The Expanding Hyperverse Creates Matter to Conserve Angular Momentum at the Small Energy Quantum Level

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ABSTRACT

The geometric mean expansion of space was previously shown to produce two quantum levels, the "small radius quantum", or SRQ, and the quantum of our quantum mechanics, the "small energy quantum", or SEQ. In this paper, it is shown that the creation of the two quantum levels conserves centripetal force and angular momentum against the whole of the observable universe. The SRQ conserves both values within its level, but the SEQ cannot do so without modifying itself. We explore a group of equations, connected to the SEQ level, that appear to represent the mass, radius, and number of elementary particles. These equations are shown to represent target values for an 'ideal' particle. The hypothesis is presented that matter is formed by the collapse and coalescence of the quanta of space, at the SEQ level, to conserve angular momentum and centripetal force. Matter is condensed space. The conservation of angular momentum and centripetal force gives a simple mechanism that operates universe-wide for the creation of matter, and is the reason all elementary particles, of a kind, are identical.

Subject headings: creation of elementary particles; creation of matter; conservation of angular momentum; conservation of centripetal force; hyperverse; number of elementary particles

Introduction

In the previous papers we have seen that the universe can be modeled as an expanding, spinning, four dimensional hypersphere, called the hyperverse [1], [2], [3]. The hyperverse is radially expanding at twice the speed of light. The surface was shown to be energy, and it is hypothesized that the surface is composed of vortices, four dimensional spinning hypervortices, similar in form to the whole. The expansion of space was shown in [3] to have a geometric mean character, producing two quantum levels, the small energy quantum, or SEQ, which is the geometric mean counterpart of the energy of the universe, and the small radius quantum, or SRQ, the geometric mean counterpart of the radius of the hyperverse. These quantum levels act together to conserve the angular momentum of the observable universe. In [3] the SRQ was shown to conserve angular momentum within its own quantum level.

The SEQ is the quantum of our experience. The radius of the SEQ [3] is approximately 6.49595×10^{-15} meters, and is on the size scale of the Compton radii of elementary particles and nucleons. The energy of the SEQ is given by $\frac{c\hbar}{R_H}$, and has the same form as the Planck relationship. R_H is the radius of the hyperverse. This paper looks specifically at the details of how the small energy quantum, the SEQ, conserves angular momentum and centripetal force, and in doing so, creates elementary particles.

1. Matter is Created to Conserve Angular Momentum and Centripetal Force at the SEQ Level

1.1. The Radius of the Small Energy Quantum

Expansion produces two closely related quantum levels, one based on the small energy, referred to here as the small energy quantum, or SEQ, and the other on the small radius, the small radius quantum, or SRQ. Each quantum level has its own associated energy and volume. The radius of the small energy quantum, R_{SEQ}, is:

$$R_{SEQ} = \left(R_H 4 l_p^2\right)^{\frac{1}{3}} = 6.4959538942274086119 \times 10^{-15}\,\mathrm{m} \tag{1}$$

where l_p is the Planck length.

This length is very close to the Compton radii (the reduced Compton wavelength) of elementary particles and nucleons. The geometric mean average of the Compton radius for all twelve quarks and leptons, of all three families, is approximately 1.15656×10^{-14} m, giving a ratio factor of less than two, compared to the SEQ radius.

1.2. The Geometric Mean Counterpart of the SEQ Radius as the Particle Radius

Using the concept of the geometric mean expansion of space, we will define the geometric mean counterpart of the SEQ radius as R_{GM_SEQ}, calculated by dividing the square of the initial length, [3], which is two times the Planck length, by the SEQ radius:

$$\frac{\left(2\sqrt{\frac{G\hbar}{c^3}}\right)^2}{\left(R_H 4l_p^2\right)^{\frac{1}{3}}} = \left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}} = \left(\frac{(2l_p)^4}{R_H}\right)^{\frac{1}{3}} = 1.608\,150\,331\,744\,687\,220\,7 \times 10^{-55}\,\mathrm{m} \qquad (2)$$

where G is the Gravitational constant.

