THE ORIGIN AND EXISTENCE

OF THE UNIVERSE

-

THE DEVELOPMENT OF

FULL DYNAMIC CHARACTERISTICS.

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ABSTRACT.

This paper presents the full dynamic characteristics of the Universe, as represented by Relativistic Domain theory developed in previous papers.

CONTENTS.

APPENDICES.

1.0 Introduction.

This paper presents the full dynamic characteristics of the Universe as represented by Relativistic Domain theory. There are eight parameters explored, covering such topics as the diameter of the Universe today, and the position of the Milky Way, (Earth), within it; galactic recession velocity and acceleration rates and the Hubble parameter and its gradient and temporal variations; and finally, the variation of temporal rates, and the speed of light. Where possible comparison with "mainstream" theory is also effected.

For full appreciation of this paper, it is essential that references [1], [2] and [3] be read first.

2.0 Determination of the Law of Recession Velocity.

2.1 Preamble.

In [1], the equation for the Hubble parameter, H_0, [1], Eq.(2.24), was derived from [1], Eq.(2.19), which was in fact the velocity of a celestial body in Phase I of the development of the Universe, i.e. during its contraction phase. This derivation was valid because the same gravitational mass drives both the contraction and expansion phases. However, some considerable simplification was employed in that analysis to enable the derivation of a value of H_0 for comparison with empirical results. While adequate for that purpose, it is not for the requirements of the derivations in this paper. Therefore, a more appropriate formulation for H_0 will be developed here from the conditions governing the expansion phase. This initially requires the development of the law of galactic recession.

2.2 The Recession Velocity Law.

It can easily be shown that in Phase II, the expansion phase, the velocity of a galactic body receding from the centre of the Universe is given by

$$\dot{\sigma} = cu_i\left(\frac{u_i^2}{u_0^2} - 1\right)^{1/2} \qquad (2.1)$$

where

- u_i is the temporal rate of the receding galactic object at σ_i, its radial position.
- u_0 is the temporal rate at σ_0, the initial radial position of the receding galactic object, i.e. at the point of inflexion.
- c is the velocity of light in Pseudo-Euclidean Space-Time, (It will be shown in this paper that this is different from the velocity of light at the Earth's surface).

and where $u_i \geq u_0$ in an anti-gravity field. Hence it is necessary to determine appropriate relationships for both u_i and u_0.

Now u_i contains both gravitational and velocity, (Special Relativity), modifiers and, from [5], is given by

$$u_i = \left(1 - \frac{\alpha_u \sigma_i^2}{\sigma_u^3} - \frac{\dot{\sigma}^2}{c^2 u_i^2}\right)^{1/2} \qquad (2.2)$$

where

α_u is the gravitational radius of the Universe.
σ_u is the physical radius of the Universe.

Solving (2.2) for $\dot{\sigma}_i$ gives

$$\dot{\sigma}_i = cu_i\left(1 - u_i^2 - \frac{\alpha_u \sigma_i^2}{\sigma_u^3}\right)^{1/2} \tag{2.3}$$

Now equating (2.1) and (2.3) gives

$$u_i = u_0\left(\frac{2 - \dfrac{\alpha_u \sigma_i^2}{\sigma_u^3}}{1 + u_0}\right)^{1/2} \tag{2.4}$$

Substitution of (2.4) back into (2.1) gives after some minor reduction

$$\dot{\sigma}_i = \frac{cu_0\left(2 - \dfrac{\alpha_u \sigma_i^2}{\sigma_u^3}\right)}{1 + u_0^2}\left(1 - \frac{\alpha_u \sigma_i^2}{\sigma_u^3} - u_0^2\right)^{1/2} \tag{2.5}$$

In (2.5), $\dot{\sigma}_i$ will be determined by expressing σ_i as a linear function of σ_u i.e. $\sigma_i = k\sigma_u$, where $k \le 1$. Thus

$$\dot{\sigma}_i = \frac{cu_0\left(2 - \dfrac{k^2 \alpha_u}{\sigma_u}\right)}{1 + u_0^2}\left(1 - \frac{k^2 \alpha_u}{\sigma_u} - u_0^2\right)^{1/2} \tag{2.6}$$

To determine u_0, note that $\dot{\sigma}_i = 0$ at the point of inflexion, i.e. when $\sigma_u = \sigma_{u0} = 2\alpha_u$. Thus from the final term in (2.6),

$$u_0 = \left(1 - \frac{k^2}{2}\right)^{1/2} \tag{2.7}$$

But from (2.2)

$$u_0 = \left(1 - \frac{\alpha_u \sigma_0^2}{\sigma_{u0}^3}\right)^{1/2} \tag{2.8}$$

and equating (2.7) and (2.8) gives

$$\frac{\sigma_0}{\sigma_{u0}} = k \tag{2.9}$$

which shows that for all galactic objects, k is independent of σ_i.

Thus substitution of (2.7) into (2.6) finally gives

$$\dot{\sigma}_i = \frac{ck\left(1-\frac{k^2}{2}\right)^{1/2}\left(2-\frac{k^2\alpha_u}{\sigma_u}\right)^{1/2}\left(1-\frac{2\alpha_u}{\sigma_u}\right)^{1/2}}{\sqrt{2}\left(2-\frac{k^2}{2}\right)} \tag{2.10}$$

This equation represents the law of galactic recession in the expansion phase of the Relativistic Domain Universe. Note that:

At the very centre of the Universe, $k = 0$ so that $\dot{\sigma}_i = 0$ whatever the value of σ_u.

When $\sigma_u = \sigma_{u0} = 2\alpha_u$ i.e. at the point of inflexion, $\dot{\sigma}_i = 0$ whatever the value of k.

Also note that (2.10) is different from Hubble's Law which is discussed below in Section 3.7.

3.0 Calculation of Dynamic Characteristics.

In order to determine the dynamic physical characteristics of the Universe, it is first necessary to obtain three specific parameters. They are first, a value for the diameter of the Universe at the present day, secondly a value for k for the position of the Milky Way, (Earth), within it, and lastly a value for the velocity of light in Pseudo-Euclidean Space-Time, i.e. in the absence of a gravitational field.

3.1 The Diameter of the Universe at the Present Day.

This parameter is obtained by putting $k = 1$ in (2.10) and integrating. Thus (2.10) becomes

$$\dot{\sigma}_u = \frac{c}{3}\left(2-5\frac{\alpha_u}{\sigma_u}+2\frac{\alpha_u^2}{\sigma_u^2}\right)^{1/2} \tag{3.1}$$

where

$\dot{\sigma}_u$ is the recession rate at the boundary of the Universe.

Converting (3.1) into an integrable version gives

$$\frac{\sigma_u d\sigma_u}{\left(2\sigma_u^2-5\alpha_u\sigma_u+2\alpha_u^2\right)^{1/2}} = \frac{c}{3}d\tau_u \tag{3.2}$$

Eq.(3.2) is a standard integral that evaluates to

$$\frac{3}{2}\left(2\sigma_u^2-5\alpha_u\sigma_u+2\alpha_u^2\right)^{1/2}+\frac{15}{\sqrt{32}}\alpha_u \boldsymbol{cosh}^{-1}\left(\frac{4\sigma_u-5\alpha_u}{3\alpha_u}\right) = c\tau_u \tag{3.3}$$

where the constant of integration is zero and τ_u is the time at the boundary of the Universe.

Eq.(3.3) in not invertible and is therefore graphed in Appendix A.1 from which the value of σ_u for τ_u = 15 billion years is 5.9 x 10^{27} cms. (15 billion years is the speculative time chosen in [1] for the age of the expansion phase of the Universe). The above figure for σ_u is in conflict with that determined in [1] when τ_u was proposed to be 9 billion years as the cosmological time of applicability for the observational data used in [1]. To resolve this conflict it is necessary to pre-empt results in later Sections of this paper, where the age of the expansion phase of the Universe is amended to 20 billion years. This results in a present day radius of the Universe, from Appendix A.1 of 7.12 x 10^{27} cms, (~7.6 x 10^9 light years).

