The Origin of Matter and Gravity: What They Are and Why They Exist

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ABSTRACT

We show a group of equations that appear to represent target values for the mass, radius, and number of elementary particles in the universe: the values of an 'ideal particle'. Quanta and particles are not static entities; they change with time. The angular momentum of the universe is continually increasing, and this requires a dynamical response to conserve angular momentum. The collapse and coalescence of quanta conserves angular momentum, resulting in the creation of particles of matter. Matter is condensed space. The increase in particle energy matches, surprisingly, the Hubble constant, and the increase in the gravitational potential energy of particles matches the accretion rate of energy predicted by this model. This gives a simple, universe-wide mechanism for the creation of matter, and is the reason all elementary particles, of a kind, are identical. The centripetal force of a particle of matter is shown to match the gravitational force; they are the same entity. Gravity is the ongoing accretion of the quanta of space by particles of matter.

Subject headings: absorption of space; accretion of quanta; creation of elementary particles; creation of matter; conservation of angular momentum; conservation of centripetal force; Hubble constant; hyperverse; model of gravity

1. Introduction

In [1], we showed that the universe can be modeled as an expanding, four dimensional hypersphere, a 'hyperverse', that is radially expanding at twice the speed of light, circumferentially at the Hubble constant, and its surface, and whose three dimensional surface volume, which is our universe, is composed of energy. Space is energy.

We hypothesized in [2] that the hyperverse surface energy consists of a matrix of four dimensional, spinning, vortices, self-similar to the whole. These vortices comprise both space and matter. Their energy dynamics, when combined with the 2c radial expansion, produce a model of time, complete with relativity.

Space is undergoing a geometric mean expansion [3], an expansion allowed by the creation of two levels of quanta, one being the quantum of our quantum mechanics. We find that quanta are not static entities, but change with time and expansion.

This paper continues the development of the hyperverse model and geometric mean expansion of space. The primary concepts of this paper are:

1. The universe conserves angular momentum and centripetal force by coalescing and collapsing the quanta of space into particles of matter.
2. Because the angular momentum of the universe is continually increasing, the conservation of angular momentum becomes something of a 'moving target', making the process of coalescence, and collapse, an ongoing process. The size, mass, and number of elementary particles change with time and expansion; matter is dynamical.
3. This ongoing accretion of the quanta space, by particles of matter, is gravity.

We will make the following claims:

- The geometric mean expansion model produces a set of equations that appear to represent target values for the mass, radius, and quantity of an ideal elementary particle.
- From these equations, we can see that matter is not a static entity. We will show that the mass and radius of elementary particles decrease with time, while the number of particles increases.
- It appears the universe creates particles of matter to conserve angular momentum and centripetal force.
- Although the small radius quantum conserves angular momentum, the small energy quantum cannot conserve angular momentum in its native state. By coalescing a specific number of the quanta of space into the volume of one SEQ, the universe can conserve angular momentum; but this alone is not sufficient.
- Centripetal force must also be conserved, and to do this, space must also collapse, or shrink, to a particular radius. This combined coalescence and collapse of space conserves both angular momentum and centripetal force, creating particles of matter.

- The model gives a simple reason why all particles of matter, of a kind, are everywhere identical in the universe. For example, all electrons are the same because they are conserving the same value of centripetal force and angular momentum, and those values are the initial values we calculated in the geometric mean paper, [3].

- The increasing angular momentum of the universe forces particles to continually accrete the quanta of space, to shrink in size, and to grow in number. Matter is not static; it is dynamic. For example, an electron today is not the same as an electron that existed in the past or will exist in the future.

- Gravity is the ongoing accretion of energy, or absorption of the quanta of space, by particles of matter.

- The rate of accretion of energy into particles is, surprisingly, the Hubble constant.

- We find that the centripetal force of the vortices of space matches the gravitational force; they are the same force.

