A Universe From Itself: The Geometric Mean Expansion of Space and the Creation of Quantum Levels

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ABSTRACT

Using the time-energy uncertainty equation and the value of delta energy for the observable universe, we find that delta time is the square of the Planck time. The time-energy uncertainty principle is shown to be a geometric mean equation, indicating the universe is undergoing a geometric mean expansion. The Planck values represent the initial state of the universe. A geometric mean-produced term, $\left(\frac{R_H}{2l_p}\right)^2$, the square of the ratio of the hyperverse radius to two times the Planck length, is shown to be the large number reported by Scott Funkhouser. It is shown that expansion produces two quantum levels, one based on the energy and the other on the radius of the observable hyperverse. Due to the geometric mean nature of expansion, the energy of the quanta are shrinking with time. A doubling of the radius of the hyperverse reduces surface vortex energy by one-half, but produces four times as many vortices, doubling of the energy of the universe, accounting precisely for the increase in energy of the universe. It appears that the universe creates the two quantum levels as a means of conserving angular momentum for the system as a whole; the observable universe grows while the quantum levels shrink. No added energy is needed to grow the universe; it comes entirely from itself.

Subject headings: conservation of angular momentum; cosmology; geometric mean expansion of space; Planck values; quantum levels; universe from itself

Introduction

There are evidences that the large and the small of the universe are deeply related. Joel C. Carvalho [1], using only atomic scale dimensions, calculated a mass, expressed in hyperverse terms, of $\frac{R_H c^2}{2G}$ for the observable universe, very close to the mass of the universe equation we developed in [2], shown here as equation (1). Carvalho's work highlights some sort of deep connection between the small and the large of the universe. Dimitar Valev [3], using dimensional analysis, discovered a geometric mean relationship, centered on the Planck mass, between the mass of the universe and what he identified as possibly the smallest mass in the universe, a value similar to that reported by Paul S. Wesson [4], who also used dimensional analysis. Hasmukh K. Tank [5] gives a number of potential geometric mean relationships between the small and the large of the universe. This paper, the second in the series, continues the exploration of hyperverse theory, and is focused on the geometric mean expansion of space and some of its consequences.

The Geometric Mean

To calculate an arithmetic mean of two numbers, the numbers are added and then divided by two. One calculates a geometric mean of two values by multiplying the two numbers and taking the square root of the product.

Figures 1A and 1B display a couple of ways of visually presenting the geometric mean, the most common being the triangle in Figure 9A, where the length of side A times the length of side B equals the square of the height: $A \times B = h^2$. As side A gets larger, side B must get smaller in order that their product remains equal to the height squared. A geometric mean preserves the square of the initial height.

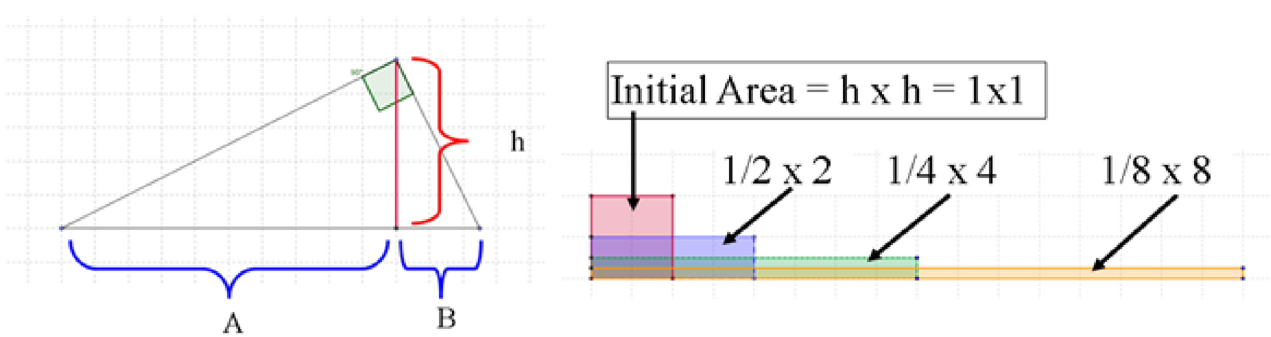

Figure 9A (left) and 9B (right). Two ways of looking at the geometric mean concept.

With the geometric mean, we see that for every large number, there is a corresponding small number. Given height 'h', if side A in the triangle of Figure 1A were one million units, side B would be one divided by one million. Expand A to one trillion, and B would be one over one trillion, and so on; small, but never zero. Just as there is no limit to how large a number can be, there is no limit to the how small a number can be; the small is as infinite as the large.

The series of rectangles in Figure 1B highlights the preservation of the initial area. As the height of the rectangle shortens, the length increases, their product conserving the initial area. A geometric mean expansion of space would therefore involve the conservation of the initial quantity.

1. The Revelation of Delta E

1.1. Delta Energy and Delta Time for the Observable Universe

Tassano [2] gave the mass of the observable universe as:

$$M_o = \frac{R_H c^2}{4G} \tag{1}$$

The energy of the observable universe is its mass times the speed of light squared, c^2, or:

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

If we take the rate of change of the energy of the observable universe with respect to the radius we get:

$$\frac{\Delta E_o}{\Delta R_H} = \frac{dE_o}{dR_H} = \frac{d\frac{R_H c^4}{4G}}{dR_H} = \frac{c^4}{4G} \tag{3}$$

Rearranging, the rate of change of energy is:

$$\Delta E_o = \frac{c^4}{4G} \Delta R_H \tag{4}$$

Since $\Delta R_H = 2c$, [2], we see that delta E, the rate of change of energy for the observable universe, is one-half the Planck power:

$$\Delta E_o = \frac{c^5}{2G} = 1.814\,592\,362\,824\,05 \times 10^{52} \, \frac{\mathrm{J}}{\mathrm{s}} \tag{5}$$

We can check this answer by multiplying our value of ΔE_o by the age of the universe; we get the energy of the observable universe:

$$\frac{c^5}{2G} \times \frac{R_H}{2c} = \frac{R_H c^4}{4G} \tag{6}$$

The time-energy uncertainty principle is commonly interpreted as saying we are restricted to how precisely we can simultaneously measure energy and time, the limit of the precision being h-bar divided by 2:

$$\Delta E_o \times \Delta t \geq \frac{\hbar}{2} \tag{7}$$

With our value of delta E for the observable universe, $\frac{c^5}{2G}$, we can calculate delta t_o, the rate of change of time for the observable universe. We get a significant result, the Planck time squared:

$$\Delta t = \frac{\hbar}{2\Delta E_o} \geq \frac{G\hbar}{c^5} \tag{8}$$

1.2. Delta Time Divided by the Total Time Gives 'Small Time'

If we divide delta time for the observable universe, by the age of the universe, $\frac{\Delta t}{T_o}$, we get what we will call 'small time', t_s:

$$\frac{\Delta t}{T_o} = \frac{\frac{G\hbar}{c^5}}{\frac{R_H}{2c}} = 2\frac{G\hbar}{R_H c^4} = t_s = 6.639\,859\,798\,408\,22 \times 10^{-105} \text{ seconds} \tag{9}$$

