there is a well-known relation connecting energy flux F to an object of luminosity L at distance r, $F = L/4\pi r^2$. The next step is a trap for the unwary, "Increase r to d_L by all of the added physical expansion causes that decrease the energy of the photons." Few cosmologists follow the photons as in Figure 1, to get the luminosity distance d_L,

$$F = L/4\pi d_L^2 . \tag{23}$$

For the SC-theory include the static expression, for small z. Add (RD – ED) = zED for the expansion and multiply by (1 +z) for the two relativistic effects. Note that d_L = 0 for z = 0.

The luminosity distance expression derived for the SC-theory is,

$$d_L = \left(c\left(t_0 - t_{em}\right) + zED\right)\left(1 + z\right) . \tag{24}$$

The above PD-effect increases ED. The distance modulus for luminosity source is,

$$m - M = 5\log\left(d_L/10pc\right). \quad (25)$$

With the absolute magnitude M known, the apparent magnitude m is,

$$m = m\text{-}M + M. \quad (26)$$

For this paper, the absolute magnitude of SNIa explosions was set to M = -19.34 mag.

Most astronomical measurements related to the expansion of the universe involve the redshift and luminosity of arriving photons. However one set of measurements was obtained of slow passive separation of galaxies [10]. These measurements [11] provide the change in the Hubble parameter $H(z)/H_0$ versus the scale factor R/R_0 as shown in Figure 4.

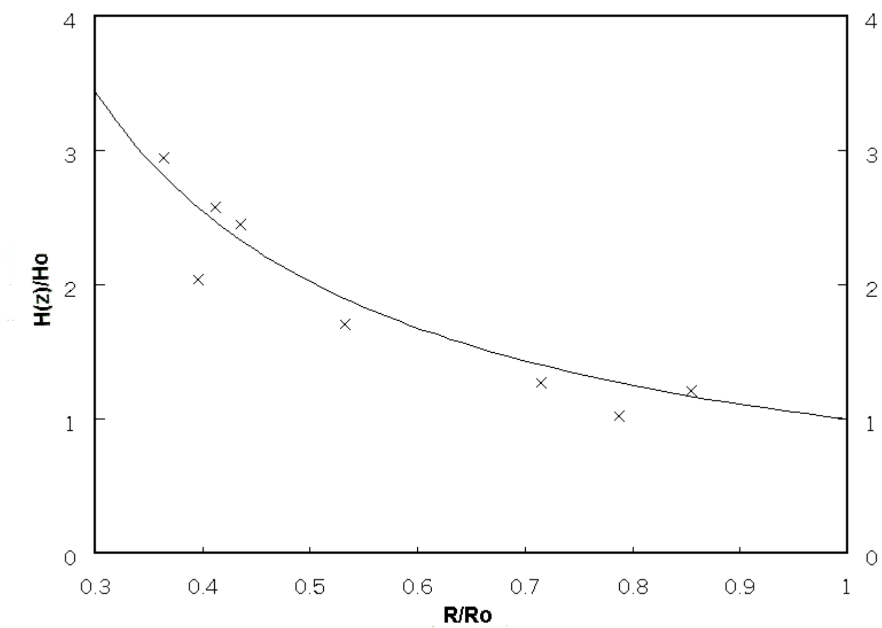

Figure 4 Measurement of passively separating galaxies that provide values of the Hubble Parameter, H, independent of redshift, are well fit by the new SC-expansion theory.

Expansion Redshift Measurements

With the claim of a new complete theory written in the mathematical language of nature, how well do its predictions of redshift measurements fit the astronomical data?

Begin with the High-z data of Riess, et al. in Figure 5.

