.

Fitting the Hyperverse Model into the Friedmann Equation Gives a Constant Expansion Rate for the Universe

James A. Tassano

ABSTRACT

We show that a 3-sphere, whose surface volume matches the volume of the observable universe, has a radius of 27.6 billion light years, meaning it would be expanding into the fourth dimension at exactly twice the speed of light. We claim this observation has deep significance. Although the whole universe is much larger than this 'observable hyperverse', the 2c expansion rate is the actual expansion rate we experience, and this is due to the increase in the duration of the unit of quantum time as the universe expands. A model of the universe based on the 2c radial expansion rate produces equations stating that both energy and matter are continuously created with expansion, starting at the time of the Big Bang. Placing these equations into the Friedmann equation also gives a constant rate of expansion. The continuous creation of matter and energy, starting with the Big Bang, is distinct from the Steady State model, which has no Big Bang. The universe as an expanding 3-sphere is not an FRW model, as energy and matter both change with one over the scale factor squared. This negates most arguments against constant-rate expansion, as they are based on the FRW model. A 2c-hyperverse cosmology provides a new, powerful model for exploring the nature of the universe.

Introduction

The universe may well be the surface volume of a four dimensional sphere, or 'hyperverse'. We show a simple and striking result that the hyper-radius of a 3-sphere, whose surface matches the volume of the observable universe, is about 27.59 billion light years. Given an age of 13.8 billion years, this 'observable hyperverse' is expanding at exactly twice the speed of light.

In a series of unpublished papers [1,2,3,4,5] we developed a cosmology based on the concept that the universe is the surface volume of a hyperverse, and claim that this 2c expansion rate is not a coincidence. We argued that although the whole hyperverse is much larger than the observable, the reason we measure the 2c expansion rate is that the ratio of the unit of quantum time to the unit of cosmic time is expanding at the same rate as the whole hyperverse, cancelling its enormous rate of acceleration, giving us the constant 2c radial rate. To state it differently, the duration of a unit of time is not a constant, but increases as the universe expands.

A core prediction of the hyperverse model is that matter is being created with expansion, starting at the time of the Big Bang. Most people associate continuous creation with the Steady State theory, but it has continuous creation for all time, and has no Big Bang. The Friedmann-Robertson-Walker (FRW) model assumes that all matter and energy was present at the time of the Big Bang. The hyperverse model gives an alternative to the Steady State and FRW models.

In this paper we show that when our equations for the continuous creation of matter and energy are placed into Friedmann equation, the result is a constant expansion rate.

1. A Review: The Hyperverse Model Produces a Constant Expansion Rate

1.1. The Shape of the Universe

Leonard Susskind has stated "we may be living on a 3-sphere, possibly we do live on a 3-sphere." [6]. The universe may be the three dimensional surface volume of a four dimensional sphere. The universe as the surface of a 3-sphere gives a curved and closed universe. Its expansion would be 'radial', into the fourth dimension, meaning that the universe is continually moving radially outwards. We will call this 4D structure the 'hyperverse', and its 3D surface volume, the universe.

Galaxies spin, and as we drop in size, stars, planets, atoms, photons, and elementary particles all possess the property of spin. We will make the assumption that spin goes all the way down to the quantum, that the quanta of space also spin. We will assume that space is comprised of 'atoms of space' [7], and they spin. These atoms of space are the quanta of space [3].

If the universe is the surface volume of the hyperverse, and it is expanding radially, there are several deductions we can make. The surface of the hyperverse exists as a separate and distinct entity from the presumable nothingness into which it is expanding. This hyperverse surface, comprised of spinning atoms of space, or vortex-like structures, or quanta, is adding more quanta as the hyperverse expands. Since we see only three dimensions, the hyperverse must be hollow, and the surface volume is only one quantum thick, in the direction of the fourth dimension.

1.2. The 2c Radial Expansion Rate

Let us ask: how big would the hyperverse be if its surface volume matched the 3D volume of our observable universe? We can calculate the size of this "observable hyperverse" by equating the volume of our 3D observable universe with the surface volume of a 4D sphere, and solving for the hyperverse radius:

$$2\pi^2 R_H^3 = \frac{4}{3}\pi r_o^3 \tag{1}$$

where R_H is the radius of the observable hyperverse and r_o is the radius of the observable universe.