3.2 Position of the Milky Way, (Earth).

It is not possible to calculate this parameter because the initial condition for the Earth, σ_0, is not known and there are no specific observational data from which reference can be taken. This parameter can therefore only be speculatively assigned on the basis of general observational results. Thus, if the centre of the Universe were visible, and if an observer were relatively close, it would be expected that it would be recognisable. Consequently, with the radius of the Universe determined as above, and with the observational capabilities available with modern technology, the distance of the Earth from the centre of the Universe must be such that the latter, if visible, is not discernible from other celestial bodies located closer.

Similarly, if the Earth were located close to the boundary of the Universe, observation of the outer Cosmos may reveal different characteristics to those currently apparent, although this may not be so readily obvious as in the opposite case above.

Consequently, for these combined reasons, it is proposed that the best speculative position to locate the Earth and its parent galaxy is at some 50% of the radius of the Universe, i.e. k = 0.5.

3.3 Temporal Rate Variation.

It is necessary to determine this variation in order to obtain the velocity of light in Pseudo-Euclidean Space-Time.

The rate at which time passes in the Universe is given by the parameter u_i of [1] Eq.(2.18), i.e.

$$u_i = \left(1 - \frac{\alpha_u \sigma_i^2}{\sigma_u^3}\right)^{1/2} \qquad (3.4)$$

Note that (3.4) differs from (2.2) because (3.4) contains only a gravitational effect whereas (2.2) also contains the Special Relativistic effect due to the velocity of recession.

Eq.(3.4) contains both σ_i and σ_u and therefore possesses both a gradient across the Universe, (the σ_i effect), and a variation with time, (the σ_u effect as the Universe expands). These variations are graphed in Appendix A.2.

3.4 The Velocity of Light.

The velocity of light in a gravitational field has been shown to be

$$v_l = cu_i \qquad (3.5)$$

where now

c is the velocity of light in Pseudo-Euclidean Space-Time

Consequently, by virtue of its relationship to u_i, v_l contains both a gradient throughout the Universe and a variation with time. These variations are effectively shown by the variations of u_i in Appendix A.2.

The velocity of light at the Earth's surface has been measured very accurately and to four decimal places is 2.9979 x 10^{10} cms/sec. This enables a figure for c in (3.5) to be calculated by inserting the appropriate parametric values for σ_i and σ_u together with that for α_u into (3.4) and (3.5).
Thus using 7.2 x 10^{27} cms for σ_u and 3.6 x 10^{27} cms for σ_i, the position of the Milky Way, (Earth), and with α_u = 1.22 x 10^{27} cms, [1], and v_l at the Earth's surface of 2.9979 x 10^{10} cms/sec., from (3.4) and (3.5) c is determined to be

$$c = \frac{v_l}{u_i} = 3.0643 \times 10^{10} \text{ cms/sec.} \tag{3.6}$$

as the velocity of light at the centre of the Universe and in pure Pseudo-Euclidean Space-Time.

3.5 Galactic Recession Velocities.

With the data now determined in Sections 3.1 to 3.4 above, it is now possible, by inserting the appropriate parameters into (2.10), to calculate the recession velocities of celestial bodies for a range of values of σ_u and k. The results are graphed in Appendix A.3 for values of σ_u of from 5.0 x 10^{27} cms to 8 x 10^{27} cms and values of k from 0.2 to 1.0 in steps of 0.2. In particular, the recession velocity of the Milky Way is shown to be ~8.59 x 10^9 cms/sec.

3.6 Galactic Recession Accelerations.

All receding celestial bodies will be subject to the anti-gravitational field of the expansion phase and their recession velocities will therefore continue to increase. The level of acceleration applied by the field is obtained by differentiating (2.10) with respect to the time which results in

$$\ddot{\sigma}_i = \frac{k\left(1-\frac{k^2}{2}\right)^{1/2}}{\sqrt{72}\left(2-\frac{k^2}{2}\right)}\left(\frac{\gamma M_u}{\sigma_u^2}\right)\frac{\left\{k^2+4\left(1-\frac{k^2\alpha_u}{\sigma_u}\right)\right\}\left\{2-5\frac{\alpha_u}{\sigma_u}+2\frac{\alpha_u^2}{\sigma_u^2}\right\}^{1/2}}{\left\{2-\left(k^2+4\right)\frac{\alpha_u}{\sigma_u}+2\frac{\alpha_u^2}{\sigma_u^2}\right\}^{1/2}} \tag{3.7}$$

Note the appearance of the Acceleration Potential term in this equation.

Insertion of the appropriate parameters into (3.7) allows calculation of the acceleration levels which are also graphed, Appendix A.4, for values of σ_u of from 5.0 x 10^{27} cms to 8 x 10^{27} cms and values of k from 0.2 to 1.0 in steps of 0.2. In particular, the recession acceleration of the Milky Way is shown to be ~1.7 x 10^{-9} cms/sec^2.

3.7 The Hubble Parameter and its Gradient and Temporal Variations.

The value of the Hubble Parameter determined in [1] was an approximate value derived from a simplified analysis for comparison with the extant empirical figure at the time that [1] was prepared. To properly determine this parameter theoretically, it is necessary to mimic the manner of observational determination. To do this, firstly, because H_0 is a function of galactic recession velocities, and these are very sensitive to the value of σ_u, as shown in (2.10), it is necessary to adjust the age of the expansion phase of the Universe to a value that results in a appropriate value for σ_u at the present day. Thus the age of the expansion phase was, as stated in Section 3.1 increased to a nominal 20 billion years, (from 15 billion years), to give a present day value of σ_u of 7.2 x 10^{27} cms.
It is also noted that in (2.10) recession velocities are also a function of k. However, it is seen from Appendix A.3 that this dependency is less critical and the value selected for the Earth, (k = 0.5), is appropriate. Also, it is necessary take account of the direction of observation of a celestial body in the relation to the radial vector direction of the Earth's recession velocity. The manner in which these conditions are inserted in the determination of H_0 are described below.

First note that the observational determination of H_0 is given by

$$H_0 = \frac{V_{EL} - V_{GL}}{D} \tag{3.8}$$

where

V_{GL} is that component of recession velocity of the object under observation along the "line of sight" of the object to the Earth.

v_{EL} is that component of the Earth's recession velocity along the "line of sight" of the object to the Earth.

D is the "distance" between the object under observation and the Earth.

It is important to note that all three parameters are subject to the time of flight of light rays emitted by the object under observation in their travel to the Earth.

If the radial velocities of recession of the object under observation and the Earth, as given by (2.10) are V_{GR} and V_{ER} then

$$V_{GL} = V_{GR}\left(1 - \frac{\sigma_E^2}{D^2}\boldsymbol{sin}^2\phi\right)^{1/2} \tag{3.9}$$

and

$$V_{EL} = V_{ER}\left\{\left(1 - \frac{\sigma_E^2}{D^2}\boldsymbol{sin}^2\phi\right)^{1/2} - \frac{\sigma_E}{D}\boldsymbol{sin}^2\phi\right\} \tag{3.10}$$

where

σ_E is the position of the Earth from the centre of the Universe.

ϕ is the angle of the recession velocity vector of the object under observation to that of the Earth.

The geometry governing (3.9) and (3.10) is shown in Appendix B.

In determining the distance between the object under observation and the Earth, it is necessary to compensate for the velocity of light at each location. At the object this would be cu_i and at the Earth cu_E. During the transit time from the point of emission to the point of reception the velocity of the light ray would gradually change from the former of these values to the latter. Therefore, the distance of an object that emitted a light ray τ_E seconds in the past would be

$$D = c\tau_E \frac{(u_i - u_E)}{2} \tag{3.11}$$

Note that this assumes a linear rate of change of the velocity of light along the path between the point of emission and the point of observation. Reference to A.2 shows this to be a not unreasonable assumption.