- Matter is made of the collapsed and coalesced quanta of space. The continually increasing angular momentum of the hyperverse forces matter to continually accrete space, and we experience this continuous accretion of space as gravity.

- Matter and gravity exist because space expands.

This paper is presented in two parts, Matter and Gravity.

Part I

Matter

2. The Ideal Particle

2.1. The Radius of the Small Energy Quantum

In [3], we showed that 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:

$$R_{SEQ} = \left(R_H 4 l_p^2\right)^{\frac{1}{3}} = 6.495\,953\,894\,227\,408\,611\,9 \times 10^{-15}\,\mathrm{m} \tag{1}$$

where l_p is the Planck length.

The SEQ radius is very close to the Compton radii (the reduced Compton wavelength) of elementary particles. The geometric mean average of the Compton radii for all twelve quarks and leptons, of all three families, is approximately $1.156\,56 \times 10^{-14}$ m, giving a ratio of the two radii of 1.78.

2.2. The Geometric Mean Counterpart of the SEQ Radius is 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:

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

where G is the Gravitational constant, and GM stands for geometric mean. This relation was discussed briefly in [3].

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 radius was the correct radius, we would 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]:

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

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

A geometric mean radius gives 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 later in this paper.

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

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

Thus, using R_{GM_SEQ} we get the conserved mass to radius ratio.

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:

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

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 expansion speed (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:

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

If we claimed the SEQ radius (the Compton radius of a particle) was the particle radius, we'd find the Schwarzschild radius was one half the small radius, which is not correct:

$$d = \frac{2G\left(\frac{\hbar}{cR_H}\right)}{c^2} = \frac{2l_p^2}{R_H} = \frac{R_s}{2} = 1.990\,579\,889\,740\,185\,209\,9 \times 10^{-96}\,\mathrm{m} \tag{5}$$

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.

2.3. 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, $\frac{R_H c^2}{4G} = 8.835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}$, and divide it by the mass of a proton, to get a rough estimate of the number of protons:

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

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}.

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

If we divide the mass of the universe by the arithmetic mean of the electron, up, and down quarks, we get:

$$\frac{8.835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}}{9.216\,959\,800\,818\,213\,513\,1 \times 10^{-30}\,\mathrm{kg}} = 9.586\,465\,283\,115\,359\,856\,3 \times 10^{81}$$

Including the neutrino in the arithmetic mean calculation gives us:

$$\frac{8.835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}}{6.912\,720\,831\,078\,142\,952\,6 \times 10^{-30}\,\mathrm{kg}} = 1.278\,195\,189\,789\,443\,509\,7 \times 10^{82}$$

The geometric mean of the electron, up, and down quark gives:

$$\frac{8.\,835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}}{1.\,543\,555\,939\,191\,495\,571\,9 \times 10^{-31}\,\mathrm{kg}} = 5.\,724\,318\,950\,999\,277\,563\,8 \times 10^{83}$$

The geometric mean of the neutrino, electron, and up and down quarks gives:

$$\frac{8.\,835\,806\,514\,641\,366\,599\,6 \times 10^{52}\,\mathrm{kg}}{5.\,250\,482\,456\,819\,872\,032\,3 \times 10^{-30}\,\mathrm{kg}} = 1.\,682\,856\,116\,044\,060\,53 \times 10^{82}$$

We see these various ways of calculating the number of particles in the observable universe gives us values in the vicinity of 10^{80} to 10^{83}.

The large number of the universe, [3], is $\left(\frac{R_H}{2l_p}\right)^2$, or about $6.\,59 \times 10^{121}$. 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, $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$:

$$\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} = 1.\,631\,670\,937\,848\,98 \times 10^{81} \tag{7}$$

We will assume that this number is 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:

$$\frac{R_H}{R_{GM\_SEQ}} = \frac{R_H}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}} \tag{8}$$

The ideal particle number implies that matter is being continuously created; the number of particles of matter is increasing with time.