Using the mid-value of 46.25 billion light years for the radius of the observable universe, we find the hyperverse radius is 27.5866 billion light years:

$$R_H = (46.25)\sqrt[3]{\frac{2}{3\pi}} \approx 27.5866 \text{ billion light years} \tag{2}$$

Since the universe is about 13.8 billion years old, the speed of radial expansion comes to twice the speed of light:

$$\frac{27.5866 \text{ billion light years}}{13.8 \text{ billion years}} = 1.999 \text{ light years per year } \Rightarrow 2c \tag{3}$$

It says our hypothetical hyperverse is expanding at exactly twice the speed of light. Is this result just chance, or is it a path to a deeper understanding of the cosmos? There is a problem though: the whole universe is vastly larger than the observable, so does the 2c expansion have meaning?

We argue in [5] that the basic unit of time, quantum time, is not a constant, but changes with expansion; the ratio of the quantum unit of atomic time to the unit of cosmic time, which is the time associated with the whole hyperverse, increases in such a manner that it cancels the accelerating increase in the growth rate of the whole hyperverse, giving us our constant, 2c radial expansion rate. Even though the whole universe is much larger than the observable universe, time expands at a rate equal to the expansion of the whole, cancelling it, giving us the constant 2c radial expansion rate that we can calculate. Essentially the observable hyperverse is a time-scaled version of the whole. Geometry is not time-scaled, and thus measurements of curvature are not effected by the time-scaling.

1.3. The Ideal Particle

The FRW model assumes all matter was created at the time of the Big Bang. Fred Hoyle had championed the idea that matter and energy were continuously created, in his Steady State theory, which was an alternative to the Big Bang concept. The Steady State model has no Big Bang.

The hyperverse model produces continual creation of matter and energy, but with a significant difference: matter and energy are continually created, starting at the moment of the Big Bang.

In [3] we argued that the hyperverse is undergoing a geometric mean expansion. The geometric mean expansion of space produces quantities that are very close to what we observe for the radius, mass, and the number of elementary particles, and explains why the large and the small of the universe are so closely related [8].

The reason that matter exists, according to the model, is that the expanding hyperverse crushes and coalesces space to conserve its continually increasing angular momentum [4].

Our 'ideal particle' values are the target values the expanding universe strives for. Using $2.62397216 \times 10^{26}$ m as the hyperverse radius, the ideal particle values we need in this discussion are shown in equations (4–5).

$$\text{particle mass} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} = 5.415\,182\,785\,216\,176\,701\,4 \times 10^{-29}\,\text{kg} \tag{4}$$

$$\text{particle number} = \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} = \left(\frac{T_o}{t_p}\right)^{\frac{4}{3}} = 1.631\,670\,937\,848\,978\,687\,4 \times 10^{81} \tag{5}$$

l_p is the Planck length, T_o is the age of the universe, t_p is the Planck time. T_o is defined as $\frac{R_H}{2c}$ [1].

1.4. The Continuous Creation of Matter

The equations of matter show that particles are not static entities, but change with time. Comparing the mass of particles after a doubling of the radius of the hyperverse, we see that the mass of particles decreases by $\left(\frac{1}{2}\right)^{\frac{1}{3}}$ with each doubling:

$$\frac{\text{particle mass now}}{\text{particle mass then}} = \frac{\left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}}}{\left(\frac{\frac{R_H}{2}c^2}{4G}\right)\left(\frac{2l_p}{\frac{R_H}{2}}\right)^{\frac{4}{3}}} = \frac{1}{2}2^{\frac{2}{3}} = 0.793\,700\,525\,984\,099\,737\,38 \qquad (6)$$

where "now" is the current radius, R_H, and "then" represents $\frac{R_H}{2}$, when the hyperverse was half its current size. The mass of the observable universe is given as $\left(\frac{R_H c^2}{4G}\right)$, which is equal to about 9.9×10^{52} kg [1].

With a doubling of the hyperverse radius, the number of ideal particles increases by $2\sqrt[3]{2} \approx 2.\,519\,8$.

$$\frac{\text{number of particles now}}{\text{number of particles then}} = \frac{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}}{\left(\frac{\frac{R_H}{2}}{2l_p}\right)^{\frac{4}{3}}} = 2\sqrt[3]{2} = 2.\,519\,842\,099\,789\,746\,329\,5 \qquad (7)$$

Using equation (5), setting T_o equal to one, and defining x as the time variable, we find that the number of particles in the observable universe increases by the 4/3 power of the current age.

$$\text{number of elementary particles as a fraction of current value} = \frac{\left(\frac{x}{t_p}\right)^{\frac{4}{3}}}{\left(\frac{1}{t_p}\right)^{\frac{4}{3}}} = x^{\frac{4}{3}} \qquad (8)$$

Figure 1 shows the number of elementary particles in the observable universe, as a fraction of the current number of particles, against normalized time, where the current time is equal to one.