From work that follows in this paper, this figure appears to be the correct choice for the radius of an elementary particle. If the Compton radii were the correct radii, we'd have a nonsensical sequence in which the more massive a particle was, the smaller would be its radius. As an extreme example, the Compton radius for the observable universe would be the small radius, R_s, as discussed in [3]:

$$\frac{\hbar}{M_o c} = \frac{\hbar}{\left(\frac{R_H c^2}{4G}\right)c} = \frac{4l_p^2}{R_H} = R_s$$

where M_o is the mass of the observable universe, c is the speed of light, and $\hbar$ is the reduced Planck constant.

Geometric mean radii give the opposite, and logically appealing sequence, in which a larger mass has a larger radius. There are several supporting lines of thought behind the choice of the geometric mean counterpart of the SEQ radius, R_{GM_SEQ}, as the particle radius, and we will look at a summary of some of them now, all of which will be addressed in more detail in this paper.

1. The mass to radius ratio

The ratio of mass to radius for the observable universe is $\frac{M_o}{R_H} = \frac{\frac{R_H c^2}{4G}}{R_H} = \frac{c^2}{4G}$

The initial mass to radius ratio is $\frac{M_{iniital}}{R_{iniital}} = \frac{\frac{\sqrt{\frac{c\hbar}{G}}}{2}}{2\sqrt{\frac{G\hbar}{c^3}}} = \frac{c^2}{4G}$

The particle mass to radius ratio, using the geometric mean radius, produces the same value: $\frac{M_{particle}}{R_{GM\_SEQ}} = \frac{\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}}{\left(\frac{(2l_p)^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^2}{4G}$

2. The GM_SEQ radius is the radius that produces the particle mass. In this restatement of the above ratio, the GM_SEQ radius in the mass equation gives the correct particle mass, discussed in detail shortly:

$$M_{particle} = \frac{c^2 R_{GM\_SEQ}}{4G} = \frac{c^2\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}{4G} = \left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}$$

3. In the light of the hyperverse model, a particle is a hollow, four dimensional spinning hypersphere, a hypervortex, with its mass at the three dimensional surface. We can ask: At what distance from the hypercenter of the particle will the escape velocity equal the speed of light? That is, what is this version of the Schwarzschild radius for a particle?

The escape velocity is given by the following equation:

$$V_{escape} = \sqrt{\frac{2GM}{d}} = c$$

Rearranging, we see that the distance is $\frac{2GM}{c^2}$:

$$\sqrt{\frac{2GM}{d}} = c \Rightarrow \frac{2GM}{d} = c^2 \Rightarrow d = \frac{2GM}{c^2} \tag{3}$$

Inserting the particle mass, we get one half of the GM_SEQ radius:

$$d = \frac{2G\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)}{c^2} = \frac{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}{2} \tag{4}$$

Recall that the Schwarzschild radius of the observable hyperverse is one half the hyperverse radius [1]. We have the same situation here, as the Schwarzschild radius of a particle is one-half the particle radius.

1.3. The Number of Particles in the Observable Universe

To calculate the number of particles in the observable universe, we can take our value for the mass of the universe, $\frac{R_H c^2}{4G} = 8.835\,806\,514\,641\,366\,599\,6 \times 10^{52}$ kg, and divide it by the mass of a proton to get a rough estimate of the number of protons:

$$\frac{8.835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}}{1.6726231 \times 10^{-27}\,\mathrm{kg}} = 5.282\,604\,619\,439\,589\,588\,1 \times 10^{79} \tag{5}$$

If we attribute 3 quarks and one electron to the hydrogen atom, we can multiply by 4 and get an estimate of the number of elementary particles: about 2×10^{80}.

$$5.282\,604\,619\,439\,589\,588\,1 \times 10^{79} \times 4 = 2.113\,041\,847\,775\,835\,835\,2 \times 10^{80} \tag{6}$$

Atomic matter is not the only matter we need to consider. Dark matter is estimated to exist at a ratio to atomic matter at about five to one [4]. We don't know the mass or density of dark matter, but let's assume it is the same as atomic matter, for rough calculations. Considering both dark matter and atomic matter, we can multiply 2×10^{80} by six (because there are roughly five parts of dark matter and one part ordinary matter) to get an estimate of the total number of all types of matter particles:

$$2.113\,041\,847\,775\,835\,835\,2 \times 10^{80} \times 6 = 1.267\,825\,108\,665\,501\,501\,1 \times 10^{81} \tag{7}$$

The large number of the universe, [3], is $\left(\frac{R_H}{2l_p}\right)^2$, or about 6.59×10^{121}. Our rough estimate of the number of particles in the observable universe is close to the square of the cube root of the large number, $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$:

$$\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} = 1.631\,670\,937\,848\,98 \times 10^{81} \tag{8}$$

We will assume this to be the ideal particle number for the observable universe and refer to the value, $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$, as the 'particle number', or number of particles.