2.4. The Particle Mass

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

$$\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} = \left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} = 5.415\,182\,785\,216\,18 \times 10^{-29}\,\text{kg} \tag{9}$$

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 mass of the elementary particles, is less than a factor of two, being, again, about 1.78.

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

$$\lambda bar = \frac{\hbar}{mc} = \frac{\hbar}{\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)c} = \sqrt[3]{R_H 4l_p} = R_{SEQ} \tag{10}$$

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

$$\text{particle mass} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \tag{11}$$

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:

$$\text{particle mass} = \frac{c^2\left(R_{GM\_SEQ}\right)}{4G} = \frac{c^2\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}{4G} \tag{12}$$

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

$$\text{particle mass} = \left(\frac{\hbar}{cR_H}\right)\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{\hbar}{c\left(R_H 4l_p^2\right)^{\frac{1}{3}}} = \frac{\hbar}{cR_{SEQ}} \tag{13}$$

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

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

2.5. 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 the actual particle radii and masses, and the total number of particles, is not coincidental, and that our 'ideal particle' values are the target values the expanding universe strives for. They are, in summary:

$$\text{particle radius} = \left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}} = R_H\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \tag{15}$$

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

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

These target values are postulated to vary from the real values due to the specific charge, or spin, relationships within the coalesced component vortices [4].

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

The product of the ideal particle mass, $\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}$, and the particle number, $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$, gives us the mass of the observable universe:

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

Of the $\left(\frac{R_H}{2l_p}\right)^2$ ($\approx 6.590\,96 \times 10^{121}$) units of small energy quanta in the observable universe, only $\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$ or $1.631\,67 \times 10^{81}$ 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.

4. Successes and Failures in Conserving Angular Momentum and Centripetal Force

4.1. Angular Momentum

Spin angular momentum, the intrinsic momentum of a spinning object (as compared to orbital angular momentum), is what we will be discussing. The term "L" will 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, the mass distribution compared to the radius. Omega is defined as the tangential velocity per unit radius, or $\omega = \frac{v_T}{r}$. Combining the terms gives us:

$$L = I\omega = mrvk \tag{19}$$

The 'k' value is defined as one for normal, uncompressed space. We will discuss the reason for this definition shortly.

The magnitude of the tangential velocity, v_T, is a constant, $\sqrt{2}c$ [2].

4.2. Are the Quanta Being Created to Counter a Runaway Angular Momentum?

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

$$L_{initial} = mrv_T = \underbrace{\left(\frac{\sqrt{\frac{c\hbar}{G}}}{2}\right)}_{\text{initial mass}} \underbrace{(2l_p)}_{\text{initial radius}} \underbrace{\left(\sqrt{2}c\right)}_{\text{tangential velocity}} = \sqrt{2}\hbar \tag{20}$$

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

The angular momentum of the observable universe, L_o is:

$$L_o = mrv_T = \left(\frac{R_H c^2}{4G}\right)(R_H)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2 \tag{21}$$

This is not the initial value; the angular momentum of the observable universe is increasing over time. Using the "now and then" approach of doubling we used in [3], we find that the angular momentum of the observable universe increases by four times with each doubling of the hyperverse radius:

$$\frac{\text{angular momentum now}}{\text{angular momentum then}} = \frac{\left(\frac{R_H c^2}{4G}\right)(R_H)\left(\sqrt{2}c\right)}{\left(\frac{\frac{R_H}{2}c^2}{4G}\right)\left(\frac{R_H}{2}\right)\left(\sqrt{2}c\right)} = 4 \tag{22}$$

The four-fold increase in angular momentum of the observable universe is a product of the two-fold increase in the mass, and the two-fold increase in the radius, with each doubling [3]. We might expect angular momentum to be conserved, but it is rapidly increasing.