Alternatively, we can express small time as a function of the age of the universe, in a form we will use later:

$$t_s = \frac{T_o}{\left(\frac{R_H}{2l_p}\right)^2} \tag{10}$$

where T_o is the age of the observable universe, $\hbar$ is h-bar (Planck's constant divided by 2 pi), l_p is the Planck length, R_H is the radius of the hyperverse and t_s is small time, the smallest unit of time in the observable universe. Small time is much shorter a unit of time than the Planck time, which is 5.39056×10^{-44} seconds. The ratio of the Planck time to small time is:

$$\frac{5.39056 \times 10^{-44}}{6.639\,859\,798\,408\,22 \times 10^{-105}} = 8.118\,484\,672\,360\,53 \times 10^{60} \tag{11}$$

This value is equal to the ratio of the hyperverse radius to two times the Planck length:

$$\frac{R_H}{2l_p} = \frac{2.62397216 \times 10^{26}\,\mathrm{m}}{3.232\,1 \times 10^{-35}\,\mathrm{m}} = 8.118\,474\,552\,148\,757\,773\,6 \times 10^{60} \tag{12}$$

Small time can also be expressed as:

$$t_s = \frac{\hbar}{2} \times \frac{1}{E_o} \tag{13}$$

1.3. The Similarity of the Time-Energy Uncertainty Principle and the Relation Between Large Energy and Small Time

Equation (13) looks much like the time-energy uncertainly principle when restated as:

$$E_o \times t_s = \frac{\hbar}{2} \tag{14}$$

In this case we have the largest unit of energy, the energy of the universe, multiplied by the smallest unit of time, 'small time', and the result is h-bar over two, $\frac{\hbar}{2}$. Comparing the two side by side, we see that $\frac{\hbar}{2}$ is not just the product of the delta values, but also of the extreme and opposite values of time and energy as well.

$$\Delta E_o \times \Delta t \geq \frac{\hbar}{2} \qquad \rightleftarrows \qquad E_o \times t_s = \frac{\hbar}{2} \tag{15}$$

This supports the validity of the concept of the existence of small time, and suggests a geometric mean relationship exists between energy and time.

1.4. The Large and the Small Form Geometric Mean Relationships

We have seen that delta time, divided by large time (the age of the universe), gives small time. Rearranging (9) gives:

$$T_o \times t_s = t_{Planck}^2 \tag{16}$$

Equation (15) is a geometric mean equation, as we have the large and the small time values equaling the square of the Planck time, implying that as the age of the universe increases, the small unit of time decreases, and the pivot point is a constant, the Planck time squared. The right hand side of equation (15) is saying the same thing: as the energy of the universe increases, the unit of small time is decreasing.

At this point, let us assume the hyperverse is undergoing a geometric mean expansion, and examine the consequences.

2. The Geometric Mean Expansion of Space

2.1. The Initial State: When the Age of the Universe Equaled Small Time

The age of the universe is $\frac{R_H}{2c}$, the reciprocal of the Hubble constant. The small time is $\frac{2G\hbar}{c^4 R_H}$. We will now explore what conditions existed when the large time and small time were identical, by setting the age of the universe equal to small time, and solving, first for the radius:

$$\text{Let the age of the universe equal small time:} \frac{R_H}{2c} = 2\frac{G}{c^4}\frac{\hbar}{R_H} \tag{17}$$

Solving for the hyperverse radius at this initial moment gives us two times the Planck length:

$$\text{initial hyperverse radius} = R_i = 2l_p \tag{18}$$

We can thus deduce that when the age of the universe was equal to the small time, the radius of the hyperverse was two Planck lengths. Let us now substitute $2l_p$ for R_H in other equations.

Substituting the initial length of $2l_p$ for the hyperverse radius in $\frac{R_H}{2c}$, our equation of the age of the universe, gives us the Planck time, t_p, as the initial time:

$$\frac{R_H}{2c} \Rightarrow \frac{2l_p}{2c} = \frac{1}{c}\sqrt{\frac{G\hbar}{c^3}} = \sqrt{\frac{G}{c^5}\hbar} = t_p \tag{19}$$

Substituting $2l_p$ for R_H in the equations of the energy and mass of the universe, and we find that the initial energy of the universe was one-half the Planck energy:

$$\frac{R_H c^4}{4G} = \frac{2l_p c^4}{4G} = \sqrt{\frac{c^5\hbar}{4G}} = \frac{E_p}{2} \tag{20}$$

The initial mass of the universe was one-half the Planck mass:

$$\frac{R_H c^2}{4G} = \sqrt{\frac{c\hbar}{4G}} = \frac{M_p}{2} \tag{21}$$

The initial angular momentum of the universe, $L = mvr$, was the square root of two times h-bar:

$$\left(\frac{2l_p c^2}{4G}\right)\left(\sqrt{2}c\right)(2l_p) = \sqrt{2}\hbar \tag{22}$$

The rotational kinetic energy, $\frac{1}{2}I\omega^2$, is the same as the energy of the initial state:

$$\frac{1}{2}\left(mr^2\right)\left(\frac{v_T}{r}\right)^2 = \frac{1}{2}mv_T^2 = \frac{1}{2}\left(\frac{(2l_p)\,c^2}{4G}\right)\left(2c^2\right) = \sqrt{\frac{1}{4G}c^5\hbar} = \frac{E_p}{2} \tag{23}$$

The initial circumference was $2\pi 2l_p$

The initial period of rotation of the universe, (with $v_L = 0$), was $2\sqrt{2}\pi t_p$:

$$Period = \frac{\text{Circumference}}{v_T} = \frac{2\pi 2l_p}{\sqrt{2}c} = 2\sqrt{2}\pi\sqrt{\frac{G}{c^5}\hbar} = 2\sqrt{2}\pi t_p \tag{24}$$

The initial frequency (also with $v_L = 0$), is the inverse of the period: $\frac{1}{2\sqrt{2}\pi t_p}$

The initial Schwarzschild radius (using the initial mass) was the Planck length. Even at the initial state, the Schwarzschild radius was one-half of the hyperverse radius.

$$R_{schwarzschild} = \frac{2GM}{c^2} = \frac{2G\sqrt{\frac{c\hbar}{4G}}}{c^2} = l_p \tag{25}$$

A summary of the initial values is given in Table 1. The subscript 'i' represents the initial value, when the current expansion started.

$R_i = 2l_p$	$l_i = l_p$
$E_i = \frac{E_p}{2}$	$M_i = \frac{M_p}{2}$
$t_i = t_p$	$L_i = \sqrt{2}\hbar$
Initial $Frequency = \frac{1}{2\sqrt{2}\pi t_p}$	Initial period of rotation $= 2\sqrt{2}\pi t_p$
Initial $KE_{rotational} = M_i c^2 = E_i$	Initial $Circumference = 4\pi l_p$

Table 1

Making the assumption that the universe is undergoing a geometric mean expansion produces Planck values for the initial condition. Although the Planck units are profoundly important in physics, they have no clear, accepted, physical significance. The work here implies that the Planck units are not the smallest units, as is sometimes claimed, but represent the initial values of the universe, the pivot points of the geometric mean expansion of space, telling us about the initial state of the universe. This explains, for example, why they have no identifiable physical significance; Planck values are historical values, preserved as geometric means, accounting for the odd range of sizes seen within the Planck values, where, for example, the Planck length is shorter than the radius of the atom, but the Planck mass is 10^{19} times greater than the mass of a proton.