Notably, we can generate the particle number by dividing the hyperverse radius by the GM_SEQ particle radius:

$$\frac{R_H}{R_{GM\_SEQ}} = \frac{R_H}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} \tag{9}$$

This implies matter is being continuously created; the number of particles of matter is increasing with time. Using the 'now and then' approach used in [3], where 'then' represents the situation when the universe was one-half its current age, and 'now' is the current time, we find that with a doubling of the hyperverse radius, the number of elementary particles increases by about 2.52 times:

$$\frac{\text{number of particles now}}{\text{\# of particles at one-half current age}} = \frac{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}}{\left(\frac{\frac{R_H}{2}}{2l_p}\right)^{\frac{4}{3}}} = 2\sqrt[3]{2} = 2.519\,842\,099\,789\,746\,329\,5 \tag{10}$$

1.4. The Particle Mass

If we divide the mass of the observable universe by the number of particles, we get the particle mass:

$$\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} = \left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} = 5.415\,182\,785\,216\,18 \times 10^{-29}\,\text{kg} \tag{11}$$

This is very close to the actual mass of particles. The geometric mean average mass of all twelve elementary particles is approximately $3.041\,49 \times 10^{-29}$ kg. As with the radii, the ratio of the mass of the ideal particle to the geometric mean of the elementary particles is less than a factor of two.

The reduced Compton radius of our particle mass, $\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}$, is R_{SEQ}:

$$\lambda bar = \frac{\hbar}{mc} = \frac{\hbar}{\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)c} = \sqrt[3]{R_H 4l_p} = R_{SEQ} \tag{12}$$

The mass of a particle, $\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}$, can be expressed in several ways. Particle mass, in terms of the mass of the observable universe is:

$$\text{particle mass} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \tag{13}$$

where $\left(\frac{R_H c^2}{4G}\right)$ is the mass of the observable universe [1].

The particle mass can be stated using the geometric mean partner of the particle radius, $\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}$, in the same form as that of the mass of the observable universe:

$$\text{particle mass} = \frac{c^2 R_{GM\_SEQ}}{4G} = \frac{c^2\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}{4G} \tag{14}$$

Particle mass can be expressed in terms of the small energy quantum, giving a Planck relationship type of structure:

$$\text{particle mass} = \left(\frac{\hbar}{cR_H}\right)\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{\hbar}{c\left(R_H 4l_p^2\right)^{\frac{1}{3}}} = \frac{\hbar}{cR_{SEQ}} \tag{15}$$

Here is a summary of several ways to express particle mass:

$$\text{particle mass} = \left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} = \frac{c\hbar}{R_H}\times\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{c^2\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}{4G} = \frac{\hbar}{c}\frac{1}{R_{SEQ}} \tag{16}$$

1.5. The 'Ideal Particle'

The geometric mean expansion model produces quantities that are very close to what we observe for particle radius and mass, and the number of particles. These quantities are deeply related, and we will claim that their similarity to actual particle radius, mass and the total number of particles is not coincidental, and these values are the 'target values' the expanding universe strives for. They are, in summary:

$$\text{particle radius} = \left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}} = R_H\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \tag{17}$$

$$\text{particle mass} = \left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \tag{18}$$

$$\text{particle number} = \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} \tag{19}$$

These target values are postulated to be altered by the specific charge, or spin, relationships within the coalesced component vortices [5].