Now, from (2.10), (3.4), (3.5), (3.6) (3.8), (3.9), (3.10) and (3.11) and the values for σ_u for the present day and k = 0.5 for the position of the Earth, the values of H_0 can be determined for the following three scenarios.

(i) For galactic objects with a recessional velocity vector lying along the same direction as that as the Earth. These calculations cover a range of distances from 0.5 x 10^9 light years to 3.0 x 10^9 light years. The results are graphed in Appendix A.5. Also shown are the extreme values and median of H_0 reported in [4], as determined from observation of type 1a supernova. Note that the gap in all plots at zero is because H_0 has no value at zero distance.

(ii) For galactic objects at a distance of 2 billion light years, for an observation angle to Earth's recessional velocity vector of from 0 to 180 degrees. These results are graphed in Appendix A.6.

(iii) For galactic objects as in (i) but for a distance of 2 billion light years over a period of age of the expansion phase of the Universe of from 10 billion years to 35 billion years. These results are graphed in Appendix A.7.

4.0 Discussion of Results.

Reference is to be made to the Appendices in effecting these comments.

4.1 The Diameter of the Universe.

The diameter of the Universe at the present day, as estimated at 14.24 x 10^{27} cms., (~15.2 x 10^9 light years), is considerably at odds with that estimated currently in the "Big Bang" theory at some 43 billion light years.
The value determined here is of course limited by the restriction of the Special Theory of Relativity, that the recessional velocity of all celestial bodies can never exceed, (or even attain), the velocity of light. In the "Big Bang" theory, with a diameter as above, and an age of some 13.7 billion years, clearly the expansion requires recessional velocities substantially greater than the velocity of light. This is explained in that theory by the introduction of a concept known as co-moving distances. This involves the continuing creation of space between the galaxies which imparts a separation velocity purportedly not subject to the restriction of Special Relativity. However, this concept appears to contradict the original "Big Bang" idea in that the expansion is no longer just due to the initial "explosion" and period of "inflation", but that the creation of space is still occurring between all celestial bodies and presumably between every atom that makes up those celestial bodies etc. It is believed that this exacerbates the anomaly as to a lack of explanation for the mechanism behind the "Big Bang", because that mechanism must presumably still be in operation today. This is considered to be one of the most serious anomalies concerning the "Big Bang" theory.

4.2 The Position of the Earth, (Milky Way), in the Universe.

The speculative positioning of the Milky Way at halfway between the centre and boundary of the Universe in this theory, has enabled very acceptable results for the parameters studied to be determined. However, those parameters are not critically sensitive to the value of k for the Earth, and a value anywhere between 0.4 and 0.6 would probably prove adequate.

4.3 Temporal Rates.

While this parameter is central to the theory, its gradient across the whole Universe today only varies from 1.0 at the centre to 0.91 at the boundary. Similarly, its maximum variation at the boundary as the Universe expands is only 0.87 at σ_u = 5.0 x 10^{27} cms. to a value of 0.92 at σ_u = 8 x 10^{27} cms. Consequently, at any particular location, such as the Earth, either variation would be unmeasurable.

4.4 The Velocity of Light.

In accordance with the discussion above the variation in the velocity of light from the centre to the boundary at the present day is only 9%. This is only 3.92 x 10^{-19} cm/sec/cm, again unmeasurable.

4.5 Galactic Recession Velocities.

The radial recession velocities of all celestial bodies conform very closely to Hubble's Law out to approximately 3.5 x 10^{27} cms. This is a necessity if Hubble's Law is to be valid for observations in any direction from the Earth. These results are of course based upon a re-assessed age of the expansion phase to ensure that the above conformance was obtained. Thus the theory has been adjusted to enable concurrence with observation. However, in any theory, in which there are very limited empirical data for comparison, such adjustments from previous speculative assessments are acceptable provided they are not too extreme. Accordingly, the 25% adjustment in expansion age incorporated here is not considered unreasonable.

4.6 Galactic Recession Accelerations

In a Relativistic Domain Universe in which the driving mechanism is an anti-gravity field, it would be expected that the rate of expansion would accelerate. This is exemplified here. The gradients are virtually linear as is obvious from (3.7) where for a constant σ_u the only variable is k. Also, as would be expected, as the Universe expanded and its average density decreased, the anti-gravity field would weaken and the resulting recession acceleration also decrease. Again the variation is close to linear.

4.7 The Hubble Parameter and its Gradient and Temporal Variations.

4.7.1 The Gradient.

The Hubble parameter as now determined in this paper, exhibits excellent agreement with the median value obtained via observation of type 1a supernova. The median value determined here, from both on and off radial calculations is 2.26 x 10^{-18} $secs^{-1}$, while that from observations, [4], is 2.27 x 10^{-18} $secs^{-1}$. What is however, possibly more significant, is the variability of H_0 both as a gradient across the Universe and as a function of time. The gradient, as graphed in A.5, shows a fairly linear variation when looking in towards the centre. When observations are made in the opposite direction however, the gradient shows a tendency to drop off as the observational distance increases. Each characteristic is linked directly to those of the recessional velocities as shown in A.3. All calculated values are however, are still well within the upper and lower limits of values determined from observation.

When looking off radial, the degree of variation is slightly less than that above but highly biased towards observation angles of between 10° and 80°. These equally straddle the point where the angle between the look direction and the velocity vector of the object under observation is a right angle, (a look angle of ~57°). This value however, does not provide the maximum value of H_0, that occurs at an observation angle of ~36° as shown in Appendix B. Note that these comments apply only to A.6 where the observation distance is 2 x 10^9 light years. At other observational distances, these angles will vary.

4.7.2 Variation with Time.

Here it is seen that as the Universe expands, H_0 decreases, although with observations made between 1.5 x 10^9 and 2.0 x 10^9 years from the point of inflexion, looking out towards the boundary, H_0 is seen to increase. This is because at that time, although the rate of expansion was low, recession acceleration was high and the recession velocities were increasing rapidly. This can clearly be seen from the graph of recession velocities showing the transition from σ_u = 3.0 x 10^{27} cms to σ_u = 5.0 x 10^{27} cms.

Finally, it is clear that H_0 appears to be declining to some constant value indicating that eventually the Universe would continue to expand forever at a constant rate. However, while that may be theoretically apparent, as expansion continued and recession velocities approached a constant value, its constituent galaxies et al would come under the increasing influence of other celestial bodies in the greater Cosmos thus gradually nullifying further expansion.

A measure of the possible fate of the Universe is quoted in [4] as

$$q = -\left(1 + \frac{\dot{H}_0}{H_0^2}\right) \tag{4.1}$$

where q is known as the deceleration parameter. (Note q must be given by: $-{V_L}/{H_0^2 D}$).

From A.7, for the period between 25 billion years and 35 billion years, in which the variation of H_0 is close to linear, $\dot{H}_0$ is estimated at -0.45 x 10^{-18} $secs^{-1}$/10 billion years. H_0 at 30 billion years from the same graph is ~1.6 x 10^{-18} $secs^{-1}$ so that these numbers inserted into (4.1) give

$$q = -\left(1 - 1.86x10^{-12}\right) \qquad (4.2)$$

This result concurs with the statements above.

<u>5.0 Conclusions.</u>

There are only three characteristics of the Universe that currently permit a comparison between the Relativistic Domain theory as presented in this and previous papers, and the "Big Bang" theory. The first two of these are (i) the size of the Universe and (ii) the age of the Universe. The comparison shows that for (i) the size of the universe in the Relativistic Domain theory is just over 35% of that estimated in the "Big Bang" theory. In the case of (ii) the age of the Universe in the Relativistic Domain Universe in the expansion phase is estimated at 20 billion years while in the "Big Bang" theory it is 13.7 billion years. The difference in both of these cases is due to the fact that in the "Big Bang" theory, due to the concept of "co-moving" distances, the rate of expansion is permitted to proceed at a velocity exceeding that of light, while in the Relativistic Domain theory it is not.