Looking at the geometric mean partner of the large angular momentum, we find:

$$L_s = \frac{L_i^2}{L_o} = \frac{\left(\sqrt{2}\hbar\right)^2}{\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2} = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 \tag{23}$$

This value of 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.

$$L_{GM} = mvr = \left(\frac{\hbar}{cR_H}\right)\left(\frac{4l_p^2}{R_H}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2 \tag{24}$$

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]. Equation (24) suggests that expansion's production of the two quantum levels is a means of conserving angular momentum.

Of additional interest is that if multiply the number of SEQ within the observable universe,

$$\frac{\text{mass of universe}}{\text{mass of SEQ}} = \frac{\frac{R_H c^4}{4G}}{\frac{c\hbar}{R_H}} = \left(\frac{R_H}{2l_p}\right)^2 = \text{number of SEQ} \tag{25}$$

by the angular momentum of L_{GM}, we get the initial angular momentum, $\sqrt{2}\hbar$:

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

We will see next that, at the SRQ level, the total angular momentum is also the conserved value, $\sqrt{2}\hbar$. This and the observation that the product of L_{GM}, and the number of SEQ, also equals $\sqrt{2}\hbar$, makes one wonder if this is an actual attempt to conserve angular momentum at the SEQ level. We see in equation (33), below, that the combination of the small energy and small radius also conserves centripetal force between themselves. These observations lead us to wonder if the small energy and small radius comprise a "false quantum". Despite the deep connection between the small energy and small radius, they have distinct identities[3].

4.3. 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.

4.4. 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 within its own quantum level, the SEQ, in its native state, cannot conserve angular momentum within its level.

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

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

$$\text{Initial Condition: } F_C = m_{initial} \times \frac{v_T^2}{r_{initial}} = \left(\frac{\sqrt{\frac{c\hbar}{G}}}{2}\right)\left(\frac{2c^2}{2\sqrt{\frac{G\hbar}{c^3}}}\right) = \frac{c^4}{2G} \tag{31}$$

We get the same for the observable universe:

$$\text{Observable Universe: } F_C = M_o \times \frac{v_T^2}{R_H} = \left(\frac{R_H c^2}{4G}\right)\left(\frac{2c^2}{R_H}\right) = \frac{c^4}{2G} \tag{32}$$

and for the combined E_s and R_s quanta:

$$\text{GM counterparts: } E_s \text{ and } R_s \text{ quanta:} \quad F_{C\_GM} = M_s \times \frac{v_T^2}{R_s} = \left(\frac{\hbar}{cR_H}\right)\left(\frac{2c^2}{\frac{4l_p^2}{R_H}}\right) = \frac{c^4}{2G} \tag{33}$$

and for the ideal particle:

$$\text{Particle: } F_C = M_{particle} \times \frac{v_T^2}{R_{particle}} = \left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(\frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G} \tag{34}$$

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

$$F_C = m\frac{v_T^2}{r} = 2c^2\frac{m}{r} \tag{35}$$

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

Thus the mass to radius ratio is:

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

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 $\frac{c^2}{4G}$:

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

4.6. 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.

4.7. Summarizing Angular Momentum and Centripetal Force Values

Table 1 gives a summary of the angular momentum and centripetal force values we have calculated thus far. The initial state gives us the values we claim the universe wants to conserve.

	L	F_C
Initial state	$\sqrt{2}\hbar$	$\frac{c^4}{2G}$
Observable	$\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^2$	$\frac{c^4}{2G}$
GM counterpart	$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^2$	$\frac{c^4}{2G}$
SRQ single	$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^6$	$\frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4$
SRQ all	$\sqrt{2}\hbar$	$\frac{c^4}{2G}\left(\frac{R_H}{2l_p}\right)^2$
SEQ single	$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$	$\frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}}$
SEQ all	$\sqrt{2}\hbar\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$	$\frac{c^4}{2G}\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$

Table 1. Summary of angular momentum and centripetal force values of various aspects of the universe

In Table 1, we see that the observable universe is conserving centripetal force, and appears to be attempting to conserve angular momentum, despite the rapid increase in the angular momentum. The quantum levels, between each other, as a unit (the GM counterpart row), conserve centripetal force, and as we argued above, that the two quantum levels seem to be making an attempt to conserve angular momentum against the observable universe (multiplying the number of SEQ by L_{GM}).