1.6. The Large Number Cube

A visual might help to understand the relationships more clearly. The large number of the universe is $\left(\frac{R_H}{2l_p}\right)^2$. If we picture a three dimensional cube with sides being the length of the cube root of the large number, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, about 4.039×10^{40}, then the total number of the cube would be obtained by multiplying the three sides, which is the large number, $\left(\frac{R_H}{2l_p}\right)^2$, 6.591×10^{121}. The number of particles equals the very bottom area, the product of just two sides, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$. See Figure 1.

Each particle can be thought of as a small square (not to scale) on the bottom, a one by one square. The number of SEQ absorbed per particle is represented by the height of the column, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, consisting of 4.039×10^{40} small energy quanta, or SEQ.

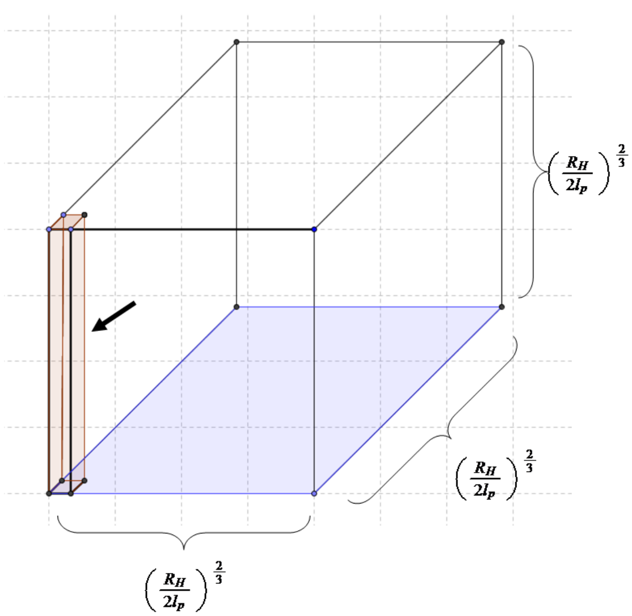

Figure 10. The large number cube. The length of each side of the cube is equal to the cube root of the large number. The square at the very bottom, shown in blue, represents the number of particles in the observable universe. The column at the front left corner is intended to help show how many SEQ are within each particle.

The energy of the observable universe is spread evenly over the whole volume. Particles represent just one side, and also hold the equivalent in mass-energy.

1.6.1. Particles Contain a Quantity of Mass-Energy Equal to the Energy of the Universe

Let us assume that the idealized particle mass is $\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}$ and that the ideal number of particles in the universe is the particle number, $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$. The product of the two gives us the mass of the observable universe:

$$\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} = \frac{R_H c^2}{4G} \tag{20}$$

Of the $\left(\frac{R_H}{2l_p}\right)^2$ ($= 6.590\,962\,905\,388\,697\,310\,3 \times 10^{121}$) units of small energy quanta in the observable universe, only $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$ or $1.631\,670\,937\,848\,98 \times 10^{81}$ have assignable mass. This is interesting, as we previously defined the energy of the universe as that of the atoms of space comprising the universe; the energy quanta are defined by their component energy. It is as though the creation of matter produces a doubling of the mass-energy of the universe, an observation that can be explained by the creation of an equal, but negative, energy of gravity; in other words, the creation of matter produces gravity [6].

1.7. Conserving Angular Momentum and Centripetal Force at the SEQ Level Creates Matter

1.7.1. Conserving Angular Momentum at Three Levels while Expanding

Spin angular momentum, the intrinsic momentum of a spinning object (as compared to orbital angular momentum), is what we will be discussing here. We will use the term "L" to represent spin angular momentum, and we will refer to it, simply, as angular momentum.

The equation for angular momentum is $L = I\omega$, where I is the moment of inertia and ω, omega, is the angular velocity. The moment of inertia is usually expressed as $I = mr^2k$, where m is the mass of the object, r is the radius, and k is the moment of inertia constant, which relates to the object's shape, indicating, roughly, how far out the mass is compared to the radius. Omega is defined as the tangential velocity per unit radius, or $\omega = \frac{v}{r}$. Combining the terms gives us $L = mrvk$. The 'k' value is defined as one for normal, uncompressed space.