2.2. The Large and Small Values of the Observable Universe

Using the concept of the geometric mean and the initial values, we can calculate the geometric mean factors of the large and small of the universe. The radius of the hyperverse, R_H, is taken to be $2.62397216 \times 10^{26}$ meters. The Planck length is 1.61605×10^{-35}meters.

We can ask what is the geometric mean counterpart to the radius of the hyperverse, a value we will call R_s. The hyperverse radius, R_H, multiplied by this small volume radius, R_s, is equal to the initial radius squared: $R_H \times R_s = (2l_p)^2$. The small radius is:

$$R_s = \frac{(2l_p)^2}{R_H} = \frac{4l_p^2}{R_H} = 3.981\,166\,633\,261\,84 \times 10^{-96}\,\mathrm{m} \tag{26}$$

The small radius can also be expressed as:

$$R_s = \frac{R_H}{\left(\frac{R_H}{2l_p}\right)^2} \tag{27}$$

The energy of the observable universe, times the small energy, should equal the initial energy squared: $E_o \times E_{SEQ} = E_i^2$. Rearranging and solving for the small energy gives us $\frac{c\hbar}{R_H}$. We will refer to this quantum of energy associated with the small energy as the 'small energy quantum', E_{SEQ}:

$$E_{SEQ} = \frac{E_i^2}{E_o} = \frac{\left(\frac{\sqrt{\frac{c^5\hbar}{G}}}{2}\right)^2}{\frac{R_H c^4}{4G}} = \frac{c\hbar}{R_H} = 1.204\,863\,888\,041\,40 \times 10^{-52}\,\frac{\mathrm{m}^2}{\mathrm{s}^2}\,\mathrm{kg} \tag{28}$$

The reader might notice two things immediately: the similarity of equation (28) to the Planck relation, and that the value of E_{SEQ} will decrease with time, as the hyperverse radius increases.

The small energy quantum can be expressed in terms of the small radius, R_s, using the same form of equation as used for the mass of the observable universe:

$$E_{SEQ} = \frac{R_s c^4}{4G} \tag{29}$$

Substituting $\frac{R_H}{\left(\frac{R_H}{2l_p}\right)^2}$ for R_s in the above equation gives:

$$E_{SEQ} = \frac{R_s c^4}{4G} = \frac{\left(\frac{R_H c^4}{4G}\right)}{\left(\frac{R_H}{2l_p}\right)^2} = \frac{E_o}{\left(\frac{R_H}{2l_p}\right)^2} \tag{30}$$

Small mass, M_s, is solved in the same manner as for energy, using the geometric mean relationship. The mass of the observable universe, multiplied by the small mass, should equal the initial mass squared: $M_o \times M_s = M_i^2$. Solving for the small mass gives:

$$M_{SEQ} = \frac{M_i^2}{M_o} = \frac{\left(\frac{\sqrt{\frac{c\hbar}{G}}}{2}\right)^2}{\frac{R_H c^2}{4G}} = \frac{\hbar}{cR_H} = 1.340\,591\,872\,566\,24 \times 10^{-69}\,\mathrm{kg} \tag{31}$$

$$M_{SEQ} = \frac{R_s c^2}{4G} = \frac{\left(\frac{R_H c^2}{4G}\right)}{\left(\frac{R_H}{2l_p}\right)^2} = \frac{M_o}{\left(\frac{R_H}{2l_p}\right)^2} \tag{32}$$

The small volume, determined by the geometric mean approach, is:

$$V_s = \frac{(\text{initial volume})^2}{\text{surface volume of hyperverse}} = \frac{\left(2\pi^2 (2l_p)^3\right)^2}{2\pi^2 R_H^3} = \frac{2\pi^2 R_H^3}{\left(\frac{R_H}{2l_p}\right)^6} \tag{33}$$

The radius for this small volume is the small radius, R_s:

$$\text{Radius of small volume} = \left(R_H^3 \left(\frac{2l_p}{R_H}\right)^6\right)^{\frac{1}{3}} = \frac{4l_p^2}{R_H} = R_s \tag{34}$$

To calculate the period of rotation, we calculate the period related to the observable hyperverse: the circumference, C_o, divided by the tangential velocity, v_T. The tangential velocity is a constant, $\sqrt{2}c$, as discussed in [7]. T_o is the age of the universe, $\frac{R_H}{2c}$.

$$\text{Period of rotation of observable universe} = \frac{C_o}{v_T} = \frac{2\pi R_H}{\sqrt{2}c} = \sqrt{2}\pi \frac{R_H}{c} = 2\sqrt{2}\pi \left(T_o\right) \tag{35}$$

Using the geometric mean relationship and our value for the small radius, we get the small period, which is a factor of the small time:

$$\text{Period of rotation of the small} = \frac{C_s}{v_T} = \frac{2\pi R_s}{\sqrt{2}c} = 2\sqrt{2}\pi \left(t_s\right) \tag{36}$$

Both periods, as does the initial period, have the same structure, $2\sqrt{2}\pi \times \mathit{time}$.

Frequency is the reciprocal of the period:

$$\text{frequency of rotation of the small} = \frac{1}{2\sqrt{2}\pi \left(t_s\right)} \tag{37}$$

For angular momentum, we will first calculate the angular momentum of the observable hyperverse, L_o. The velocity is the tangential velocity, $\sqrt{2}c$.

$$L_o = mrv = \left(\frac{R_H c^2}{4G}\right)(R_H)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2 = 9.829\,702\,483\,454\,73 \times 10^{87}\,\frac{\text{m}^2}{\text{s}}\,\text{kg} \tag{38}$$

From this we can calculate the geometric mean partner of the large angular momentum:

$$L_s = \frac{L_i^2}{L_o} = \frac{\left(\sqrt{2}\hbar\right)^2}{\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2} = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 = 2.262\,781\,599\,120\,41 \times 10^{-156}\,\frac{\text{m}^2}{\text{s}}\,\text{kg} \tag{39}$$

Notice that L_s matches the angular momentum derived from using the two quantum quantities, E_s and R_s:

$$L_s = mrv = \left(\frac{\hbar}{cR_H}\right)\left(\frac{4l_p^2}{R_H}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 \tag{40}$$

The large and small angular momentums will be critical in the discussion of matter and gravity, [8] and [9].

2.3. Summarizing the Values

Table 2 shows the initial, large, and small values for the observable hyperverse. To clarify, 'small' refers to the value generated from the geometric mean expansion; some quantities, as we will see, are attributable to the small energy quantum and others to the small radius quantum, both of which we will explore next.