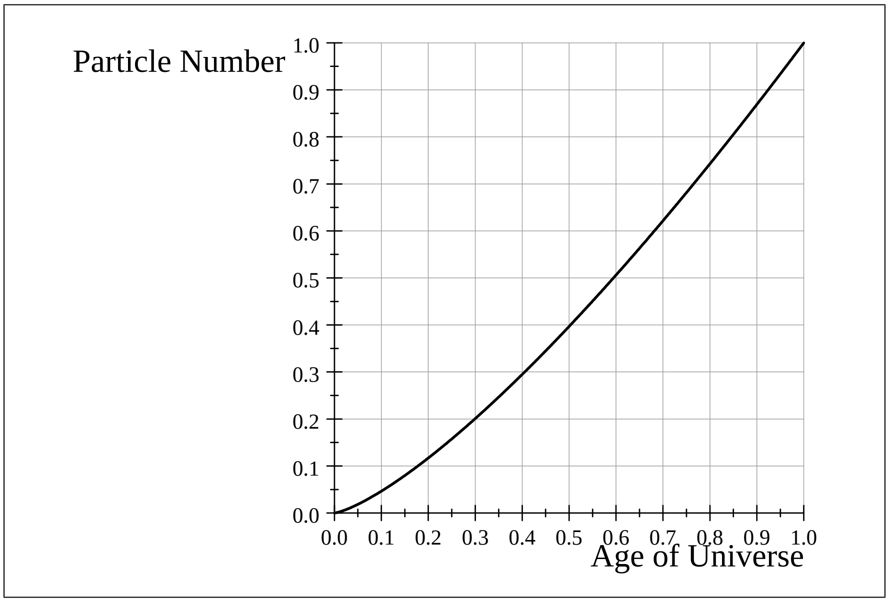


Figure 1. The number of elementary particles in the observable universe as a function of time, as a fraction of the current values. The number of particles increases with time.

Letting 'x' represent the age of the universe, where the current age is equal to one, we find particle mass decreases over time. This is shown graphically in Figure 2.

$$\text{particle mass as a fraction of current value} = \frac{\left(\frac{xc^2}{4G}\right)\left(\frac{2l_p}{x}\right)^{\frac{4}{3}}}{\left(\frac{c^2}{4G}\right)(2l_p)^{\frac{4}{3}}} = \left(\frac{1}{x}\right)^{\frac{1}{3}} \tag{9}$$

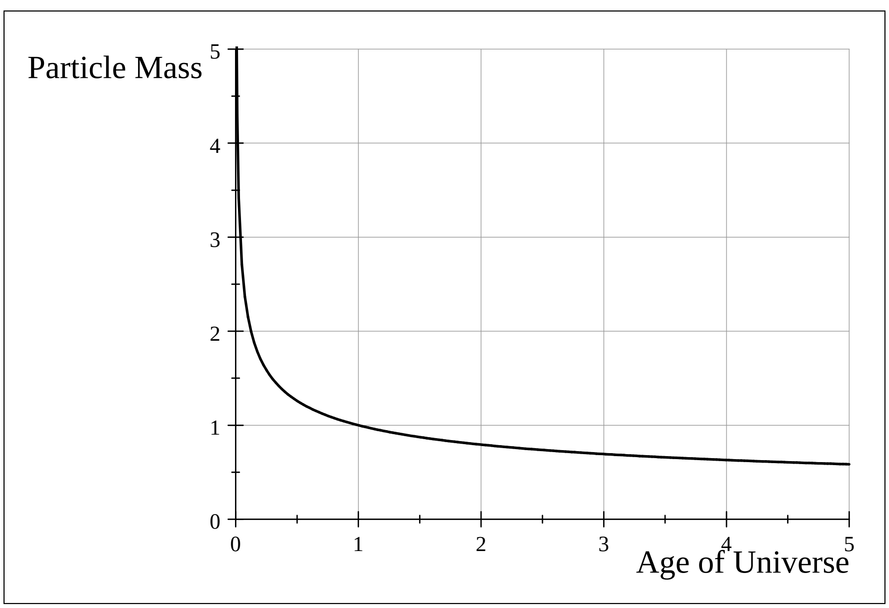


Figure 2. Particle mass as a function of time. Particle mass decreases with time.The point 1,1 represents the current age of the universe and particle mass.

The total energy of particles is the product of the energy and number of particles.