1.7.2. A Dynamical Response is Required to Conserve Angular Momentum

The angular momentum of the universe increases over time. Using the "now and then" approach of doubling, we find that the angular momentum of the observable universe increases by four times with each doubling:

$$\frac{\text{angular momentum now}}{\text{angular momentum then}} = \frac{\left(\frac{R_H c^2}{4G}\right)(R_H)\left(\sqrt{2}c\right)}{\left(\frac{\frac{R_H}{2}c^2}{4G}\right)\left(\frac{R_H}{2}\right)\left(\sqrt{2}c\right)} = 4 \tag{21}$$

This is a critical observation. With expansion, the angular momentum of the universe increases. For the universe and its quantum components, to conserve angular momentum requires a dynamical response, which is the basis of gravity, [6].

1.7.3. The Angular Momentum of the Universe

In [3], the angular momentum at the moment expansion started, L_{inital}, was identified as$\sqrt{2}\hbar$:

$$L_{initial} = mrv_T = \left(\frac{\sqrt{\frac{c\hbar}{G}}}{2}\right)(2l_p)\left(\sqrt{2}c\right) = \sqrt{2}\hbar \tag{22}$$

where v_T is the tangential velocity of the vortex, m is its mass and$r$ is its radius.

and the angular momentum of the observable universe, $L_o = \sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2$:

$$L_o = mrv_T = \left(\frac{R_H c^2}{4G}\right)(R_H)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2 \tag{23}$$

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

$$L_s = \frac{L_i^2}{L_o} = \frac{\left(\sqrt{2}\hbar\right)^2}{\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2} = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 \tag{24}$$

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

$$L_o = mvr = \left(\frac{\hbar}{cR_H}\right)\left(\frac{4l_p^2}{R_H}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 \tag{25}$$

The small energy, defined as $\frac{c\hbar}{R_H}$, is the geometric mean counterpart of the energy of the universe, while the small radius, defined as $\frac{4l_p^2}{R_H}$, is the geometric mean counterpart of the hyperverse radius [3]. It appears that expansion's production of the two quantum levels gives a means of conserving angular momentum. There are $\frac{\frac{R_H c^4}{4G}}{\frac{c\hbar}{R_H}} = \left(\frac{R_H}{2l_p}\right)^2$ SEQ within the observable universe. The product of that number and L_s is the initial angular momentum, $\sqrt{2}\hbar$:

$$\left(\frac{R_H}{2l_p}\right)^2 \times \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 = \sqrt{2}\hbar \tag{26}$$

The universe may be attempting to conserve overall angular momentum by the creation of these quanta.

1.7.4. The Angular Momentum of the SRQ is Conserved

The small radius, R_s, has an associated energy, $\left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^6$, called the small radius quantum, or SRQ, whose energy density matches that of both an SEQ and the universe. The angular momentum of one small radius quantum is:

$$L_{SRQ} = \left(\left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^6\right)\left(\frac{4l_p^2}{R_H}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^6 \tag{27}$$

There are $\left(\frac{R_H}{2l_p}\right)^6$ units of small radius quanta within the observable universe. Multiplying the angular momentum of one SRQ by their total number gives us $\sqrt{2}\hbar$:

$$\text{total } L_{SRQ} = \sqrt{2}\hbar \left(\frac{2l_p}{R_H}\right)^6 \times \left(\frac{R_H}{2l_p}\right)^6 = \sqrt{2}\hbar \tag{28}$$

The sum of the SRQ angular momenta matches the initial value and thus, at the level of the small radius quantum, angular momentum is conserved.

1.7.5. The Angular Momentum of the SEQ Presents a Problem

The angular momentum of the small energy quantum is:

$$\text{for one SEQ: } L_{SEQ} = \left(\frac{\hbar}{cR_H}\right)\left(\left(R_H 4l_p^2\right)^{\frac{1}{3}}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar \left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{29}$$

There are $\left(\frac{R_H}{2l_p}\right)^2$ units of small energy quanta within the observable universe, and therefore the sum of the angular momenta of the SEQ is $\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$:

$$\textit{total } L_{SEQ} = \sqrt{2}\hbar \left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^2 = \sqrt{2}\hbar \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} \tag{30}$$

This value is greater than $\sqrt{2}\hbar$ but less than that of the observable universe, which is $\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2$. Therefore the SEQ cannot obtain, in its native state, the conserved value of angular momentum.