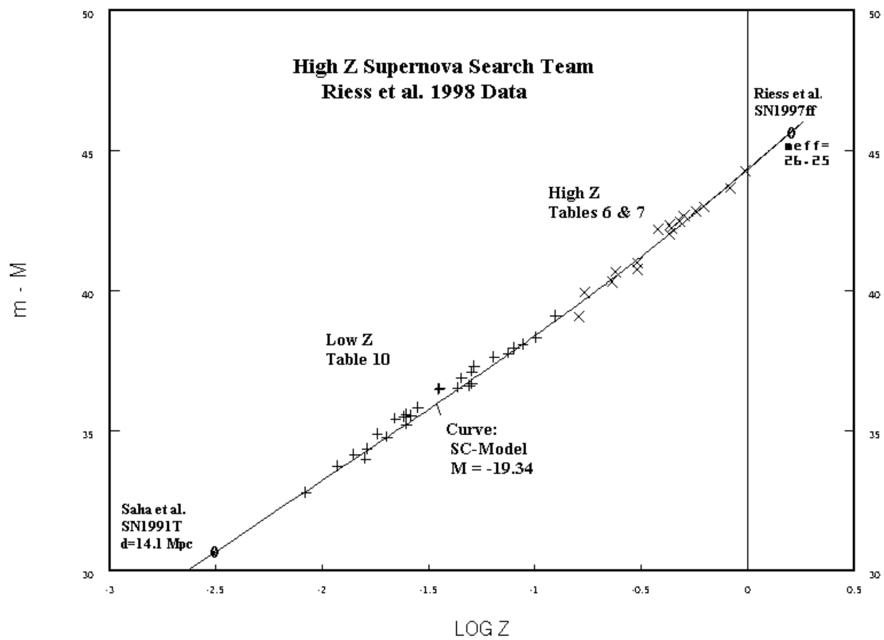

Figure 5 The SNIa data of the High Z Search team of Riess, et al.[12] are shown in log-log form. The SC predicted log-log theoretical curve also shows an excellent fit with no free parameters

The Hubble diagrams, m(z), of the data of the two SNIa search teams versus SC-theory have already been presented in the viXar archives [8, 9].

Discussion

The author is proud of the new SC-theory and its good fit to the SNIa data. The new theory with its spatial fourth dimension and dark mass is considerable different than the Big Bang ΛCDM theories of today. The often-quoted paper by Davis and Lineweaver [13] on the misconceptions in present theories on cosmology, was mentioned earlier as problem (7) of the "comoving coordinates". In the derivative of their Equation (19), they fail to include, $\dot{R}_0$, the derivative of the current radius of the 3-D universe. While that may be a good approximation over a few centuries of time, it certainly is not over the billions of years of increasing R_0. Also their Figure 6, with parametric curves cut off at x = 0, is dishonest. It is clear their curves with accelerated expansion would return to deceleration in the future, $\left(-1 \le z \le 0\right)$. The SC-curve on this plot, extended, is asymptotic to $\Delta z = 0$ at z = -1.

The BB-model acknowledges none of this physics with its ΛCDM infinite, $\Omega = 1$, universe and comoving coordinates. The components of the important SC-luminosity distance, d_L, resulting from this SC-emission distance, are shown in Fig. 6.

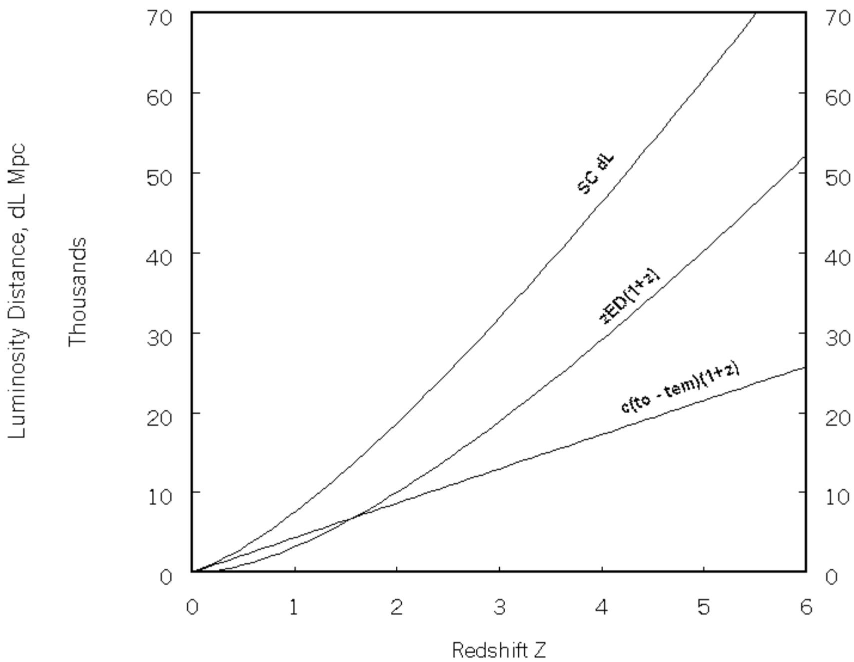

Figure 6 The SC-luminosity distance, d_L, is the sum of the component due to the 3-D distance to the source and that component solely due to the expansion. The photon delay effect is contained in the expression for the emission distance, ED.

