The Hubble Constant is a Measure of the Increase in the Energy of the Universe

James A. Tassano

jimtassano@goldrush.com

ABSTRACT

We postulate the universe to be the three dimensional surface volume of an expanding, hollow, four dimensional hypersphere, called the hyperverse. Using current measurements, we find that a hyperverse, whose surface volume matches the volume of the observable universe, has a radius of 27.7 billion light years, giving a radial expansion rate of twice the speed of light, and a circumferential expansion rate that matches the Hubble constant. We show that the Hubble constant is a measure of the increase in the energy of the universe, implying the hyperverse surface, our universe, is composed of energy. The 2c radial expansion both sets the speed limit in the universe, and is the basis of time. The hypersphere model provides a positively curved, and closed universe, and its 2c radial expansion rate, and circumferential expansion rate matching the Hubble expansion, give strong support that the universe is the 3D surface volume of an expanding 4D hypersphere.

Subject headings: 2c radial expansion of space; basis of time; cosmology; Hubble constant; hyperverse; shape of the universe

Introduction

What if the universe was the three dimensional surface volume of a hollow, four dimensional, expanding hypersphere, what we will call a 'hyperverse', similar to the expanding balloon analogy used often in cosmology? We present here a series of calculations that give striking support for this concept.

The main idea of this paper is that the universe can be modeled, accurately, and very productively, as the surface volume of an expanding four dimensional hyperverse. This approach produces, immediately, many claims:

- We find the hyperverse is expanding at twice the speed of light.
- We discuss that, although the speed of light is the fastest translational velocity in the universe, the fastest velocity is one associated with the combination of rotational and translational velocity, and it is twice the speed of light.
- The 2c radial expansion therefore sets the speed limit in the universe; nothing can move faster than the rate of radial expansion.
- The 2c radial expansion rate gives us a basis of time, as we find the direction to which the cosmological arrow of time points.
- The hyperverse circumference is expanding at exactly the expansion rate we measure for the universe, the Hubble constant. This is a significant result.
- We discover a simple and elegant, hyperverse-related, equation for the Hubble constant.
- The Hubble constant can be stated as the rate energy is added to the universe.
- The 'front' of the expanding hyperverse is energy. The universe is not a vacuum; space is energy.
- Modeling the universe as the surface volume of a hyperverse is a very productive way to describe the shape of the universe.

1. The Universe as the Surface Volume of a Four Dimensional Sphere

We will start with the concept that space actually exists, consisting of discrete units, vortex-like 'atoms of space'. Lee Smolin [1] wrote of the idea that space might consist of 'atoms of space'. This author developed Smolin's idea into a model of how to build elementary particles using a vortex as the basic building block of space [2], and that lead to thoughts on the structure of space.

If we assume these vortices take up space, we can ask: "if space takes up space, where is there room for the additional atoms of space created by expansion?"

Packing additional atoms of space into an already full universe is not reasonable. The universe is huge, the atoms of space small, and the addition of space is occurring throughout the universe, meaning the pressure from the added atoms of space would be identical throughout. The only direction available is into the fourth dimension.

A hollow, four dimensional hypersphere, or hyperverse, would easily allow, and even require, the addition of new atoms of space as its surface expanded radially into the fourth dimension. Consider a three dimensional sphere such as a balloon, the two dimensional surface area being a 'flatland universe' for the balloon. Radial expansion of the balloon (making the balloon bigger) increases its surface area, requiring the addition of more surface area. Every point on the balloon's surface is in total contact with the next higher dimension. A 4D hypersphere has a 3D surface volume. Just as every point on the 2D surface of a 3D sphere touches the next higher, third dimension, every point on the 3D surface volume touches the next higher, fourth dimension. Despite the universality of the "balloon model" to demonstrate the expansion of space, it appears to not have been examined using the measurements of today's precision cosmology.

2. The Edge of Space is Everywhere

With the universe as the surface volume of a hollow, four dimensional hypersphere, every point in the universe is on the surface of the hyperverse, and we can state that every point in space touches nothingness. The edge of space exists at every point in space; every point in the universe is on the edge of space. The center of the hyperverse, however, does not exist on the surface; it resides at the center of the hypervolume of the hyperverse. Importantly, every point in the universe lies at the same distance from the center of the hyperverse. .