If in the Relativistic Domain theory the contraction phase is also included in the estimate of age, then the figure of 45 billion years, suggested in [1], is now, due to the amendment to the age of the expansion phase, likewise amended to 60 billion years with a total life cycle of possibly some 80 to 100 billion years, the ultimate fate being the complete dispersion of all galactic objects etc back into the greater Cosmos. This was the conclusion drawn in earlier papers and is essentially confirmed by the results obtained here.

The third characteristic that can be compared between the two theories is of course the Hubble parameter. The range of values determined from observation is from ~2.88 x 10^{-18} $secs^{-1}$, (88.5 Km/sec/Mpc), to ~1.8 x 10^{-18} $secs^{-1}$, (55.4 Km/sec/Mpc). Those for this paper are calculated as ~ 2.53 x 10^{-18} $secs^{-1}$, (77.7 Km/sec/Mpc), to 1.91 x 10^{-18} $secs^{-1}$, (58.7 Km/sec/Mpc). Two factors which affect these ranges are (i) for those determined from observation, the extreme difficulty in making the measurements will induce minor errors which may have inflated the range, and (ii) for the calculated figures, only one off radial relative distance, 2 billion light years, was considered. Other lower distances may inflate the range.

The median figures for the two sets of values are remarkably close, i.e. 2.27 x 10^{-18} $secs^{-1}$ from observations against 2.26 x 10^{-18} $secs^{-1}$ for the calculated values here, a difference of less than 0.5%. This suggests that the values selected for the age of the expansion phase of the Universe, 20 billion years, and the position of the Earth within it, k = 0.5, are most appropriate.

APPENDIX A.

Graphical Representation of Results.

A.1 Physical Radius of the Universe.

This shows the physical radius of the Universe from the point of inflexion out to an age of the expansion phase of ~50 billion years. At that age the diameter of the Universe would be some 42.4 billion light years.

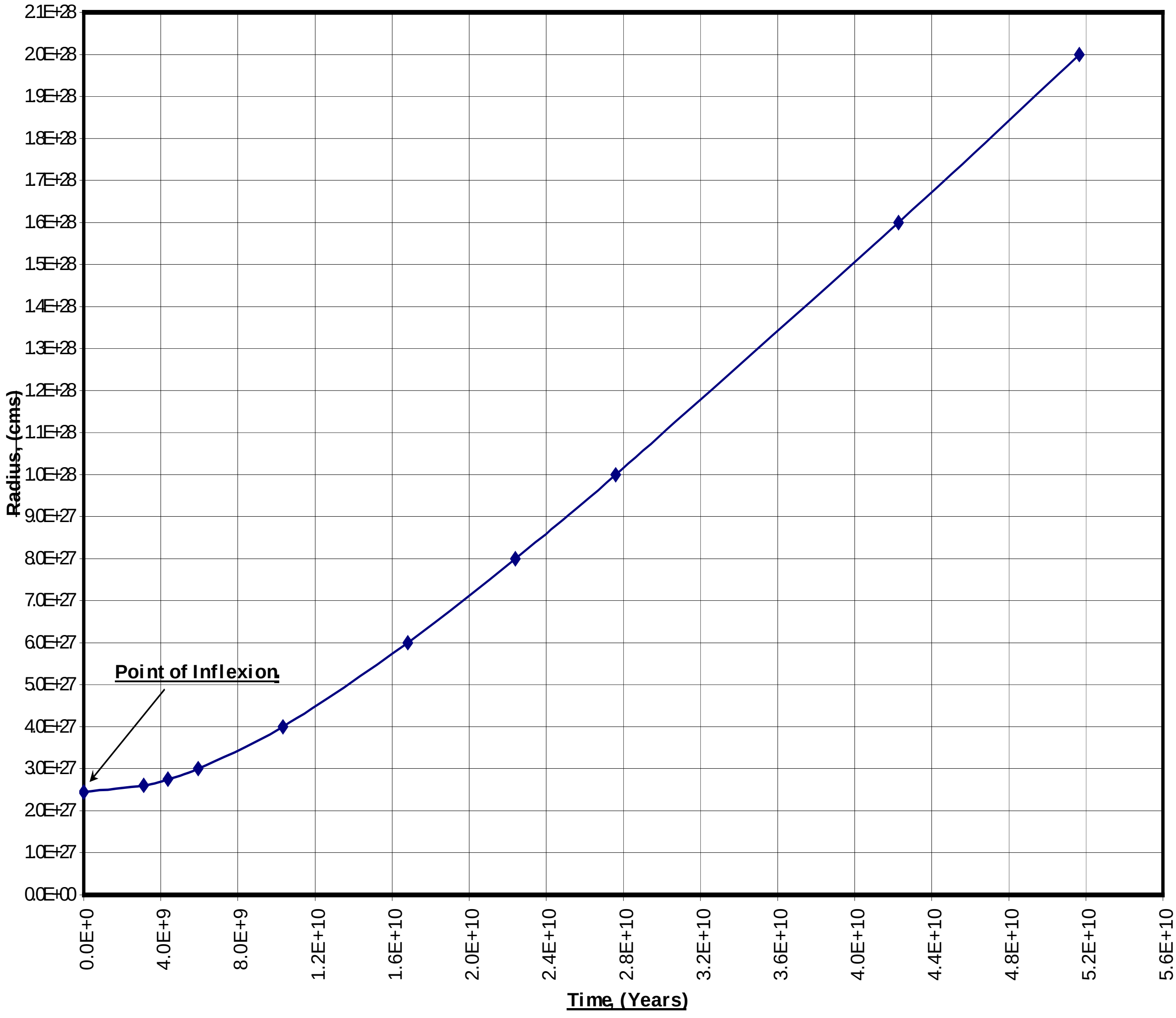

Fig. A.1 - Physical Radius of the Universe.

A.2 Temporal Rate Variation.

This shows both the gradient and the variation with time of the temporal rate throughout the Universe. Note that at any particular value of k, the value of u_i increases approximately linearly with σ_u, i.e. the age of the expansion phase. In particular, the value of u_i for the Earth varies only from 0.97 at σ_u = 5.0E27 cms to 0.98 at σ_u = 8.0E27 cms, (a time period of a little over eight billion years.), with the current value lying between these two.