	Initial	Large	Small
Radius	$2l_p$	R_H	$R_s = \frac{4l_p^2}{R_H}$
Time	t_p	$T_o = \frac{R_H}{2c}$	$t_s = 2\frac{G\hbar}{c^4 R_H}$
Energy	$\frac{E_p}{2} = \frac{\sqrt{\frac{c^5\hbar}{G}}}{2}$	$E_o = \frac{R_H c^4}{4G}$	$E_s = \frac{c\hbar}{R_H} = \frac{R_s c^4}{4G} = E_{SEQ}$
Mass	$\frac{M_p}{2} = \frac{\sqrt{\frac{c\hbar}{G}}}{2}$	$M_o = \frac{R_H c^2}{4G}$	$\frac{\hbar}{cR_H}$
Angular Momentum	$\sqrt{2}\hbar$	$\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2$	$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2$
Period	$2\sqrt{2}\pi\,(t_p)$	$2\sqrt{2}\pi\,(T_o)$	$2\sqrt{2}\pi\,(t_s)$
Frequency	$\frac{1}{2\sqrt{2}\pi(t_p)}$	$\frac{1}{2\sqrt{2}\pi(T_o)}$	$\frac{1}{2\sqrt{2}\pi(t_s)}$

Table 2. A summary of some dimensions of a universe undergoing a geometric mean expansion.

2.4. Large and Small Delta Values

Let us now determine the delta values for the small and large aspects of the geometric mean expansion. We can calculate the rate of change of its small counterpart, R_s, which we use here as the radius of the small radius quantum, by dividing the square of the the initial radius, $(2l_p)^2$, by ΔR_H. We get:

$$\Delta R_{small} = \frac{4l_p^2}{\Delta R_H} = \frac{4\frac{G\hbar}{c^3}}{2c} = \frac{2G\hbar}{c^4} = 1.742\,280\,725\,732\,64 \times 10^{-78}\,\mathrm{m\,s} \tag{41}$$

Since delta E for the observable hyperverse is $\Delta E_o = \frac{c^5}{2G}$, small delta E comes out as h-bar divided by two, $\frac{\hbar}{2}$:

$$\Delta E_{small} = \frac{(\text{initial energy})^2}{\Delta E_o} = \frac{\left(\frac{\sqrt{\frac{c^5\hbar}{G}}}{2}\right)^2}{\frac{c^5}{2G}} = \frac{\hbar}{2} = 5.272\,863\,3 \times 10^{-35}\,\frac{\mathrm{m}^2}{\mathrm{s}}\,\mathrm{kg} \tag{42}$$

Small delta mass, ΔM_{small}, is $\frac{\hbar}{2c^2}$:

$$\Delta M_{small} = \frac{(\text{initial mass})^2}{\Delta M_o} = \frac{\left(\frac{\sqrt{\frac{c\hbar}{G}}}{2}\right)^2}{\frac{c^3}{2G}} = \frac{\hbar}{2c^2} = 5.866\,851\,646\,308\,07 \times 10^{-52}\,\mathrm{s\,kg} \tag{43}$$

Delta time is the Planck time squared. The initial time is the Planck time. To get the geometric mean counterpart, we divide the square of the initial time by our value of Δt. Since they are the same, we get one, just the number one, a quantity without any dimensions such as length, energy, mass or time:

$$\Delta t_{small} = \frac{\left(\sqrt{\frac{\hbar G}{c^5}}\right)^2}{\frac{\hbar G}{c^5}} = 1 \tag{44}$$

Table 3 summarizes the large and small delta values, and shows their geometric means, matching those of the large and small from Table 2.

	big Δ	small Δ	$\sqrt{\text{big } \Delta \times \text{small } \Delta}$
$\Delta Radius$	$2c$	$\frac{2G\hbar}{c^4}$	$2l_p$
$\Delta Energy$	$\frac{c^5}{2G}$	$\frac{\hbar}{2}$	$\frac{E_p}{2}$
$\Delta Mass$	$\frac{c^3}{2G}$	$\frac{\hbar}{2c^2}$	$\frac{M_p}{2}$
$\Delta Time$	1	$\frac{\hbar G}{c^5}$	t_p

Table 3. A listing of the large and small delta values of the universe.

2.5. Generating new uncertainty principles

Using delta energy for the observable universe in the time-energy uncertainty equation produced the Planck time squared, equation (8). Using Table 3, the large and small delta values, we see that the product of small delta energy and large delta time also produces $\frac{\hbar}{2}$:

$$\Delta E_{small} \times \Delta t_{big} = \frac{\hbar}{2} \times 1 = \frac{\hbar}{2} \tag{45}$$

We can use these delta values to create additional uncertainty relationships. For example, small delta energy times large delta radius gives:

$$\Delta E_{small} \times \Delta R_{big} = \frac{\hbar}{2} \times 2c = c\hbar \tag{46}$$

while large delta energy multiplied by small delta radius gives the same value:

$$\Delta E_{big} \times \Delta R_{small} = \frac{c^5}{2G} \times \frac{\hbar G}{c^5} = c\hbar \tag{47}$$

This same approach can be used for other pairs of quantities, using a large value with a small value, an exercise we will leave for the reader.

3. Expansion Creates Two Quantum Levels

3.1. The Small Energy Quantum

The small energy quantum, E_{SEQ}, is the geometric mean counterpart of the energy of the observable universe. It has its own radius, distinct from the small radius, R_s. If we divide the energy of the hyperverse by the energy of the small energy quantum, we see there are $\left(\frac{R_H}{2l_p}\right)^2$ units of E_{SEQ} within the observable universe:

$$\text{number of small energy quanta} = \frac{\frac{R_H c^4}{4G}}{\left(\frac{R_H c^4}{4G}\right)\left(\frac{2l_p}{R_H}\right)^2} = \left(\frac{R_H}{2l_p}\right)^2 \tag{48}$$

The volume and radius of the small energy quantum can be calculated by dividing the volume of the observable universe, V_o, by the number of small energy quanta, $\left(\frac{R_H}{2l_p}\right)^2$, and calculating the radius:

$$\text{volume of a small energy quanta} = \frac{V_o}{\text{number of small energy quanta}} = \frac{2\pi^2 R_H^3}{\left(\frac{R_H}{2l_p}\right)^2} = 2\pi^2\left(R_H 4l_p^2\right) \tag{49}$$

The small energy quantum radius is the cube root of the term $\left(R_H 4l_p^2\right)$:

$$R_{SEQ} = \text{radius of small energy quanta} = \sqrt[3]{\left(R_H 4l_p^2\right)} = 6.495\,953\,894\,227\,41 \times 10^{-15}\ \text{m} \tag{50}$$

This radius can also be expressed as:

$$R_{SEQ} = R_H\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{51}$$

As a check, the ratio of the energy density of the small energy quantum to the volume of the small energy quantum is the same as the energy density of the universe, so we have consistency:

$$\frac{E_{SEQ}}{V_{SEQ}} = \frac{\left(\frac{R_H c^4}{4G}\right)\left(\frac{2l_p}{R_H}\right)^2}{2\pi^2\left(R_H 4l_p^2\right)} = \frac{E_o}{V_o} \tag{52}$$