An important difference between the two models is the scale factor difference for the extra non-baryonic mass. The GR-model considers it a variant form of matter scaling as R^{-3} but the SC-model considers it a variant form of 4-D mass scaling as R^{-2}, as shown in Figure 7.

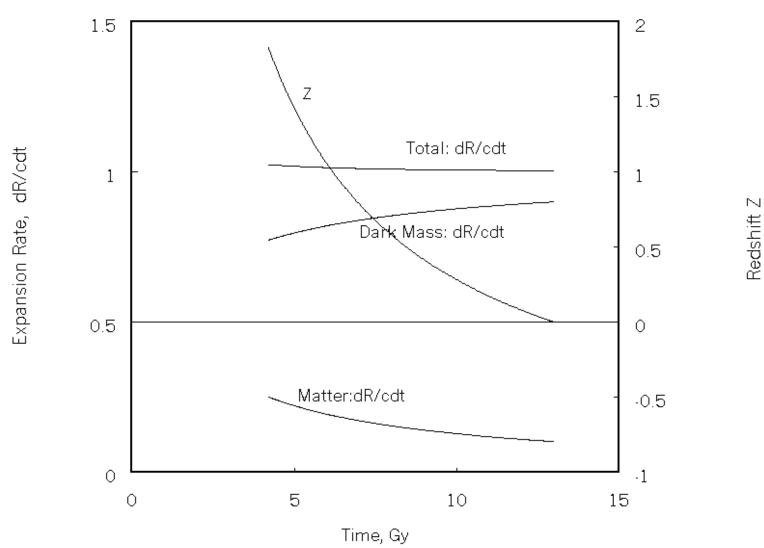

Figure 7 The difference of the SC-model that accounts for the fit to the supernova IA data is the strong contribution of the reproducing dark mass to the expansion rate $\dot{R}/c$ of the universe.

Global Predictions

So far in the development, the telescope has been on Earth at the present (R_0,t_0), If the new theory has captured the real space-time of our universe, one should be able to move to either future or past space-times $\left(R_0^{'}, t_0^{'}\right)$ and predict what hypothetical observers would measure with their hypothetical telescopes at their z' of choice. At the beginning of the computer program, a factor F is requested and if F is different than unity, then $R'_0 = FR_0$. A separate program or subroutine can provide t'_0 corresponding to R'_0. Fortunately it turns out that z' = F(1 + z) – 1.

An example will be presented where time, t, and space, R, increase to the right but redshift z has a different basis, $z = \left(1/\left(R/R_0\right)\right) - 1$, so if $R/R_0 > 1$, z < 0, and photons cannot be received from the future, that is negative z. For the first example, from Figure 6, seven High-z Gold SNIa of Riess, et al. were projected back to an earlier time t = 6.4 Gy and size, f = R/R_0 = 0.5, and all seven appeared on its solid constant-time theoretical curve. Then the seven were projected further back to f = 0.4 at t = 5.0 Gy with the results of Figure 8.