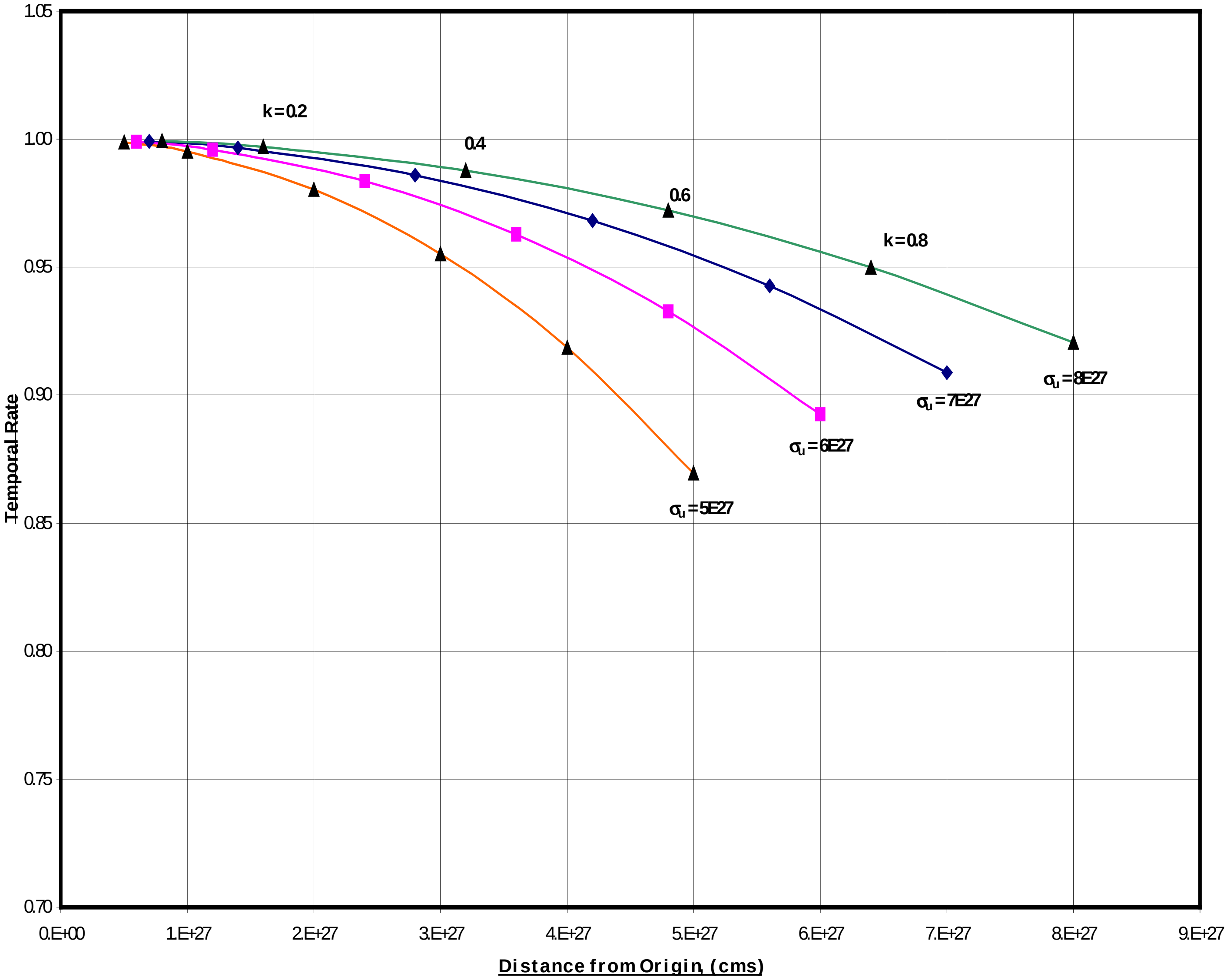

Fig. A.2 - Temporal Rate Variations.

A.3 Galactic Recession Velocity.

This figure shows the gradient of galactic recession velocities for values of σ_u from 5.0E27 cms to 8.0E27 cms, (a time period of ~ eight billion years.). Also shown is the current median value of H_0 determined from the values obtained by observation as reported in [4]. This median value results from an observation range of up to ~ 2 billion light years with a lowest value of ~ 1.8 x 10^{-18} secs^{-1}, (55.4 Km/sec/Mpc), and a highest value of 2.88 x 10^{-18} secs^{-1}, (88.5 Km/sec/Mpc). The median value is 2.27 x 10^{-18} secs^{-1}. A point representative of Earth is also shown together with a point representing a galactic object lying on the same radial position vector, at a distance of ~ 2 billion light years.

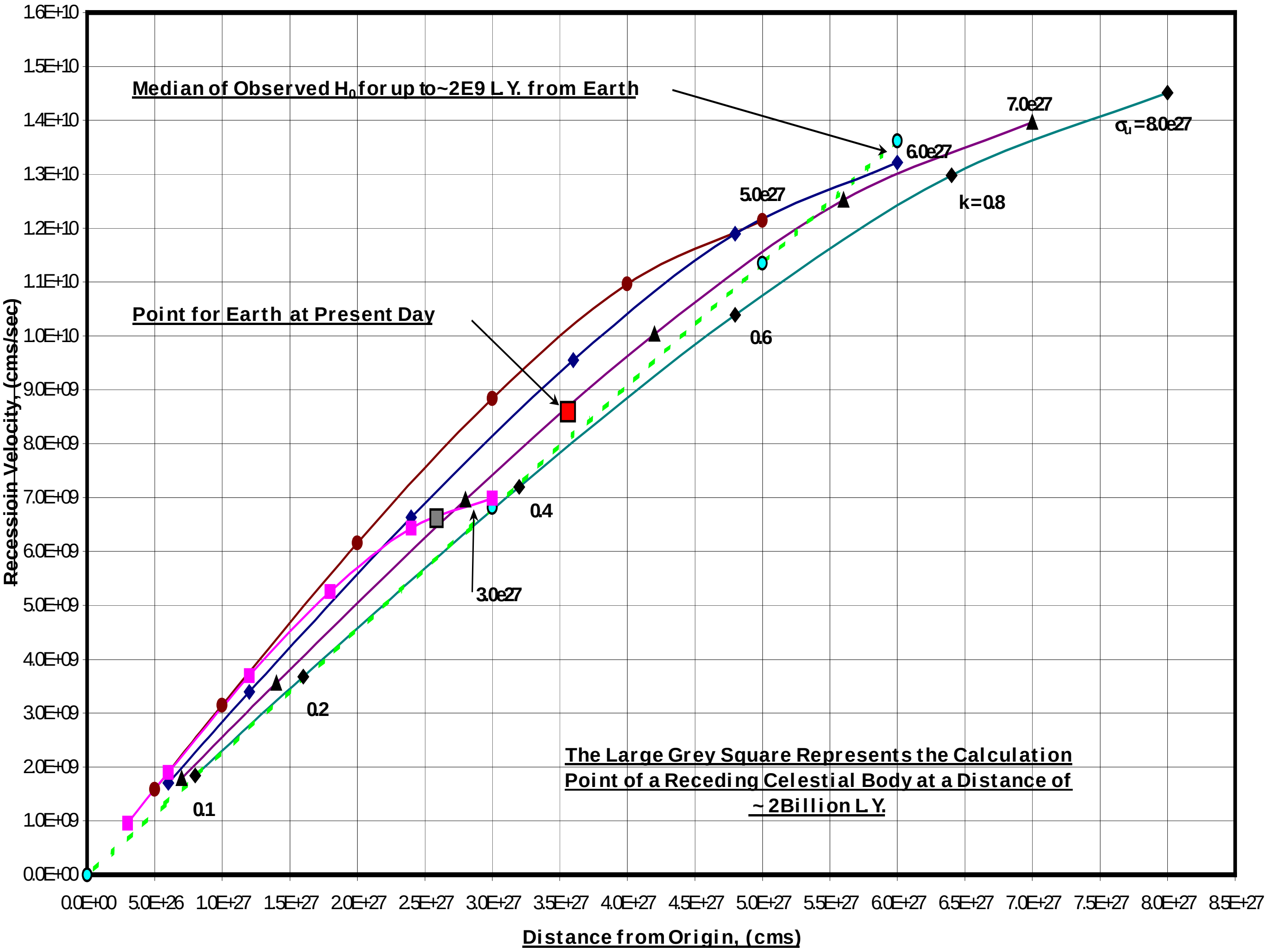

Fig. A.3 - Galactic Recession Velocities.

A.4 Galactic Recession Accelerations.

These results show the rate of galactic recession acceleration, its gradient and variation with time.