3.2. The Small Radius Quantum

The small radius, R_s, or $\frac{4l_p^2}{R_H}$, has its own associated energy. Dividing the volume of the observable universe by the volume of a 4D-sphere with radius R_s, we get the number of small radius volumes within the observable universe:

$$\text{number of small volumes} = \frac{2\pi^2 R_H^3}{2\pi^2 \left(\frac{4l_p^2}{R_H}\right)^3} = \left(\frac{R_H}{2l_p}\right)^6 \tag{53}$$

Dividing the energy of the observable universe by the number of small volumes gives the energy per small radius volume:

$$\text{SRQ energy} = \frac{\frac{R_H c^4}{4G}}{\left(\frac{R_H}{2l_p}\right)^6} = \frac{R_H c^4}{4G} \times \left(\frac{2l_p}{R_H}\right)^6 = 2.773\,581\,940\,492\,9 \times 10^{-296}\,\frac{\text{m}^2}{\text{s}^2}\,\text{kg} \tag{54}$$

As with the small energy quantum, or SEQ, the ratio of the energy density of the energy associated with the small radius to its volume is the same as the energy density of the universe, again confirming consistency:

$$\frac{E_{SV}}{V_{SV}} = \frac{\left(\frac{R_H c^4}{4G}\right)\left(\frac{2l_p}{R_H}\right)^6}{2\pi^2 R_H^3 \left(\frac{2l_p}{R_H}\right)^6} = \frac{E_o}{V_o} \tag{55}$$

The unit of energy given to us by the small radius will be referred to as the small radius quantum, or SRQ.

3.3. The Quanta are Distinct

It appears that the geometric mean expansion of space creates these two quantum levels, the small energy quantum, or SEQ, from the energy of the observable universe, and the small radius quantum, or SRQ, from its radius. In addition to both quantum levels being generated by expansion, they are closely related as such:

$$\frac{E_{SEQ}}{R_{SRQ}} = \frac{c^4}{4G} \tag{56}$$

This ratio matches the energy to radius ratio of the observable hyperverse:

$$\frac{E_o}{R_H} = \frac{\frac{R_H c^4}{4G}}{R_H} = \frac{c^4}{4G} \tag{57}$$

Despite the deep relationship between the quantum levels, both the SEQ and the SRQ have distinct identities.

The small energy quanta, or SEQ, derived as the geometric mean counterpart of the energy of the observable universe, and which has its own associated energy and radius, consists of $\left(\frac{R_H}{2l_p}\right)^4$ small radius quanta, or SRQ, volumes:

$$\frac{\text{number of small volume quanta}}{\text{number of SEQ}} = \frac{\left(\frac{R_H}{2l_p}\right)^6}{\left(\frac{R_H}{2l_p}\right)^2} = \left(\frac{R_H}{2l_p}\right)^4 = 4.344\,079\,202\,020\,98 \times 10^{243} \tag{58}$$

The small radius quantum, or SRQ, is derived as the geometric mean counterpart of the radius of the observable universe. A side-by-side comparison is shown in Table 4:

	SEQ	SRQ
Radius	$\left(R_H 4l_p^2\right)^{\frac{1}{3}}$	$\frac{4l_p^2}{R_H}$
Energy	$\frac{c\hbar}{R_H}$	$\frac{c\hbar}{R_H}\left(\frac{2l_p}{R_H}\right)^4$

Table 4. Comparing the energy and radii of the two quantum levels

3.4. Significant Geometric Means for the Derived Quanta

As stated, the SEQ energy and the SRQ radius are geometric mean counterparts of the energy and radius of the observable universe, respectively. That leaves us to enquire as to what might be the geometric mean counterparts of the SEQ radius and the SRQ energy. The results are profound.

3.4.1. The Size of the Whole Universe - a First Look

We can take the energy value of the SRQ, and using the geometric mean concept, determine its large partner energy. Dividing the square of the initial energy by the small radius quantum energy gives $E_o\left(\frac{R_H}{2l_p}\right)^4$:

$$E_{\text{large}}=\frac{\left(\frac{\sqrt{\frac{c^5\hbar}{G}}}{2}\right)^2}{\frac{R_Hc^4}{4G}\times\left(\frac{2l_p}{R_H}\right)^6}=\left(\frac{R_Hc^4}{4G}\right)\left(\frac{R_H}{2l_p}\right)^4=E_o\left(\frac{R_H}{2l_p}\right)^4 \tag{59}$$

The result hints at the possible energy, and size, of the whole universe, greater by a factor of $\left(\frac{R_H}{2l_p}\right)^4$, or 4.3×10^{243} times the observable. The whole universe is potentially immensely larger than the observable universe.

3.4.2. The Particle Radius

The small energy quantum radius, R_{SEQ}, is $6.495\,953\,894\,227\,41\times10^{-15}$ meters, and is very close to the reduced Compton wavelength of elementary particles and nucleons. The geometric mean counterpart of the small energy quantum radius, R_{GM_SEQ}, is:

$$R_{GM\_SEQ}=\frac{(2l_p)^2}{\left(R_H4l_p^2\right)^{\frac{1}{3}}}=\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}=1.608\,150\,331\,744\,687\,220\,7\times10^{-55}\,\text{m} \tag{60}$$

It will be argued in [8] that the similarity of R_{SEQ} to the Compton radius of an elementary particle is not a coincidence, and that R_{GM_SEQ}, the geometric mean counterpart of R_{SEQ}, is the actual, idealized, particle radius, and leads to a model of both matter [8] and gravity [9].

4. The Large Number of the Universe

4.1. The Ratio of the Large to the Small

The reader may have noticed the repeated occurrence of the term $\left(\frac{R_H}{2l_p}\right)^2$, the ratio of the hyperverse radius to the small radius, $\frac{R_H}{R_s}$, or $\frac{R_H}{\frac{4l_p^2}{R_H}}$. This number, $\left(\frac{R_H}{2l_p}\right)^2$, will be referred to as the 'large number':

$$\text{The large number}=\frac{\text{large radius}}{\text{small radius}}=\frac{R_H}{\frac{4l_p^2}{R_H}}=\left(\frac{R_H}{2l_p}\right)^2=6.590\,962\,905\,388\,70\times10^{121} \tag{61}$$

Its reciprocal is:

$$\text{The reciprocal of the large number} = \left(\frac{2l_p}{R_H}\right)^2 = 1.517\,228\,991\,203\,11 \times 10^{-122} \tag{62}$$

The large number is the common ratio of the large and the small in the observable universe:

$$\frac{\text{large time}}{\text{small time}} = \frac{\frac{R_H}{2c}}{2\frac{G}{c^4}\frac{\hbar}{R_H}} = \left(\frac{R_H}{2l_p}\right)^2 \tag{63}$$

$$\frac{\text{large energy}}{\text{SEQ energy}} = \frac{\frac{R_H c^4}{4G}}{\frac{c\hbar}{R_H}} = \left(\frac{R_H}{2l_p}\right)^2 \tag{64}$$

Volume is the cube of the radius and this ratio of large to small is the cube of the large number:

$$\frac{\text{large energy}}{\text{small volume energy}} = \frac{\frac{R_H c^4}{4G}}{2\pi^2 R_H^3 \left(\frac{2l_p}{R_H}\right)^6} = \left(\left(\frac{R_H}{2l_p}\right)^2\right)^3 = \left(\frac{R_H}{2l_p}\right)^6 \tag{65}$$

The small values of the universe can be expressed in terms of the large number as shown in some examples in Table 5:

	Small
Radius	$R_s = R_H \left(\frac{2l_p}{R_H}\right)^2$
Time	$T_s = T_o \left(\frac{2l_p}{R_H}\right)^2$
Energy	$E_{SEQ} = E_o \left(\frac{2l_p}{R_H}\right)^2$
Mass	$M_s = M_o \left(\frac{2l_p}{R_H}\right)^2$

Table 5. Expressing features of the universe in terms of the large number.