3. The Radius of the Observable Hyperverse

The current radius of the observable universe is around 46 to 46.5 billion light years and the age of the universe was recently revised to 13.8 billion years. [3]. We can calculate the radius of the observable hyperverse by setting the surface volume of the 4D hypersphere equal to the 3D volume of our universe:

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

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:

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

4. We are Moving into the Fourth Dimension at Twice the Speed of Light

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

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

The hyperverse radius is growing at $2c$, meaning the hyperverse surface is moving at two times the speed of light into the fourth dimension. Since every point in the universe is on the front of that expansion, we are moving at two times the speed of light into the fourth dimension.

It is a striking concept, even staggering. In one second of our time, we have moved two light seconds of distance, or about 600,000 kilometers, in a direction to which we cannot point. The moon is 384,000 kilometers away, so the distance we move radially, in one second, is about one and a half times the distance to the moon. We are at any location for a truly tiny, fleeting moment. Do we experience or feel this somehow? We will conjecture that this is the basis of time.

Events in the past are indeed far behind us, not just in memory, but in distance, and they occurred in a location which no longer exists because the 'front', the hyperverse surface, has moved radially. A model of time, with relativity, is given in [4].

5. The 2c Radial Expansion Sets the Speed Limit in the Universe

Let us look at what the true maximum velocity in the universe actually is. The speed of light is taken almost universally as the maximum translational velocity, the fastest that information can be transferred between two points in the universe. Is there a faster velocity?

Consider this thought experiment. You watch an automobile go by you, travelling at the speed of light, and realize the tires are rolling on the ground. The tire has both rotational and translational motion. The top of a tire travels at an instantaneous velocity of twice the speed of the automobile. In the case of a car going at the speed of light, the top of the tire is moving at twice the speed of light. Thus 2c is the true maximum velocity within the universe, although that velocity is an instantaneous value. The maximum translational velocity is still the speed of light.

It appears that the 2c radial expansion of space is what sets the speed limit within the universe; nothing can move faster than the universe radially expands. We will see in [4] that the radial expansion creates relativity, and explains why the speed of light is the maximum translational velocity within the universe.

6. The Hubble Expansion is the Circumferential Expansion of the Hyperverse

Any two points on the surface of a 4D hypersphere, in any direction, lie upon its circumference. The rate of separation between two points on the circumference of a circle is the rate of circumferential expansion. The rate of change of the circumference of a circle, relative to the radius, is 2π:

$$\frac{\Delta C_H}{\Delta R_H} = \frac{d\,(2\pi R_H)}{d\,(R_H)} = 2\pi \tag{4}$$

The rate of change of the hyperverse radius, delta R_H, is $2c$. Substituting $2c$ for ΔR_H gives:

$$\Delta C_H = 2\pi \Delta R_H = 2\pi\,(2c) \tag{5}$$

Dividing the rate of change of the circumference of the hyperverse, $2\pi\,(2c)$, by the circumference of the hyperverse, gives the fractional change of the circumference, and that value is the Hubble constant:

$$\frac{\Delta C_H}{C_H} = \frac{2\pi\,(2c)}{2\pi R_H} = \frac{2c}{R_H} = H \tag{6}$$

where H is the Hubble constant, C_H is the hyperverse circumference, ΔC_H is the rate of change of the hyperverse circumference, and c is the speed of light.

Calculating the value of the Hubble constant, based on equation (6), gives us:

$$H = \frac{2c}{R_H} = \frac{2\,(2.99792458 \times 10^8\,\mathrm{m\,s^{-1}})}{27.586\,6 \ \text{ million light years}} \approx 21.73 \text{ kilometers per second per million light years} \tag{7}$$

The Hubble constant is the measure of the rate of separation of galaxies in the universe, or simply, the rate space expands. Estimates of the Hubble constant range from around 20.78 to 22.69 kilometers per second per million light years [5], and our calculated value falls squarely in this range; the Hubble expansion is the circumferential expansion of the hyperverse.

7. The Mass of the Observable Universe

Fred Hoyle [6] calculated the mass of the universe to be $\frac{c^3}{2GH}$. By substituting $\frac{2c}{R_H}$ for the Hubble constant, H, we get, in hyperverse terms, a mass of $\frac{R_H c^2}{4G}$.