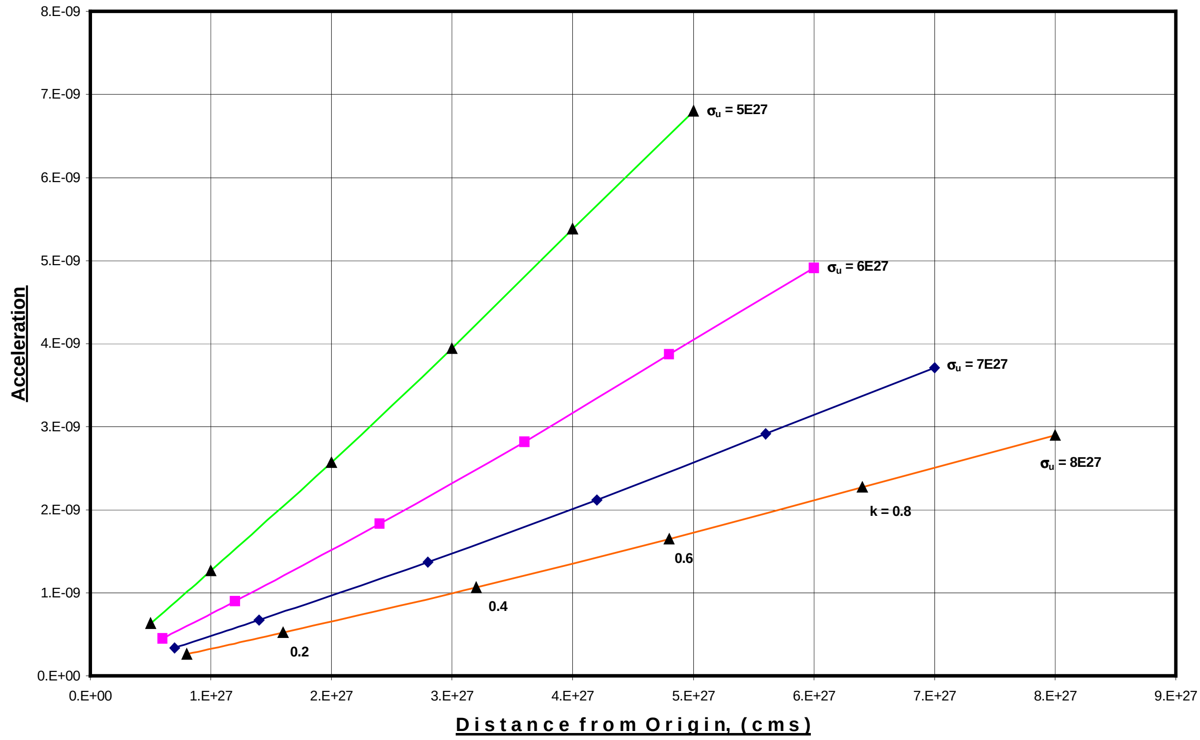

Fig. A.4 - Galactic Recession Accelerations.

A.5 H_0 Along the Radial Position of the Earth.

This figure shows the variation of H_0 along the Earth's radial vector from the centre of the Universe. Over the observational range the median of calculated values is 2.19 x 10^{-18} $secs^{-1}$.

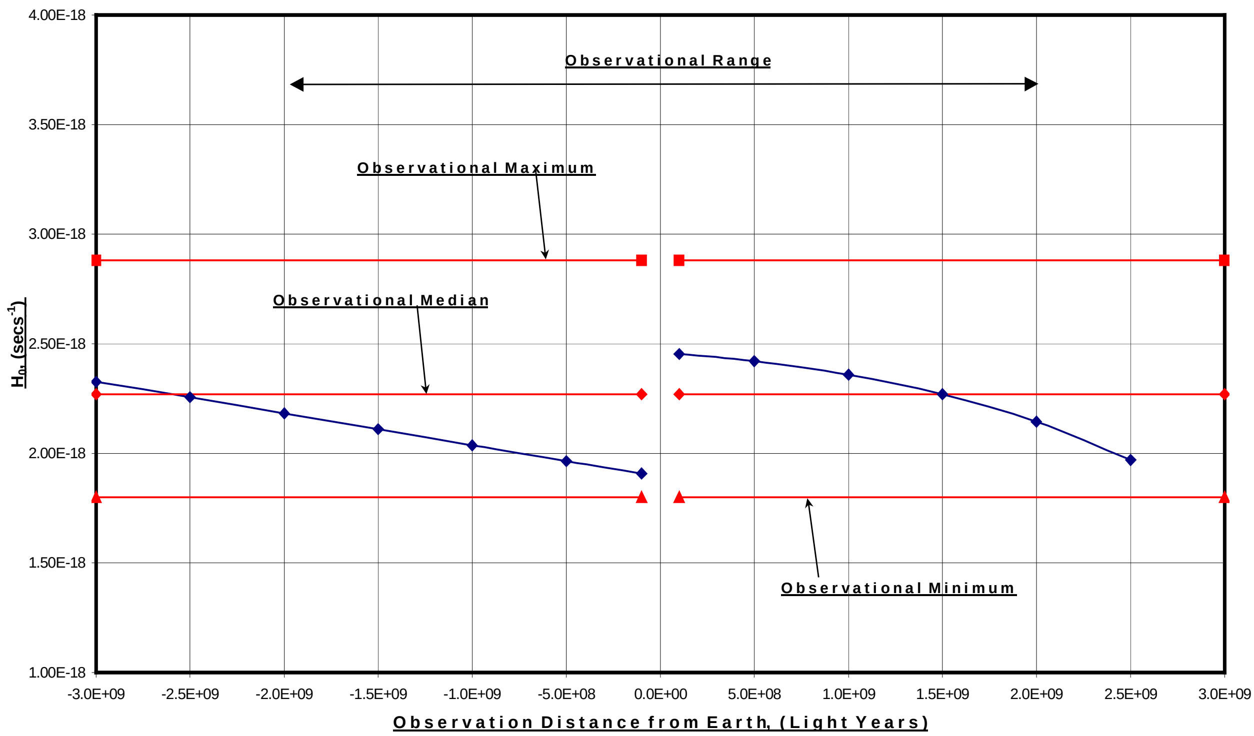

Fig. A.5 - H_0 Gradient for Look Inward/Outward Along Radial with σ_u = 7.12E27 cms.

The observed median will most likely contain mostly off radial measurements

A.6 H_0 Off the Radial Position of the Earth.

This figure shows the variation in calculated H_0 results at angles to the Earth's radial position of from zero to 180° for a separation distance of ~2 billion light years. The median value over the complete range is 2.33 x 10^{-18} $secs^{-1}$.