4.2. The Large Number

In 2008, Scott Funkhouser [6] reported six cosmological numbers equaling approximately 10^{122}, very close to the 6.59×10^{121} figure that we are seeing repeatedly in our calculations.

The precision of our figure will vary depending on what value is used for the hyperverse radius; in this paper, the value used is $2.62397216 \times 10^{26}$ m.

One of the examples Funkhouser gave as producing this large number is the ratio of the initial mass density to the vacuum mass density. Calculating this ratio of mass densities gives us the large number:

$$\frac{\text{initial mass density}}{\text{mass density of universe}} = \frac{\frac{\text{initial mass}}{\text{initial volume}}}{\frac{\text{mass of the observable universe}}{\text{surface volume of hyperverse}}} = \frac{\frac{\frac{\sqrt{\frac{c\hbar}{G}}}{2}}{2\pi^2\left(2\sqrt{\frac{G\hbar}{c^3}}\right)^3}}{\frac{\frac{R_H c^2}{4G}}{2\pi^2 R_H^3}} = \left(\frac{R_H}{2l_p}\right)^2 \tag{66}$$

4.3. The Number of Frame Advances

The hyperverse model incorporates the concept of frame advances [7], the incremental steps of radial expansion. It was proposed that a frame advance is one radial length. The number of frame advances since the start of expansion is the ratio of the hyperverse radius to the small radius, and that works out to be the large number:

$$\text{Number of frame advances} = \frac{\text{radius of hyperverse}}{\text{small radius}} = \frac{R_H}{\frac{4l_p^2}{R_H}} = \left(\frac{R_H}{2l_p}\right)^2 \tag{67}$$

Small time was defined, in equation (10), as $\frac{T_o}{\left(\frac{R_H}{2l_p}\right)^2}$. Small time is thus the age of the universe divided by the number of frame advances, or the average time per frame advance.

5. Creating the Observable Universe from a Planck Scale Vortex

5.1. The Number of Doublings is the Square Root of the Large Number

To calculate the number of times the hyperverse has doubled, we can ask what value of 'n' solves this equation:

$$2^n \times 2l_p = R_H \quad \text{or} \quad 2^n = \frac{R_H}{2l_p} \tag{68}$$

There have been about 202.3 doublings of the hyperverse since expansion started:

$$\log_2\left(\frac{R_H}{2l_p}\right) = \log_2\left(\frac{2.62397216 \times 10^{26}\,\mathrm{m}}{2\,(1.61605 \times 10^{-35}\,\mathrm{m})}\right) = 202.336\,894\,366\,120\,619\,5 \tag{69}$$

The value of $2^{202.336\,894\,366\,120\,619\,5}$ is the square root of the large number:

$$2^{202.336\,894\,366\,120\,619\,5} = 8.118\,474\,552\,148\,757\,782\,8 \times 10^{60} \tag{70}$$

We can use the equation $2^n \times 2l_p = R_H$ to check that it produces the hyperverse radius, which it does:

$$\left(8.118\,474\,552\,148\,757\,782\,8 \times 10^{60}\right) \times 2\left(1.61605 \times 10^{-35}\,\mathrm{m}\right) = 2.623\,972\,160\,000\,000\,003\,0 \times 10^{26}\,\mathrm{m} \tag{71}$$

We can apply the doubling concept to energy: $2^{202.336\,894\,366\,120\,619\,50} \times$ initial energy:

$$2^{202.336\,894\,366\,120\,619\,50} \times \frac{1.956\,333\,046\,737\,717\,225\,4 \times 10^{9}}{2}\,\mathrm{J} = 7.941\,226\,863\,350\,439\,148 \times 10^{69}\,\mathrm{J} \tag{72}$$

which is our value for the energy of the universe as derived from $\frac{R_H c^4}{4G}$.

The doubling applies to time as well, giving us the correct age of the universe:

$$\left(8.118\,474\,552\,148\,757\,782\,8 \times 10^{60}\right) \times 5.39056 \times 10^{-44}\,\mathrm{s} = 4.376\,312\,418\,183\,1 \times 10^{17}\,\mathrm{s} \tag{73}$$

5.2. Doubling: 'Now' versus 'Then' for the Observable Universe

An easy way to see the effects of a doubling of the size of the hyperverse is to compare the hyperverse today, or "now", to when its radius was one-half the current size, which we will refer to as "then". Let us start with the radius:

$$\frac{\text{large radius now}}{\text{large radius then}} = \frac{R_H}{\frac{R_H}{2}} = 2 \tag{74}$$

As we would expect, the large radius has doubled with a doubling of the large radius. Next, we see that the small radius, R_s, shrinks by one-half with a doubling of the hyperverse radius:

$$\frac{\text{SRQ radius now}}{\text{SRQ radius then}} = \frac{\frac{4l_p^2}{R_H}}{\frac{4l_p^2}{\frac{R_H}{2}}} = \frac{1}{2} \tag{75}$$

Let us look at the SEQ radius, R_{SEQ}, which we generated as the radius of the small energy quantum. We find that it actually gets a little larger with expansion, growing by $\sqrt[3]{2}$ as the hyperverse radius doubles:

$$\frac{R_{SEQ}\text{ now}}{R_{SEQ}\text{ then}} = \frac{\left(R_H 4l_p^2\right)^{\frac{1}{3}}}{\left(\frac{R_H}{2}4l_p^2\right)^{\frac{1}{3}}} = \sqrt[3]{2} \ = 1.259\,921\,049\,894\,87 \tag{76}$$

The surface volume of the observable hyperverse, which is the volume of the observable universe, increases eight times:

$$\frac{\text{hyperverse surface volume now}}{\text{hyperverse surface volume then}} = \frac{2\pi^2 R_H^3}{2\pi^2\left(\frac{R_H}{2}\right)^3} = 8 \tag{77}$$

while the surface volume of the small volume (based on R_s) shrinks by one-eighth:

$$\frac{\text{small surface volume now}}{\text{small surface volume then}} = \frac{2\pi^2 R_s^3}{2\pi^2\left(\frac{R_s}{2}\right)^3} = \frac{2\pi^2\left(\frac{4l_p^2}{R_H}\right)^3}{2\pi^2\left(\frac{4l_p^2}{\frac{R_H}{2}}\right)^3} = \frac{1}{8} \tag{78}$$