The SRQ conserves the initial angular momentum, but not centripetal force, and the SEQ fails at everything. Here is where matter comes in. Let us look at what we think the universe is doing to conserve angular momentum and centripetal force.

5. Creating Particles of Matter Conserves Angular Momentum and Centripetal Force

5.1. Elementary Particles Conserve Angular Momentum and Centripetal Force

Elementary particles have intrinsic spin. The equation of spin for particles is:

$$S = \hbar\sqrt{s\,(s+1)} = L \tag{41}$$

where S is the spin angular momentum and s is the spin quantum number. In these papers, we use the term 'L' for the spin angular momentum.

For a spin-1 particle, $s = 1$, we get $L = \hbar\sqrt{1\,(1+1)} = \sqrt{2}\hbar$, our initial, and conserved, angular momentum. An electron, for example, is a spin-1/2 particle, and its angular momentum would be $L = \hbar\sqrt{\frac{1}{2}\left(\frac{1}{2}+1\right)} = \frac{\sqrt{3}}{2}\hbar$. Resolving the creation of different spin is not currently part of this model.

We can calculate the centripetal force of the ideal particle:

$$F_C = M_{particle}\frac{v_T^2}{R_{particle}} = \left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} \frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G} \tag{42}$$

We get the initial, conserved value. We could add this row to Table 1:

	L	F_C
elementary particles	$\sqrt{2}\hbar$	$\frac{c^4}{2G}$

Particles conserve the initial values. We will make the claim that the universe creates particles of matter to conserve angular momentum and centripetal force.

5.2. Coalescing and Shrinking SEQ Conserves both L and $\mathbf{F}_C$, Creating Particles of Matter

The angular momentum of one SEQ is $\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$. If $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ were packed, or combined, into the space of one SEQ, the conserved angular momentum of $\sqrt{2}\hbar$ 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, $\sqrt{2}\hbar$:

$$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \sqrt{2}\hbar \tag{43}$$

Or we can express this as:

$$L = \left(\underbrace{\left(\frac{\hbar}{cR_H}\right)}_{\text{mass of one SEQ}} \underbrace{\left(\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}\right)}_{\text{number of SEQ packed into volume of one SEQ}}\right) \left(\underbrace{\left(R_H 4l_p^2\right)^{\frac{1}{3}}}_{\text{SEQ radius}}\right) \left(\underbrace{\sqrt{2}c}_{\text{tangential velocity}}\right) = \sqrt{2}\hbar \tag{44}$$

where the total mass is the mass of one SEQ, times number of SEQ compressed into the SEQ volume.

This action conserves angular momentum, but not the centripetal force; it would still be short of the conserved value, $\frac{c^4}{2G}$, as shown here:

$$F_C = m\frac{v^2}{r} = \left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(\frac{2c^2}{\left(R_H 4l_p^2\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{45}$$

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

$$F_C = m\frac{v_T^2}{r} = \left(\left(\frac{\hbar}{cR_H}\right) \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}\right) \frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^4}{2G} \tag{46}$$

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 $\frac{c^2}{4G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$:

$$\frac{M_{SEQ}}{R_{GM\_SEQ}} = \frac{\frac{\hbar}{cR_H}}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^2}{4G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{47}$$

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 $\frac{c^2}{4G}$.

$$\text{particle mass to radius} = \frac{c^2}{4G}\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{c^2}{4G} \tag{48}$$

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

$$\frac{\text{particle mass}}{\text{particle radius}} = \frac{\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \frac{c^2}{4G} \tag{49}$$

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.