Unlike the SRQ, which conserves angular momentum both in combination with the small energy, and within its own quantum level, the SEQ, in its native state, cannot conserve angular momentum within its level.

If $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ were combined into one entity, the conserved quantity would be achieved. That is, multiplying the angular momentum of one SEQ, $\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$, by $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, produces the conserved quantity, $\sqrt{2}\hbar$:

$$\sqrt{2}\hbar \left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \sqrt{2}\hbar \tag{31}$$

This number, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, is the number we used in the large number cube to show how many SEQ were within one particle. It appears the universe is combining the necessary number of SEQ to achieve the conserved angular momentum value.

1.7.6. Centripetal Force and the Mass to Radius Ratio are Conserved

Centripetal force, F_C, is the product of mass and angular acceleration. For the initial condition, the centripetal force was $\frac{c^4}{2G}$:

$$\text{Initial Condition: } F_C = m \times \frac{v_T^2}{r} = \left(\frac{\sqrt{\frac{c\hbar}{G}}}{2}\right)\left(\frac{2c^2}{2\sqrt{\frac{G\hbar}{c^3}}}\right) = \frac{c^4}{2G} \tag{32}$$

We get the same for the observable universe:

$$\text{Observable Universe: } F_C = m \times \frac{v_T^2}{r} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2c^2}{R_H}\right) = \frac{c^4}{2G} \tag{33}$$

and for the combined E_s and R_s quanta:

$$E_s \text{ and } R_s \text{ quanta: } F_C = m \times \frac{v_T^2}{r} = \left(\frac{\hbar}{cR_H}\right)\left(\frac{2c^2}{\frac{4l_p^2}{R_H}}\right) = \frac{c^4}{2G} \tag{34}$$

and for particles:

$$\text{Particle: } F_C = m \times \frac{v_T^2}{r} = \left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(\frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G} \tag{35}$$

The tangential velocity is constant at $\sqrt{2}c$ [2]. With centripetal force equal to $\frac{c^4}{2G}$, the ratio of mass to radius is $\frac{c^2}{4G}$:

$$F_C = m\frac{v_T^2}{r} = m\frac{2c^2}{r} \Rightarrow \frac{F_C}{2c^2} = \frac{m}{r} \Rightarrow \frac{\frac{c^4}{2G}}{2c^2} = \frac{c^2}{4G} \tag{36}$$

Thus the mass to radius ratio is $\frac{c^2}{4G}$:

$$\frac{m}{r} = \frac{c^2}{4G} \tag{37}$$

This relationship is identical to the mass of the observable universe equation. Because the centripetal force is conserved in the above entities, they all have a mass to radius ratio of $\frac{c^2}{4G}$:

$$\frac{c^2}{4G} = \frac{M_i}{R_i} = \frac{M_s}{R_s} = \frac{M_o}{R_H} = \frac{M_{particle}}{R_{particle}} \tag{38}$$

1.7.7. *The SEQ is a Problem Again*

However, for one SEQ, the centripetal force is not $\frac{c^2}{4G}$:

$$\text{One SEQ: } F_C = m\frac{v_T^2}{r} = \left(\frac{\hbar}{cR_H}\right)\left(\frac{2c^2}{\left(R_H 4l_p^2\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \tag{39}$$

Multiplying that value, $\frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}}$, by $\left(\frac{R_H}{2l_p}\right)^2$, the number of SEQ in the observable universe, does not conserve centripetal force either:

$$\text{Total for all SEQ: } F_C = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \times \left(\frac{R_H}{2l_p}\right)^2 = \frac{c^4}{2G}\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \tag{40}$$

Thus native SEQ conserve neither angular momentum nor centripetal force.