The total energy of the universe doubles with a doubling of the hyperverse radius:

$$\frac{\text{total hyperverse energy now}}{\text{total hyperverse energy then}} = \frac{\frac{R_H c^4}{4G}}{\frac{\frac{R_H}{2}c^4}{4G}} = 2 \tag{79}$$

The energy of the small energy quantum (SEQ) shrinks to one-half per doubling of the hyperverse radius:

$$\frac{\text{the small energy quantum now}}{\text{the small energy quantum then}} = \frac{\frac{c\hbar}{R_H}}{\frac{c\hbar}{\frac{R_H}{2}}} = \frac{1}{2} \tag{80}$$

The number of SEQ increases by four times with a doubling:

$$\frac{\text{the number of SEQ now}}{\text{the number of SEQ then}} = \frac{\left(\frac{R_H}{2l_p}\right)^2}{\left(\frac{\frac{R_H}{2}}{2l_p}\right)^2} = 4 \tag{81}$$

The surface volume of a SEQ increases by two with a doubling:

$$\frac{\text{volume of one SEQ now}}{\text{volume of one SEQ then}} = \frac{2\pi^2\left(R_H 4l_p^2\right)}{2\pi^2\left(\frac{R_H}{2}4l_p^2\right)} = 2 \tag{82}$$

The energy of the small radius quantum (SRQ) shrinks to 1/32:

$$\frac{\text{the small radius quantum energy now}}{\text{the small radius quantum energy then}} = \frac{\frac{c\hbar}{R_H}\left(\frac{2l_p}{R_H}\right)^4}{\frac{c\hbar}{\frac{R_H}{2}}\left(\frac{2l_p}{\frac{R_H}{2}}\right)^4} = \frac{1}{32} \tag{83}$$

while the number of SRQ volumes increases by 64 times:

$$\frac{\text{number of SRQ now}}{\text{number of SRQ then}} = \frac{\left(\frac{R_H}{2l_p}\right)^6}{\left(\frac{\frac{R_H}{2}}{2l_p}\right)^6} = 64 \tag{84}$$

The energy density of the SEQ drops to one quarter:

$$\frac{\text{SEQ energy density now}}{\text{SEQ energy density then}} = \frac{\frac{\frac{c\hbar}{R_H}}{2\pi^2\left(R_H 4l_p^2\right)}}{\frac{\frac{c\hbar}{\frac{R_H}{2}}}{2\pi^2\left(\frac{R_H}{2}4l_p^2\right)}} = \frac{1}{4} \tag{85}$$

The energy density of the SRQ also drops to one quarter:

$$\frac{\text{SRQ energy density now}}{\text{SRQ energy density then}} = \frac{\frac{\left(\frac{R_H c^4}{4G}\right)\left(\frac{2l_p}{R_H}\right)^6}{2\pi^2 R_H^3\left(\frac{2l_p}{R_H}\right)^6}}{\frac{\left(\frac{\frac{R_H}{2}c^4}{4G}\right)\left(\frac{2l_p}{\frac{R_H}{2}}\right)^6}{2\pi^2\left(\frac{R_H}{2}\right)^3\left(\frac{2l_p}{\frac{R_H}{2}}\right)^6}} = \frac{1}{4} \tag{86}$$

And the energy density of the observable hyperverse also drops to one quarter:

$$\frac{\text{hyperverse energy density now}}{\text{hyperverse energy density then}} = \frac{\frac{\frac{R_H c^4}{4G}}{2\pi^2 R_H^3}}{\frac{\frac{\frac{R_H}{2} c^4}{4G}}{2\pi^2 \left(\frac{R_H}{2}\right)^3}} = \frac{1}{4} \tag{87}$$

Time is directly proportional to the hyperverse radius, wherein a doubling of the hyperverse radius is accompanied by a doubling in the time passed:

$$\frac{\text{time now}}{\text{time then}} = \frac{\frac{R_H}{2c}}{\frac{\frac{R_H}{2}}{2c}} = 2 \tag{88}$$

Let us summarize some of the critical values. An arrow pointing up indicates the quantity increases with time, while a downward pointing arrow means the quantity decreases with time:

	observable	SRQ	SEQ
Radius	$R_H = 2x \uparrow$	$R_{SRQ} = \frac{1}{2}x \downarrow$	$R_{SEQ} = \sqrt[3]{2}x \uparrow$
Volume per unit	$V_o = 8x \uparrow$	$V_{SRQ} = \frac{1}{8}x \downarrow$	$V_{SEQ} = 2x \uparrow$
Energy per unit	$E_o = 2x \uparrow$	$E_{SRQ} = \frac{1}{32}x \downarrow$	$E_{SEQ} = \frac{1}{2} \downarrow$
Number of units	1	$64x \uparrow$	$4x \uparrow$
Total Energy = Energy x Number	$2x \uparrow$	$2x \uparrow$	$2x \uparrow$
Energy Density	$\frac{1}{4} \downarrow$	$\frac{1}{4} \downarrow$	$\frac{1}{4} \downarrow$

Table 6. Summary of the effects of a doubling the hyperverse radius, on the observable hyperverse and the two quantum levels.

5.3. The Speed of Light Remains Constant

Like the tangential velocity, the speed of light remains constant. The speed of light can be described as the distance light travels in one unit of time. With our geometric mean values, we see that light travels one small length, which is one half the small radius, in one small unit of time:

$$\frac{\text{small radius}}{\text{small time}} = \frac{\frac{R_s}{2}}{t_s} = \frac{\frac{\frac{4l_p^2}{R_H}}{2}}{2\frac{G}{c^4}\frac{\hbar}{R_H}} = c \tag{89}$$

Using a 'now and then' approach, even with a doubling of the hyperverse radius, which alters both the value of the small length and small time, the speed of light remains constant:

$$\frac{\frac{4l_p^2}{\frac{R_H}{2}}}{2\frac{G}{c^4}\frac{\hbar}{\frac{R_H}{2}}} / \frac{\frac{4l_p^2}{\frac{\frac{R_H}{2}}{2}}}{2\frac{G}{c^4}\frac{\hbar}{\frac{\frac{R_H}{2}}{2}}} = 1 \tag{90}$$

5.4. The Continuous Creation of Energy

With a doubling of the hyperverse radius we find that the radius of the small radius quantum shrinks by one-half, accompanied by a decrease in the energy per small radius quantum, to 1/32 of the starting value, while the number of SRQ increases from one to sixty four, producing a net increase in energy of two times, matching the increase of the universe. At the SEQ level, the total energy doubles as well.