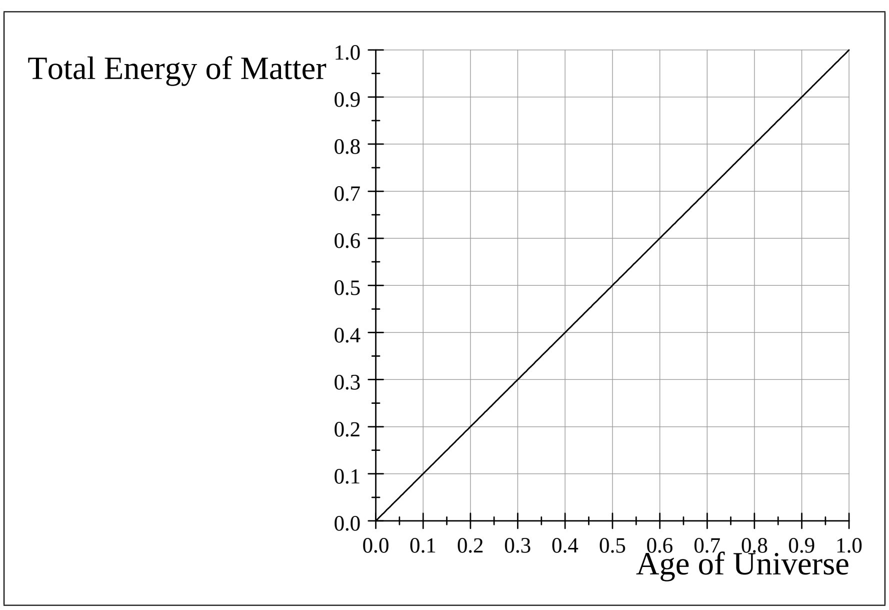
$$\left(\frac{R_H c^4}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} = \frac{c^4 R_H}{4G} \tag{10}$$

With a doubling of the hyperverse radius, the total energy of matter increases by a factor of two.

$$\frac{\frac{c^4 2R_H}{4G}}{\frac{c^4 R_H}{4G}} = 2 \tag{11}$$

We can again convert the hyperverse radius to time, $R_H = T \times 2c$, so that $\frac{c^4 R_H}{4G} = \frac{c^4 T \times 2c}{4G}$. Setting the total current energy of matter to equal one, we find that the energy of matter increases at a constant rate, with a slope of one.

$$\frac{\frac{1}{4G} c^2 T 2c}{\frac{1}{4G} c^2 2c} = T \tag{12}$$



The total energy of the universe increases at a constant rate with expansion. Both axes represent the fraction of the current values.

We can determine how the density of matter changes over time by looking at the effect of a doubling of the hyperverse radius. Taking the ratio of the densities with a doubling, we get

$$\frac{\frac{\frac{c^4 2R_H}{4G}}{2\pi^2(2R_H)^3}}{\frac{\frac{c^4 R_H}{4G}}{2\pi^2 R_H^3}} = \frac{1}{4} = \frac{1}{a^2} \tag{13}$$

With a doubling of the hyperverse radius, the density of matter decreases by one-fourth. To express this in terms of standard cosmology, we can state that the energy density of matter changes by one over the scale factor squared: $\frac{1}{a^2}$.

1.5. The Continuous Creation of Energy

The hyperverse model also states that energy is continuously created with expansion. As the hyperverse grows in size, the energy of the observable hyperverse increases. Using the energy equation, $\frac{c^4 R_H}{4G}$, we can see that as the hyperverse expands, the energy increases in direct proportion. The total energy doubles with a doubling of the hyperverse radius, and its density changes by one over the scale factor squared, $\frac{1}{a^2}$.

2. Placing the Hyperverse Values into the Friedmann Equation

In the FRW model, it is assumed that all matter was created at the time of Big Bang, so that the density of matter changes with the cube of the scale factor, $\frac{1}{a^3}$, and that the density of space remains constant. In the hyperverse model, the density of both matter and energy vary as the square of the scale factor, $\frac{1}{a^2}$.

The current best estimates for omega matter and vacuum, based on the FRW model, are about 0.32 and 0.68 [9], allowing the FRW model to be written as

$$\Delta a^2 = a^2 H_0^2 \left(\frac{\Omega_m}{a^3} + \Omega_v\right) \Delta t^2 = a^2 H_0^2 \left(\frac{0.23}{a^3} + 0.77\right) \Delta t^2 \tag{14}$$

$$\frac{\Delta a}{\Delta t} = H_0 \left(\frac{0.23}{a} + 0.77a^2\right)^{\frac{1}{2}} \tag{15}$$

In the hyperverse model, omega matter and vacuum are each equal to 0.5 [4]. The hyperverse expansion model can be written as:

$$\Delta a^2 = a^2 H_0^2 \left(\frac{\Omega_m}{a^2} + \frac{\Omega_v}{a^2} \right) \Delta t^2 = a^2 H_0^2 \left(\frac{0.5}{a^2} + \frac{0.5}{a^2} \right) \Delta t^2 = H_0^2 \Delta t^2 \tag{16}$$

The a's cancel out, and we get:

$$\frac{\Delta a}{\Delta t} = H_0 \tag{17}$$

The rate of change of the scale factor, as a function of time, is a constant.