1.7.8. *Packing and Shrinking the SEQ Conserves both L and F_C, Creating Particles of Matter*

If we packed $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ into the volume of one SEQ, angular momentum would be conserved, but not the centripetal force; it would still be short of the target value, the conserved value, as shown here:

$$F_C = m\frac{v^2}{r} = \left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(\frac{2c^2}{\left(R_H 4l_p^2\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{41}$$

But by also shrinking the SEQ radius to the GM_SEQ radius, the radius we have claimed is the true particle radius, we can conserve both angular momentum and centripetal force using $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ:

$$F_C = m\frac{v_T^2}{r} = \left(\left(\frac{\hbar}{cR_H}\right) \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}\right) \frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^4}{2G} \tag{42}$$

Looking at this differently, for one SEQ, compressed to the radius of the geometric mean of the SEQ radius, we have a mass to radius ratio of $\frac{c^2}{4G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$:

$$\frac{M_{SEQ}}{R_{GM\_SEQ}} = \frac{\frac{\hbar}{cR_H}}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^2}{4G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{43}$$

Multiplying this ratio by the number of SEQ within a particle, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, gives us the conserved mass to radius ratio of $\frac{c^2}{4G}$.

$$\text{particle mass to radius} = \frac{c^2}{4G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{c^2}{4G} \tag{44}$$

This matches our value for the ratio of the mass of a particle to the GM_SEQ radius:

$$\frac{\text{particle mass}}{\text{particle radius}} = \frac{\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^2}{4G} \tag{45}$$

For the seemingly problematic SEQ, the compression of $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ into a volume with the R_{GM_SEQ} radius, $\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}$, allows the universe to conserve both angular momentum and centripetal force at the SEQ level. This compression and coalescence of small energy quanta creates particles of matter. Matter is concentrated space, formed to conserve angular momentum and centripetal force.

1.7.9. The SRQ Behaves

The centripetal force of a small radius quantum is $\frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4$:

$$\text{One SRQ: } F_C = m\frac{v_T^2}{r} = \left(\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\left(\frac{2c^2}{\frac{4l_p^2}{R_H}}\right) = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4 \tag{46}$$

The small radius, the radius of the SRQ, is actually smaller than the particle radius, to start with.

$$\text{Radius of the SRQ: } \frac{4l_p^2}{R_H} = \frac{(3.232\,1\times10^{-35}\,\mathrm{m})^2}{2.62397216\times10^{26}\,\mathrm{m}} = 3.981\,166\,633\,261\,840\,704\,9\times10^{-96}\,\mathrm{m} \tag{47}$$

The particle radius is

$$\text{Particle Radius: } \left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}} = 1.608\,150\,331\,744\,687\,220\,7\times10^{-55}\,\mathrm{m} \tag{48}$$

Thus, if one SRQ expanded its radius to the particle radius, its centripetal force would lower by a factor of $\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$ to:

$$F_C = m\frac{v_T^2}{r} = \left(\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{14}{3}} = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{49}$$

There are $\left(\frac{R_H}{2l_p}\right)^4$ SRQ per SEQ, so if we packed $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ into the particle, the resulting centripetal force for the SRQ would be $\frac{c^4}{2G}$, thus conserving F_C as well:

$$\frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}\times\left(\frac{R_H}{2l_p}\right)^4\times\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{c^4}{2G} \tag{50}$$

The SRQ conserves angular momentum and centripetal force without any alteration.

1.7.10. The Regulation of Particle Size

That the universe is compressing space at the SEQ level to conserve angular momentum and centripetal force gives a simple, universe-wide, self-regulating mechanism for determining particle number and size. If any more or less quanta of space collapsed to form a particle, then the angular momentum of the particle would vary from the target value of $\sqrt{2}\hbar$. All particles collapse to the point that their angular momentum and centripetal force matches the initial, conserved values. It is a beautifully simple system that produces identical particles everywhere in the universe, and one that produces the number of elementary particles that we find in the universe.

This concept raises many interesting questions, such as: How does the universe know to create a particle? Where would a particle form? How is the information transferred within the universe? In any case, the conservation of angular momentum combined with the conservation of centripetal force, at the small energy quantum level, appears to give rise to the elementary particles, regulating their size and number.

1.7.11. Comparing Real Particles to the Idealized Particle

Real elementary particles, like the electron, and up and down quarks, have differing radii and masses from our idealized particle. The hyperverse model suggests a possible internal structure of elementary particles, discussed at a conceptual level in [5]. The difference between particles, their charges, masses and radii, are likely related to the interaction of the component quanta, whose spins are presumably fixed in orientation with collapse, so that the spin of adjacent quanta vary from particle type to particle type, resulting in varying amounts of attraction or repulsion between the quanta of a particle, changing the particle density and size.