This leads to another issue we need to discuss. Compressing the radius from the SEQ radius to the particle radius appears to result in a decrease in the angular momentum, as such:

$$L = \left(\left(\frac{\hbar}{cR_H}\right)\left(\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}\right)\right)\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{50}$$

Recall that the general equation of angular momentum is $L = mrvk$, where k is the moment of inertia constant. The constant 'k' is related to the distribution of the mass relative to the radius. The solution to the apparent decrease in angular momentum lies with the change in the 'k' value. We will address this shortly.

5.3. The Large Number Cube

A visual aid, Figure 1, might help. 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 area at the very bottom, in blue, which is the product of two sides, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}$.

A particle is made by collapsing the column above each point on the bottom. For example, the number of SEQ absorbed per particle is represented by the height of the brown column, $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, consisting of 4.039×10^{40} small energy quanta, or SEQ, shown by the arrow.

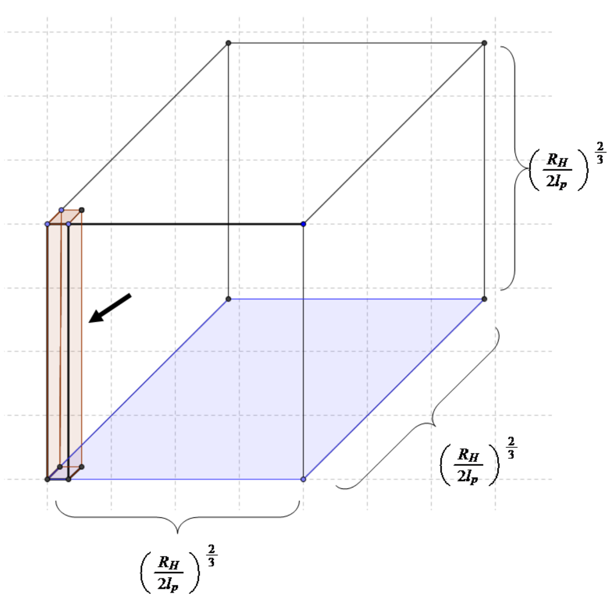

Figure 1. The large number cube. The length of each side of the cube is equal to the cube root of the large number. The square at the very bottom, shown in blue, represents the

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.

5.4. Condensing $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ into an SEQ Volume, and Shrinking the Radius to the Particle Radius, Also Makes the SRQ Behave

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

$$\text{One SRQ: } F_C = m\frac{v_T^2}{r} = \left(\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\left(\frac{2c^2}{\frac{4l_p^2}{R_H}}\right) = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4 \tag{51}$$

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

$$\text{Radius of the SRQ: } \frac{4l_p^2}{R_H} = \frac{(3.232\,1\times10^{-35}\,\mathrm{m})^2}{2.62397216\times10^{26}\,\mathrm{m}} = 3.981\,166\,633\,261\,840\,704\,9\times10^{-96}\,\mathrm{m} \tag{52}$$

The particle radius is

$$\text{Particle Radius: } \left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}} = 1.608\,150\,331\,744\,687\,220\,7\times10^{-55}\,\mathrm{m} \tag{53}$$

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:

$$F_C = m\frac{v_T^2}{r} = \left(\frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\left(\frac{2c^2}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}\right) = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^{\frac{14}{3}} = \frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{54}$$

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:

$$\frac{c^4}{2G}\left(\frac{2l_p}{R_H}\right)^4\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}\times\left(\frac{R_H}{2l_p}\right)^4\times\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{c^4}{2G} \tag{55}$$

SEQ are composed of SRQ, with $\left(\frac{R_H}{2l_p}\right)^4$ SRQ in the volume of one SEQ. Coalescing $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$SEQ into the volume of one SEQ means we have $\left(\frac{R_H}{2l_p}\right)^4 \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SRQ in the volume of one SEQ. The angular momentum of this many SRQ is the conserved value:

$$\left(\left(\frac{R_H}{2l_p}\right)^4 \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \times \frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\left(\left(R_H 4l_p^2\right)^{\frac{1}{3}}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar \tag{56}$$