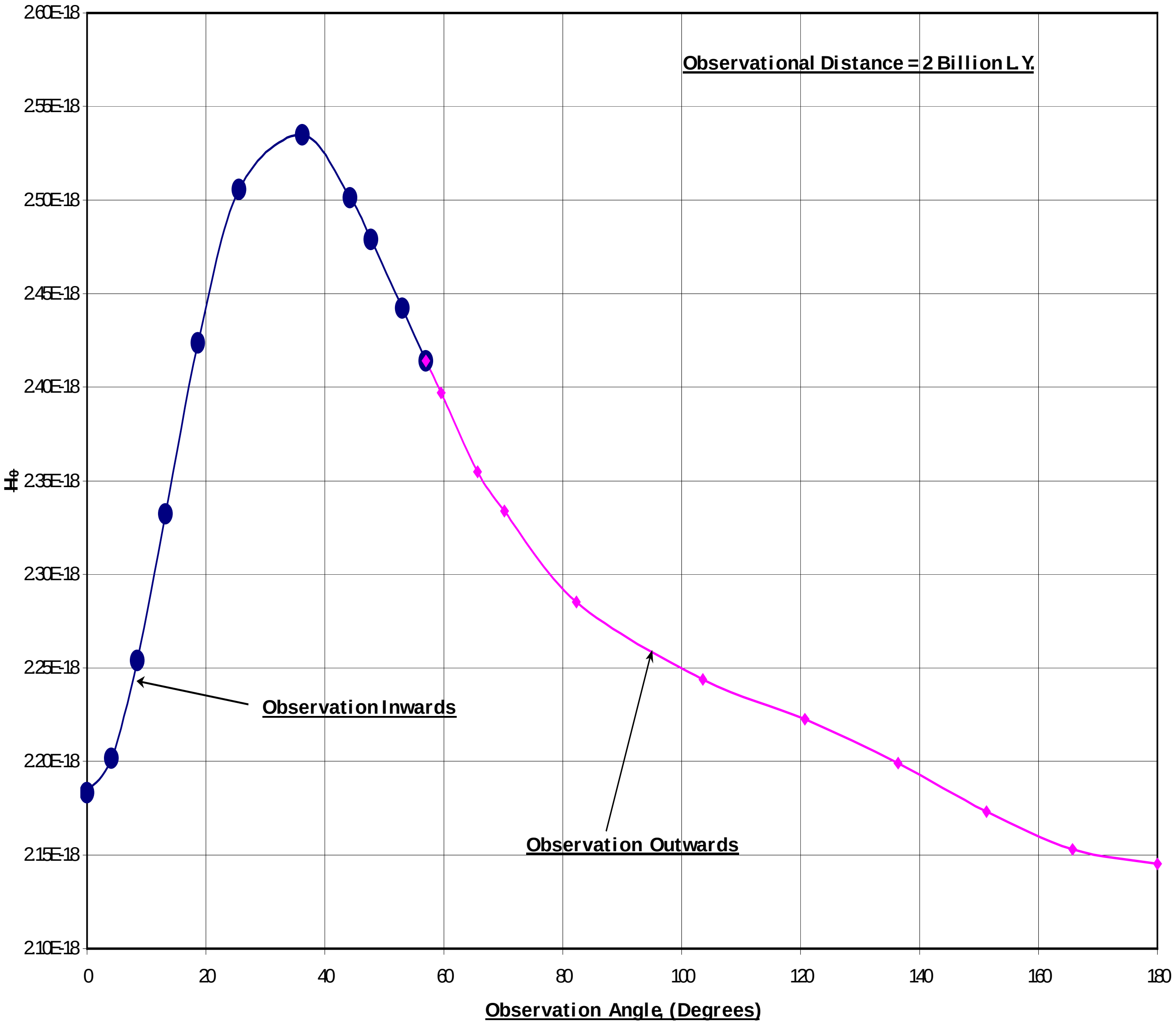

Fig. A.6 - Variation of H_0 with Angle of Observation to Radial Position of the Earth.

A.7 Variation of H_0 with Time.

This final figure shows the variation of calculated H_0 along the Earth's radius vector with time from the point of inflexion.

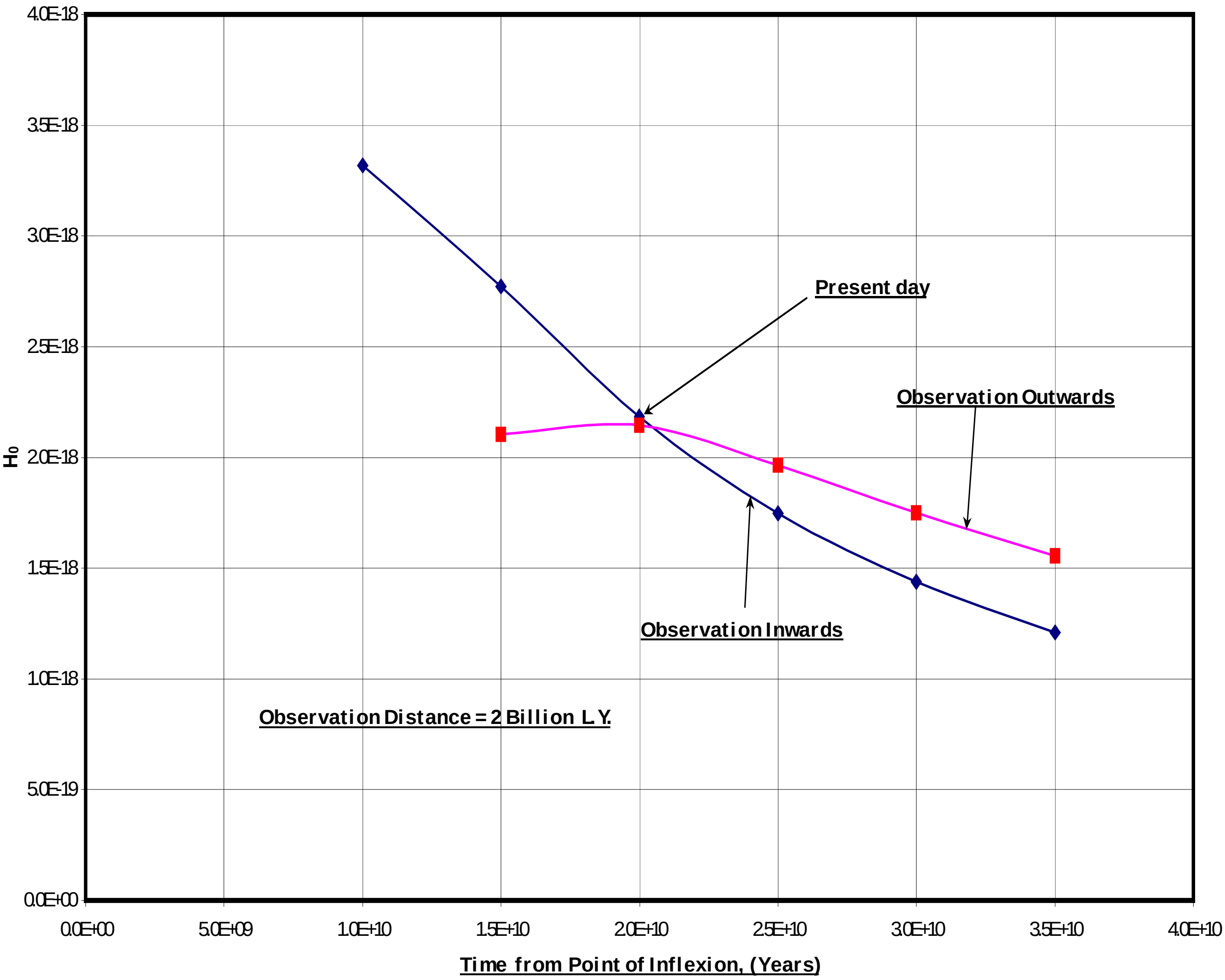

Fig. A.7 - H_0 Variation with Time, (k = 0.5), (Along Radial).

APPENDIX B.

Geometry for Off Radial Calculations of H_0.