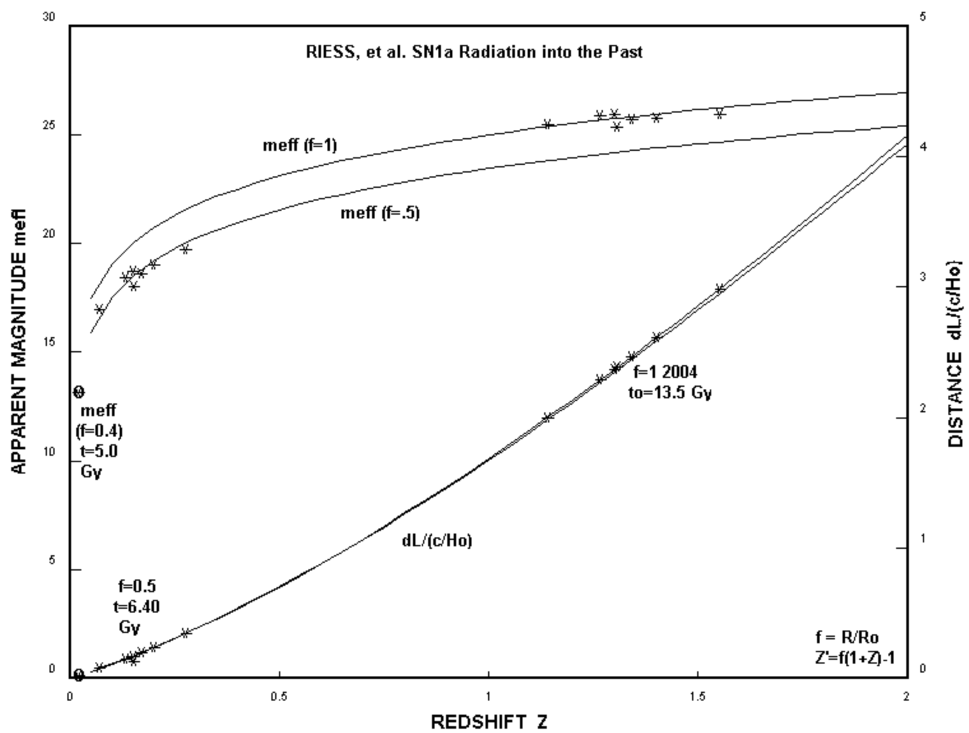

Figure 8 Projection of high-z redshift SNIa measurements back to early hypothetical observers. For f =0.5 ,all seven appear, but for f = 0.4, only one, appears; the other six have not yet exploded. Also shown is the universal curve for d_L divided by c/H_0 = 4400 Mpc.

One who tries to model nature with mathematical equations is always on the lookout for means to check the accuracy of his work, something more revealing than just reading the computer code. It occurred to the author that something might be learned by trying to simulate a technique called “Radar Ranging”, where the distance to one of our planets is obtained by bouncing a radar beam photons off its surface. Their timing and distance are not yet accurate enough to determine if the out trip is shorter than the back trip.

With a computer one can simply fire a photon forward into 3-D space, $v = Hr + c$, a distance to a preset r = r_{max} , stop and reverse velocity, $v = -\left(Hr - c\right)$, and fire the photon back to the starting point. Examination of Figure 1 predicts that if the reverse of direction occurs at z > 1.7, (Hr > |c|, then the photon will continue forward a short distance before actually reversing direction. Figure 9 shows the result.