Just as the particle radius is the geometric mean of the SEQ radius, the real particle radii would be the geometric mean of the reduced Compton wavelength of the real particles. For example, the true radius of the electron would be:

$$R_e = \frac{4l_p^2}{\frac{\hbar}{m_e c}} = 4\frac{G}{c^2}m_e = 2.705\,218\,242\,135\,866\,147 \times 10^{-57}\,\mathrm{m} \tag{51}$$

The $\frac{m}{r}$ ratio for the electron is

$$\frac{\text{electron mass}}{\text{electron radius}} = \frac{9.1093897 \times 10^{-31}\,\mathrm{kg}}{2.705\,218\,242\,135\,866\,147 \times 10^{-57}\,\mathrm{m}} = \frac{3.367\,340\,038\,638\,735\,633\,4 \times 10^{26}}{\mathrm{m}}\,\mathrm{kg} \tag{52}$$

which matches the particle mass/radius ratio:

$$\frac{5.415\,182\,785\,216\,176\,701\,4 \times 10^{-29}\,\mathrm{kg}}{1.608\,150\,331\,744\,687\,220\,7 \times 10^{-55}\,\mathrm{m}} = \frac{3.367\,336\,173\,939\,179\,125\,7 \times 10^{26}}{\mathrm{m}}\,\mathrm{kg}$$

and the ratio of the mass of the observable universe to the hyperverse radius:

$$\frac{8.835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}}{2.62397216 \times 10^{26}\,\mathrm{m}} = \frac{3.367\,340\,038\,638\,735\,633\,4 \times 10^{26}}{\mathrm{m}}\,\mathrm{kg}$$

1.7.12. Testing the Radius and Mass Relationship using the Koide Formula

As a test of the validity of the geometric mean of the Compton wavelength of the elementary particles as a valid radius of particles, we can run the proposed radius and mass relation through the Koide equation. Koide [6] showed an amazing relationship between the masses of the electron, muon and tau electron as:

$$(m_e) + (m_\mu) + (m_\tau) = 2/3\left(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau}\right)^2 \tag{53}$$

Substituting our geometric mean derived radii for these particles gives us:

$$\left(4\frac{G}{c^2}m_e\right) + \left(4\frac{G}{c^2}m_\mu\right) + \left(4\frac{G}{c^2}m_\tau\right) = 2/3\left(\sqrt{4\frac{G}{c^2}m_e} + \sqrt{4\frac{G}{c^2}m_\mu} + \sqrt{4\frac{G}{c^2}m_\tau}\right)^2 \tag{54}$$

This reduces to $(m_e + m_\mu + m_\tau) = \frac{2}{3}\left(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau}\right)^2$, matching the Koide formula. Any variation from a constant multiplication factor for the radii would violate the equivalency, supporting the case for the particle radii to be the geometric means of their Compton radii.

Interestingly, we can flip it so that we insert the mass values instead of the radii. Rearranging our equation of the particle radius to display the mass,

$$m_e = \frac{1}{4G}c^2 R_e \tag{55}$$

and inserting this into the Koide formula gives:

$$\left(\frac{1}{4G}c^2R_e\right) + \left(\frac{1}{4G}c^2R_\mu\right) + \left(\frac{1}{4G}c^2R_\tau\right) = \frac{2}{3}\left(\sqrt{\frac{1}{4G}c^2R_e} + \sqrt{\frac{1}{4G}c^2R_\mu} + \sqrt{\frac{1}{4G}c^2R_\tau}\right)^2 \tag{56}$$

which reduces to $(R_e + R_\tau + R_\mu) = \frac{2}{3}\left(\sqrt{R_e} + \sqrt{R_\mu} + \sqrt{R_\tau}\right)^2$. Testing, using the calculated radii, confirms the identity.

1.8. The Expansion of Space is Ongoing

Since the expansion of space is a continuing process, and the angular momentum of the observable universe is continually increasing, matter is not static and fixed. In Tassano [7] we explore the consequences of the continuing expansion of space, and find that particles of matter must both increase in number and continue to absorb space, in order to continue to conserve angular momentum; the model of matter creation generates gravity.

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