As with the SEQ, collapsing the radius from the SEQ radius to the particle radius, causes the angular momentum of the SRQ to appears to drop to$\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$:

$$\left(\left(\frac{R_H}{2l_p}\right)^4 \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \times \frac{\frac{R_H c^2}{4G}}{\left(\frac{R_H}{2l_p}\right)^6}\right)\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)\left(\sqrt{2}c\right) = \sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}} \tag{57}$$

Thus, the coalescing of $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$SEQ into the volume of one SEQ conserves angular momentum for both the SEQ and the SRQ, and decreasing the SEQ radius to the particle radius allows conservation of centripetal force, but we have an apparent decrease in the angular momentum. Let us now examine the moment of inertia constant, 'k', and how it is altered by the collapse of space.

5.5. Why k=1 for the Hyperverse

We have seen that if $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ SEQ are compressed into the volume of one SEQ, the angular momentum is conserved at $\sqrt{2}\hbar$. But when we shrink the radius from the SEQ radius to the particle radius, our equation, $L = mrv$ gives us a shrinkage in the angular momentum to $\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$. We get the exact same result when we look at the SRQ, where we go from the conserved state to $\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$. Both the SEQ and SRQ are off by the same factor, $\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$. Notice, if we multiplied the resultant angular momentum by $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, we get our conserved value.

The solution is in the general equation of angular momentum, which is $L = mrvk$. The term, 'k', is the moment of inertia constant and it is related to the distribution of mass in relation to the axis of rotation. For example, the moment of inertia, I, for a spinning, hollow 3D sphere is $\frac{2}{3}mr^2$. It is not mr^2 because the mass is not all the same distance from the axis of rotation. Some of the mass is at or near the poles, for example, while some of the mass is at the equator.

We have set the 'k' value of the hyperverse at $k = 1$. And we claim the hyperverse, which is hollow, has spin. If the hyperverse turned on an axis, that is, it had a north and south pole, like a hollow 3D rotating sphere, then we'd expect it to have a moment of inertia constant less than one, so that the equation of angular momentum, $L = I\omega$, would produce a lower angular momentum than we are currently using:

$$L = I\omega \Rightarrow \left(kmr^2\right)\left(\frac{v_T}{r}\right) = kmrv_T \tag{58}$$

$$\Rightarrow \;\; kmrv_T < mrv_T. \tag{59}$$

Our model of the hyperverse is one of a surface consisting of individual atoms of space, or quanta, each with its own spin. The hyperverse, according to this model, is not a four dimensional sphere rotating on an axis, but one whose surface is formed by individual spinning atoms of space. There is no axis of rotation for the whole. All points on the surface are at an equal distance from the center, which is the only reference point of spin. Thus, $k = 1$ for the hyperverse.

5.6. The Particle Radius is the Geometric Mean of the SEQ Radius and the SRQ Radius

Coalescing $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ units of SEQ into the volume of one SEQ conserves angular momentum for both the SEQ and SRQ, but does not conserve centripetal force. Collapsing the SEQ radius to the particle radius allows conservation of centripetal force, but appears to lose the conserved angular momentum, its value dropping to $\sqrt{2}\hbar\left(\frac{2l_p}{R_H}\right)^{\frac{2}{3}}$ for both quantum levels.