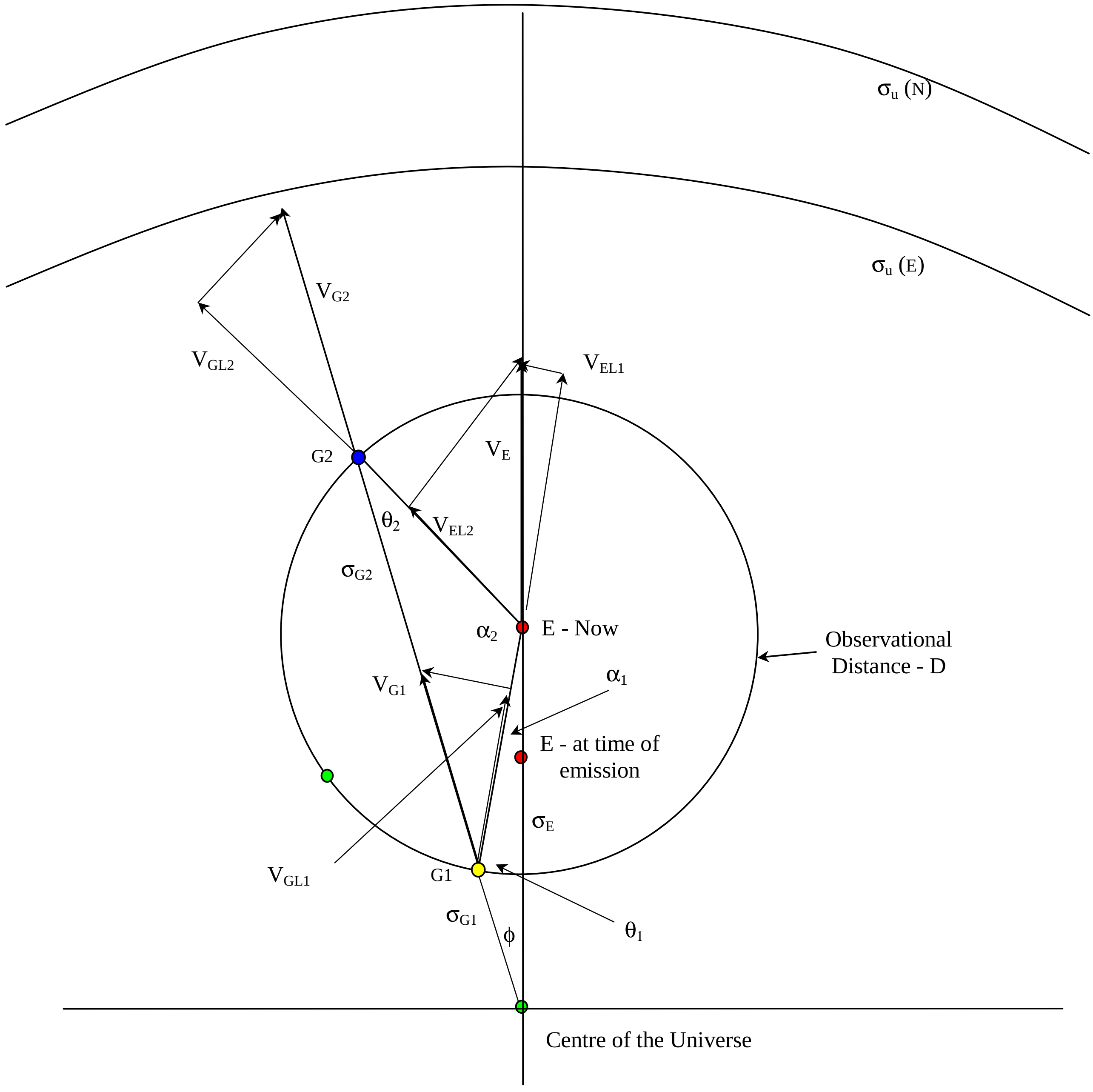

Fig. B.1 - Geometry for Off Radial Calculations of H_0.

In Fig. B.1 the parameters are defined as follows.

$G_{1,2}$ Galaxies 1 and 2 under observation.

E(N) Position of the Earth at the present day.

E(E) Position of the Earth at the time of emission of light rays from $G_{1,2}$.

ϕ Angle of the recession velocity vector of the galaxies under observation to that of the Earth.

$\sigma_{1,2}$ Distance of the galaxies G_1 and G_2 from the centre of the Universe at the time a light ray is emitted.

σ_E Distance of the Earth from the centre of the Universe at the present day.

D Line of sight distance between Earth at the present day, and, Galaxies G_1 and G_2 at the time of light ray emission.

$\theta_{1,2}$ Angle between D and the velocity vectors of the galaxies under observation.

$\alpha_{1,2}$ Angle between D for each galaxy under observation and the velocity vector of the Earth.

$V_{G1,2}$ Velocity vector magnitudes of the galaxies under observation.

V_E Velocity vector magnitude of the Earth.

$V_{EL1,2}$ Component of V_E along D.

$V_{GL1,2}$ Components of $V_{G1,2}$ along D.

$\sigma_{u(N)}$ Radius of the Universe at the present day.

$\sigma_{u(E)}$ Radius of the Universe at the the time of emission from G_1 and G_2.

● Point at the observation distance D at which $V_{GL1,2}$ is zero.

Note that in Fig. B.1 G_1 is below ● and G_2 is above it.

Consider the case of galaxy G_1. The line of sight velocity difference along D is

$$V_D = V_E \boldsymbol{cos}\,\alpha_1 - V_{G1}\boldsymbol{cos}(180-\theta_1) \tag{B.1}$$

In (B.1) from Fig. B.1

$$\boldsymbol{cos}(180-\theta_1) = -\boldsymbol{cos}\,\theta_1 \tag{B.2}$$

and

$$\cos\alpha_1 = -(\cos\theta_1 \cos\phi - \sin\theta_1 \sin\phi) \qquad \text{(B.3)}$$

Also from Fig. B.1

$$\sin\theta_1 = \frac{\sigma_E}{D}\sin\phi \qquad \text{(B.4)}$$

so that

$$\cos\theta_1 = -\left(1 - \frac{\sigma_E^2}{D^2}\sin^2\phi\right)^{1/2} \qquad \text{(B.5)}$$

The negative sign applies because $\theta_1 > 90°$. Substituting (B.2) and (B.5) into (B.1) yields

$$V_L = V_E\left\{\left(1 - \frac{\sigma_E^2}{D^2}\sin^2\phi\right)^{1/2}\cos\phi + \frac{\sigma_E}{D}\sin\phi\right\} - V_{G1}\left(1 - \frac{\sigma_E^2}{D^2}\sin^2\phi\right)^{1/2} \qquad \text{(B.6)}$$

In the case of G_2 an identical analysis yields the same relationship, i.e.

$$V_L = V_E\left\{\left(1 - \frac{\sigma_E^2}{D^2}\sin^2\phi\right)^{1/2}\cos\phi + \frac{\sigma_E}{D}\sin\phi\right\} - V_{G2}\left(1 - \frac{\sigma_E^2}{D^2}\sin^2\phi\right)^{1/2} \qquad \text{(B.7)}$$

and in each case if $\phi = 0$, $V_L = V_E - V_{G1,2}$.

Finally, H_0 for both cases is given by

$$H_0 = \frac{V_L}{D} \qquad \text{(B.8)}$$

Note that from Fig. B.1 it is also possible to determine $\sigma_{1,2,}$ i.e.

$$\sigma_{1,2} = \sigma_E \cos\phi + \left(D^2 - \sigma_E^2 \sin^2\phi\right) \qquad \text{(B.9)}$$

However, this could only be determined by observation if the precise distance and direction of the centre of the Universe were known.

Note also in (B.6) and (B.7) when $\sin\phi = D/\sigma_E$

$$V_L = V_E \frac{D}{\sigma_E} \qquad \text{(B.10)}$$

so that

$$H_0 = \frac{V_E}{\sigma_E} \qquad \text{(B.11)}$$

Finally, note that the maximum value of H_0 occurs when the observation angle is given by

$$\boldsymbol{sin}\,\alpha = \frac{\left(V_E^2 - V_G^2\frac{\sigma_E^2}{\sigma_G^2}\right)^{1/2}}{\frac{\sigma_E}{\sigma_G}\left(V_E^2 - V_G^2\frac{\sigma_E^4}{\sigma_G^4}\right)^{1/2}} \tag{B.12}$$

This can only be determined by iteration because both V_G and σ_E are α dependent. Iteration gives a value of α of ~ 35.9°.

Appendix C.

The Limits of Recessional Velocity and Acceleration.

C.1 The Limit of recessional Velocity.

From (2.10) $\dot{\sigma}_i = c$ when

$$\left(2-\frac{k^2}{2}\right)^2 = \frac{k^2}{2}\left(1-\frac{k^2}{2}\right)\left(2-k^2\frac{\alpha_u}{\sigma_u}\right)\left(1-\frac{2\alpha_u}{\sigma_u}\right) \tag{C.1}$$

Because recessional velocity is highest at the boundary of the Universe, (C.1) will occur there, thus putting $k = 1$ in (C.1) yields after minor reduction

$$\sigma_u^2 + \frac{5}{7}\alpha_u\sigma_u - \frac{2}{7}\alpha_u^2 = 0 \tag{C.2}$$

The roots of (C.2) are

$$\sigma_u = \frac{13}{24}\alpha_u \qquad or \qquad -\frac{23}{14}\alpha_u \tag{C.3}$$

Because σ_u can never be less that $2\alpha_u$ this condition can never occur, i.e. $\dot{\sigma}_i \le \dot{\sigma}_u < c$ where c is the velocity of light in free Pseudo-Euclidean Space-Time.

C.2 The limit of Recessional Acceleration.

Differentiating (3.1) gives

$$\ddot{\sigma}_u = \frac{c^2}{9}\left(\frac{5}{2}\frac{\alpha_u}{\sigma_u^2} - \frac{2\alpha_u}{\sigma_u^3}\right) \tag{C.4}$$

so that $\ddot{\sigma}_u = 0$ when

$$\sigma_u = \frac{4}{5}\alpha_u \tag{C.5}$$

Again this is less than the minimum value of σ_u and so can never occur.

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