The Schwarzschild radius can be defined as the distance between points at which the accumulated expansion of space produces a separation speed equaling the speed of light. If we divide the speed of light by the Hubble constant, we get the Schwarzschild radius:

$$R_{schw} = \frac{c}{H} \tag{8}$$

With the hyperverse surface radially expanding at twice the speed of light, at one-half the hyperverse radius, the universe is radially expanding at the speed of light:

$$R_{schw} = \frac{c}{\left(\frac{2c}{R_H}\right)} = \frac{R_H}{2} \tag{9}$$

The equation of the Schwarzschild radius, where G is the gravitational constant and M is mass, is:

$$R_{schw} = \frac{2GM}{c^2} \tag{10}$$

Inserting Hoyle's mass value of $\frac{R_H c^2}{4G}$ into the Schwarzschild radius equation, (10), gives:

$$R_{schw} = \frac{2GM}{c^2} = \frac{2G\left(\frac{R_H c^2}{4G}\right)}{c^2} = \frac{R_H}{2} \tag{11}$$

Fred Hoyle's mass produces a match to equation (9), and thus the mass of the universe, M_o, will be defined as:

$$M_o = \frac{R_H c^2}{4G} = 8.835\,8 \times 10^{52}\,\mathrm{kg} \tag{12}$$

8. The Hubble Constant Measures the Change of the Mass and Energy in the Universe

If we take the rate of change, the derivative, of the mass of the observable universe in respect to the radius, we get:

$$\frac{dM_o}{dR_H} = \frac{d\frac{R_H c^2}{4G}}{dR_H} = \frac{c^2}{4G} \tag{13}$$

Rearranging, the rate of change of mass, ΔM_o, is

$$\Delta M_o = \frac{c^2}{4G}\Delta R_H \tag{14}$$

Since $\Delta R_H = 2c$, we see that $\Delta M_o = \frac{c^3}{2G}$:

$$\Delta M_o = \frac{c^3}{2G} \tag{15}$$

This value can also be obtained by dividing the mass of the observable universe by the age of the universe, which is the inverse of the Hubble constant:

$$\Delta M_o = \frac{\frac{R_H c^2}{4G}}{\frac{R_H}{2c}} = \frac{c^3}{2G} \tag{16}$$

If we divide the total change in mass by the total mass of the observable universe, M_o, we get the incremental change in mass, which matches the Hubble constant:

$$\frac{\Delta M_o}{M_o} = \frac{\frac{c^3}{2G}}{\frac{R_H c^2}{4G}} = \frac{2c}{R_H} = H \tag{17}$$

From mass-energy equivalence, the Hubble constant is the incremental change in the energy of the observable universe:

$$H = \frac{\Delta E_o}{E_o} = 2.285\,027\,734\,440\,597\,113\,7 \times 10^{-18}\ \mathrm{J\,/\,s\,/\,J} \tag{18}$$

where E_o is the energy of the observable universe, and ΔE_o is the rate of change of energy in the observable universe.

Thus we can argue that the Hubble constant is not just a measure of the rate of separation of galaxies, or of the circumferential expansion of the hyperverse, but is, at a deeper level, a measure of the increase of mass and energy in the observable universe.

The Hubble constant, defined here as 21.73 kilometers per second per million light years, is a value expressed as distance per time per distance. The distance values cancel out; the Hubble constant is a dimensionless number per second, $\frac{2.285 \times 10^{-18}}{\mathrm{s}}$. Therefore, there is no inherent conflict in stating the Hubble constant as $2.285 \times 10^{-18}\ \mathrm{J\,/\,s\,/\,J}$.

This calculation implies that the universe is composed of energy. The difference between space, and the nothingness into which it expands, is the presence of energy, and it is energy that forms the advancing front of the hyperverse. Space exists, and it is energy.

The Universe is the Surface Volume of the Hyperverse

A radial expansion rate of twice the speed of light, and a circumferential expansion rate matching the Hubble constant, are striking observations that are unlikely to be coincidental. Additionally, a universe as the surface volume of a hollow, four dimensional sphere gives us a positively curved, closed, and finite universe. The Hubble constant as a measure of the increase of energy of the universe implies the hyperverse has a surface composed of energy, and this energy is being added continually as space expands. These features help make an expanding hyperverse an appealing model for the structure of the universe.

The hyperverse model is developed much further in [4], [7], and [8], where we give mechanisms for the creation of time, quanta, and matter and gravity.

Acknowledgments

I wish to thank Dr. Terry Pilling of North Dakota State University for his helpful comments on this paper.

References

1. Smolin, L. 2001. Three Roads to Quantum Gravity. Basic Books. First Edition. pp. 95-97.

2. Tassano, J. "A Conceptual Model of the Structure of Elementary Particles." submitted 2013

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

4. Tassano, J. "A Model of Time." submitted 2013

5. "Hubble's Law." Wikipedia. Wikimedia Foundation, 08 Jan. 2013. Web. 02 Aug. 201

6. 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.

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

8. Tassano, J. "The Origin of Matter and Gravity: What They Are and Why They Exist." submitted, 2013