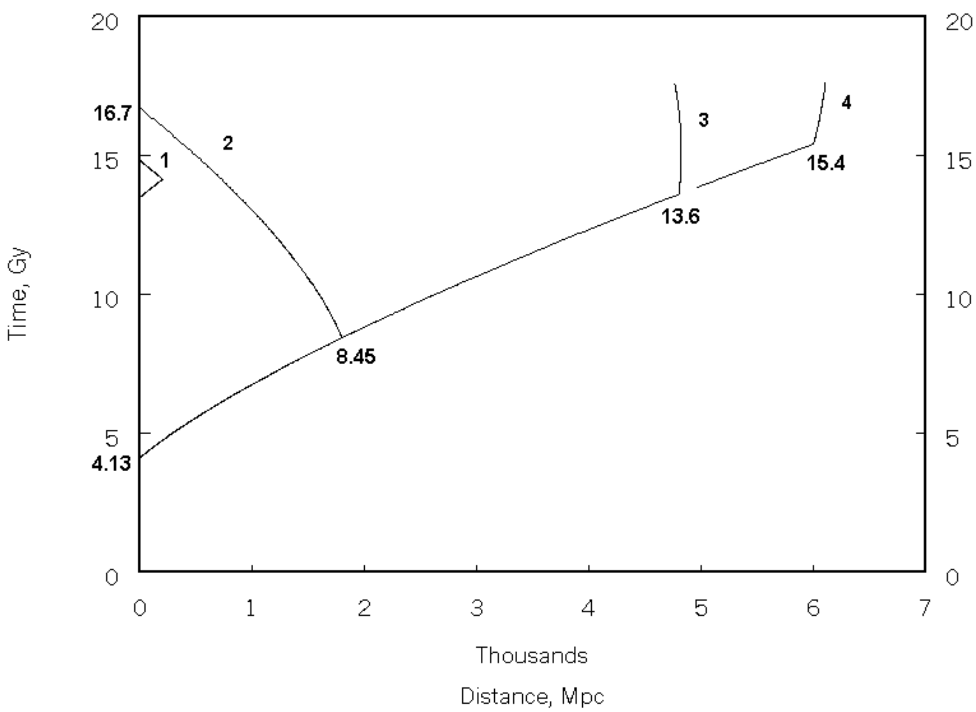

Figure 9 Computer Radar Ranging to confirm the Photon Delay effect, Hr > |c|. Run 1 was made for the present to 20 Mpc. Runs 2, 3, 4 were made from F = 1/3at age t_0 =4.07 Gy. Not until r_{max} = 4800 Mpc did PD- effect appear and was confirmed by stronger effect at 6000 Mpc.

Any would-be cosmologist must study and accept the expansion picture of Figure 1.

There are many more plots available of various parameters of the new theory [1], but the balance of this paper will be dedicated to an analysis of deeper questions of what has been obtained and what further can be obtained.

Summary

Proof of completeness of the new theory was shown by the ability to move around freely in our universe in both the past and the future, and computer radar confirmation of the basic PD-effect. But Hubble's simple linear law for the expansion of the universe with small corrections for peculiar velocities gives the impression that the correct space-time theory should also be rather simple. Unfortunately many have been so-persuaded as shown by simple comoving coordinate concepts.

The first contact and agreement with quantum theory follows in the next two paragraphs.

In the beginning during the era of radiation domination, there was only one time, the asymmetric, $t = \sqrt{3/32\pi G\rho}$. Then during matter domination, another time became operable, a symmetric time for our 3-D universe. The asymmetric time (with the arrow) continued for the SC-4-D expansion of space. The added fourth dimension and the production of 4-D special cells, l_p^4 , to expand the 4-D ball is fundamental to the SC-theory. But except for the 3-sphere mathematics, no hypothesis of cellular 3-D space was necessary, although 3-D cells of volume, l_p^3 , were used

On the other hand it was discovered that the spatial condensation rate on the bare surface of the 4-D ball agreed exactly with quantum theory for vacuum energy. That equality also finally defined a long-standing unknown, a definition of energy, $E = \dot{N}_4 \hbar$, including Einstein's rest mass energy, Mc^2. If production of 4-D space is energy, how can our 3-D space have energy? Finally one must consider the interaction between epi-space and our universe. Anticipating this problem, a guiding principle was formed that any foreign object in epi-space would support catalytic spatial condensation. Therefore the massive particles in 3-D space must support SC.

The SC-production on the 4-D ball was a simple self-controlled process with the next 4-D Cell immediately stopping SC on the previous 4-D cell. With a mass particle, the SC-process continues to provide the energy with the new 4-D cells falling to the bare surface of the 4-D ball. But a matter particle contains many different types of smaller particles such as electrons and quarks that probably require two-way communication consisting of alternate one-way communication.

Now suppose the characteristic epi-time is many orders of magnitude smaller than Planck time, t_p, could it be that what are considered dual states in our relative slow 3-D time, are really rapid oscillations between fixed states in epi- time?

On the subject of beginnings, for the purposes of this paper the author was satisfied with the following symmetry-breaking concept. The old pre-existing Epi-universe could barely support its 10 spatial dimensions and at one point a 4-D spatial particle was produced. This was a foreign particle in Epi-space and a catalytic site for further production of such new 4-D particles. Exponential production of free such particles followed. However a 4-D particle occupies less volume than the total volume of the Epi-particles that formed it. Thus the in-coming Epi-space drove the free 4-D particles into a 4-D ball, with continued SC on its surface. The 9-D region grew faster than the 4-D ball and the reduced M-D pressure ended further production of new universes.

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