The hyperverse model gives us a constant, 2c expansion rate. When we place the results of the hyperverse model into the Friedmann equation, we also get a constant expansion rate.

3. A Constant Expansion Rate

There are several simplifying assumptions built into the FRW model, the commonly mentioned ones being that the universe is spatially homogeneous and isotropic. The FRW model also assumes that all matter came into existence at the time of the Big Bang. From this assumption, the density of energy and matter are shown to vary with expansion and time: matter density is thought to vary with the cube of the scale factor, and the vacuum energy density is constant. The assumption that all matter was created at the time of the Big Bang is central to the ΛCDM model, despite the lack of a model to explain the origin of matter.

The alternative is commonly seen to be the Steady State theory, which proposed that matter is continuously created, for all time, and that there was no initial state, or Big Bang [10]. It was a debate about whether or not there was a Big Bang. The hyperverse model has continuous creation starting at the Big Bang.

There is currently a discussion about whether the universe is expanding at a constant rate or not. Melia, and others, [11] have argued that the universe is expanding at a constant velocity, so that the horizon radius is at all time equal to ct, and that the age of the universe is the inverse of the Hubble Constant. The arguments in support of this coasting universe, or Rh=ct universe, assume that the universe follows the ΛCDM model, and that the Cosmological Principle and Weyl's postulate are the keys to deducing that the universe is undergoing a constant expansion rate.

Those debating the constant expansion model [12,13] claim the Rh=ct universe violates the ΛCDM model. For example, Lewis [13] has argued that the universe cannot be undergoing a constant expansion rate, based on the matter content of the universe. The arguments, however, are based on the FRW model.

The hyperverse model is not an FRW model, as both the continuous creation of matter and energy are scaled by $\frac{1}{a^2}$. We find a constant expansion rate both from the 2c radial expansion rate calculation and from the application of its predictions in the context of the Friedmann equation.

Acknowledgments

The author would like to thank Burt Jordaan for useful discussions.

References

1. Tassano, J.A. "The Hubble Constant is a Measure of the Increase in the Energy of the Universe." 2013. Unpublished manuscript.

2. Tassano, J.A. "A Model of Time." 2013. Unpublished manuscript.

3. Tassano, J.A. "A Universe from Itself: The Geometric Mean Expansion of Space and the Creation of Quanta." 2013. Unpublished manuscript.

4. Tassano, J.A. "The Origin of Matter and Gravity: What They Are and Why They Exist." 2013. Unpublished manuscript.

5. Tassano, J.A. "Quantum Time is the Time it Takes for an Elementary Particle to Absorb a Quantum of Energy". 2015. Unpublished manuscript.

6. Susskind, L. "Cosmology Lecture 3" Stanford University. Published on Feb 4, 2013. YouTube. https://www.youtube.com/watch?v=nJlWYDcGr8U. 22:30. Accessed 19 October 2015.

7. Smolin, Lee. "Atoms of space and time." Scientific American 290.1 (2004): 66-75.

8. Carvalho, Joel C., Derivation of the Mass of the Observable Universe. International Journal of Theoretical Physics, 1995 Dec. 34(12):2507-2509.

9. Planck Collaboration. Planck 2013 results. XVI. Cosmological parameters. arXiv:1303.5076v1 [astro-ph.CO]

10. Helge Kragh (1996). Cosmology and Controversy: The Historical Development of Two Theories of the Universe. Princeton University Press. p. 212, Chapter 5. ISBN 0-691-00546-X.

11. Melia, Fulvio, and A. S. H. Shevchuk. "The Rh= ct universe." Monthly Notices of the Royal Astronomical Society 419.3 (2012): 2579-2586.

12. Bilicki, Maciej, and Marina Seikel. "We do not live in the Rh= ct universe." Monthly Notices of the Royal Astronomical Society 425.3 (2012): 1664-1668.

13. Lewis, Geraint F. "Matter matters: unphysical properties of the Rh= ct universe." Monthly Notices of the Royal Astronomical Society (2013): stt592.