The first doubling was like any other. Energy doubled from one-half the Planck energy to the Planck energy, while the doubling of this initial hyperverse radius produced 64 hypervortices comprising the surface of the now rapidly expanding hyperverse. Approaching this a little differently, since rotational kinetic energy of a single vortex is $\frac{1}{2}I\omega^2$, or$\frac{1}{2}mr^2\left(\frac{\sqrt{2}c}{r}\right)^2$, which reduces to mc^2, multiplying this energy by the number of vortices, 64, we get the doubled energy. The initial energy was one half the Planck energy, so the first doubled energy was the Planck energy:

$$\frac{1}{2}mv_T^2 = \frac{1}{2}\left(\left(\frac{\frac{4l_pc^2}{4G}}{\left(\frac{4l_p}{2l_p}\right)^6}\right)\left(\sqrt{2}c\right)^2\right) \times \left(\frac{4l_p}{2l_p}\right)^6 = \sqrt{\frac{1}{G}c^5\hbar} = E_{Planck} \tag{91}$$

The expansion created energy from its very start. From an initial energy of one half the Planck energy, or about 9.78×10^8 joules, the current energy of the observable universe has increased by 8.1186×10^{60} times, or $\frac{R_H}{2l_p}$, to its current value of about 7.94×10^{69} joules.

As discussed in [8], the ratio of mass or energy to the radius is conserved with expansion, the relationship being quite visible in our equation of the mass of the universe, $E_o = \frac{R_Hc^4}{4G}$. The ratio of mass to radius is a constant, $\frac{c^4}{4G}$:

$$E_o = R_H\left(\frac{c^4}{4G}\right) \tag{92}$$

From this equation, we see that a doubling of the radius would produce a doubling of the energy; they are closely bound; increasing the radius increases the energy, supporting the 'now vs then' calculations. All of this also tells us that the universe is continually creating energy.

In equation 17 of [2], we saw that the Hubble constant could be defined as the ratio of the change in the energy of the observable universe to its total energy,

$$H = \frac{\Delta E_o}{E_o} \tag{93}$$

implying that the Hubble constant is a measurement of the increase in energy in the universe, a continual process.

6. Conserving Angular Momentum

Looking only at the angular momentum of the observable universe, equation (38), we would conclude that angular momentum is not conserved. But looking at the angular momentum of the two quantum levels, equation (40), we make the peculiar observation that the increase in the angular momentum of the observable universe appears to be countered by the existence of these two quantum levels, suggesting the angular momentum of the whole system is conserved.

6.1. The Quantum Levels Conserve Angular Momentum Against the Whole

At the initial state, both the SEQ and SRQ were identical quanta. As the following calculations show, there was no separation between the quantum levels or between them and the initial state. We can take our initial values for energy and radius, plug in the energy and radius values for both the SEQ and SRQ, and we get the initial values. Both quantum levels were united at the initial state.

SEQ, energy: $\left(\frac{R_H c^4}{4G}\right)\left(\frac{2l_p}{R_H}\right)^2 \Rightarrow \left(\frac{2l_p c^4}{4G}\right)\left(\frac{2l_p}{2l_p}\right)^2 = \frac{\sqrt{\frac{c^5\hbar}{G}}}{2}$

SEQ radius: $\left(R_H 4l_p^2\right)^{\frac{1}{3}} \Rightarrow \left(2l_p 4l_p^2\right)^{\frac{1}{3}} = 2l_p$

SRQ energy: $\frac{c\hbar}{R_H}\left(\frac{2l_p}{R_H}\right)^4 \Rightarrow \frac{c\hbar}{2l_p}\left(\frac{2l_p}{2l_p}\right)^4 = \frac{\sqrt{\frac{c^5\hbar}{G}}}{2}$

SRQ radius: $\frac{4l_p^2}{R_H} \Rightarrow \frac{4l_p^2}{2l_p} = 2l_p$

With expansion, the two quantum levels started to form immediately. What is particularly interesting is the angular momentum of the primary quantum characteristics, the small energy of the SEQ and the small radius of the SRQ, work together to balance the increase of the whole, as shown in equation (40).

It can be argued that the two quantum levels conserve angular momentum between themselves. The number of SEQ is the large number:

$$\text{number of SEQ} = \frac{E_o}{E_{SEQ}} = \frac{\frac{R_H c^4}{4G}}{\frac{c\hbar}{R_H}} = \left(\frac{R_H}{2l_p}\right)^2 \tag{94}$$

Multiplying the number of SEQ by the angular momentum obtained using the energy of the SEQ and the radius of the SRQ gives the conserved value.

$$\left(\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 \times \left(\frac{R_H}{2l_p}\right)^2\right) = \sqrt{2}\hbar \tag{95}$$

The two quantum levels may thus exist in order to conserve angular momentum against the whole. Let us look at what happens within each quantum level.

6.2. The SRQ Conserves Angular Momentum

With the SRQ, we found a doubling creates 64 units, each with 1/32 the energy. After the first doubling, the angular momentum of one SRQ would have been 1/64 of the conserved quantity:

$$L = mrv = \left(\frac{\frac{4l_p c^2}{4G}}{\left(\frac{4l_p}{2l_p}\right)^6}\right)\left(\frac{4l_p^2}{4l_p}\right)\left(\sqrt{2}c\right) = \frac{1}{64}\sqrt{2}\hbar \tag{96}$$

Each doubling of the hyperverse creates 64 SRQ, thus allowing conservation of the initial angular momentum. We can see the conservation of angular momentum at the SRQ level directly by multiplying the SRQ mass, the SRQ radius, the tangential velocity, and the number of SRQ within the universe:

$$\left(\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\left(\frac{4l_p^2}{R_H}\right)\left(\sqrt{2}c\right)\left(\left(\frac{R_H}{2l_p}\right)^6\right) = \sqrt{2}\hbar \tag{97}$$

6.3. The SEQ Conserves Angular Momentum by Creating Matter

The SEQ is the quantum of our quantum physics. The small energy quantum's radius is large, near the Compton wavelength of particles, and the energy equation, $\frac{c\hbar}{R_H}$, has the form of the Planck relationship, a fundamental quantum physics equation.

The angular momentum of an SEQ is:

$$L_{SEQ} = \left(\frac{\hbar}{cR_H}\right)\left(\left(R_H 4l_p^2\right)^{\frac{1}{3}}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{98}$$

and given there are $\left(\frac{R_H}{2l_p}\right)^2$ SEQ, we have a total angular momentum of $\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$:

$$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^2 = \sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} \tag{99}$$

At first glance, it seems the SEQ does not conserve angular momentum. Since [8] and [9] discuss in length how the SEQ conserves angular momentum, let us just state a conclusion from those papers: the SEQ conserves angular momentum by creating particles of matter.

7. A Universe From Itself

In our daily experience, a force, or torque, is needed to increase angular momentum, and the application of a force puts in place a new conserved value. Since the universe is conserving angular momentum, we can deduce that no additional force or energy is being added.

Many cosmologists believe the universe came from nothing; where else could the vast increase in energy come from? Nothingness seems the only source. There is an alternative; the geometric mean expansion of space gives us a way to grow a universe without added energy. It appears that the creation and continued shrinkage, or relative shrinkage, of quantum levels allows the whole to expand. The whole gets larger while the components shrink, the process following a geometric mean relationship.

Expansion is self-contained, the whole expanding while the quanta shrink. It is not a universe from nothing; the universe creates itself, out of itself, and this creation appears to be driven by a need to conserve angular momentum. The universe comes from itself.

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