The ratio of the SEQ radius to the particle radius is $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$:

$$\frac{\text{SEQ radius}}{\text{particle radius}} = \frac{\left(R_H 4l_p^2\right)^{\frac{1}{3}}}{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}} = \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \tag{60}$$

The ratio of the particle radius to the SRQ radius is also $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$:

$$\frac{\text{particle radius}}{\text{SRQ radius}} = \frac{\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}}{\frac{4l_p^2}{R_H}} = \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \tag{61}$$

Since the two ratios are equal, we can rearrange them as such:

$$\frac{\text{particle radius}}{\text{SRQ radius}} = \frac{\text{SEQ radius}}{\text{particle radius}} \Rightarrow (\text{SRQ radius})\,(\text{SEQ radius}) = (\text{particle radius})^2 \tag{62}$$

The geometric mean of the SEQ radius and the SRQ radius happens to be the particle radius:

$$\underbrace{\left(\left(R_H 4l_p^2\right)^{\frac{1}{3}}\right)}_{\text{(SEQ radius)}} \times \underbrace{\left(\frac{4l_p^2}{R_H}\right)}_{\text{(SRQ radius)}} = \underbrace{\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)^2}_{\text{(particle radius)}^2} \tag{63}$$

We have previously defined the particle radius as the geometric mean counterpart to the SEQ radius, against the initial radius:

$$R_{SEQ} \times R_{GM\_SEQ} = R_{initial}^2 \tag{64}$$

So the particle radius is not just the geometric mean partner of the SEQ radius, the particle radius is also the geometric mean of the SEQ and SRQ radii. The particle radius is a very special value in the cosmos.

5.7. Compression and Expansion Change the k value

Let us picture the expansion of an SRQ up to the size of a particle, as in Figure 2. The large circle represents a particle, and the smaller circle, an SRQ. The SRQ must expand to fill the volume of the particle. The SRQ mass, which in the small radius quantum, is at a distance equal to the SRQ radius from the center of the SRQ, finds itself at a much greater distance from the center after expanding to the size on a particle. The new location of the SRQ mass is $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ times the small radius, from the center. The mass distribution, relative to the initial, native radius, is $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ times the initial distance. The 'k' value, the moment of inertia constant, in this case, is outside the initial radius, making $k = \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$.

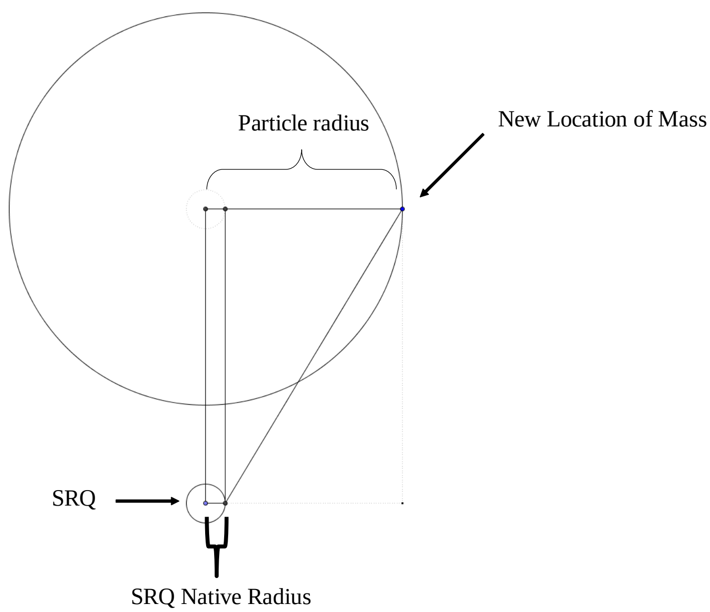

Figure 2. The SRQ Expanding to the Particle Radius. The bottom circle represents an SRQ. The larger circle represents a particle. With the SRQ expanding to fit the particle volume, we see that the SRQ mass, which lies upon its circumference, must move away from the initial radius. The factor of difference is $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, thus increasing the 'k' factor by the amount needed to conserve angular momentum.

Looking at the situation for the SEQ, shrinking its radius to the particle radius, Figure 3, we find again that the mass can be viewed as existing at a distance $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ outside the radius.

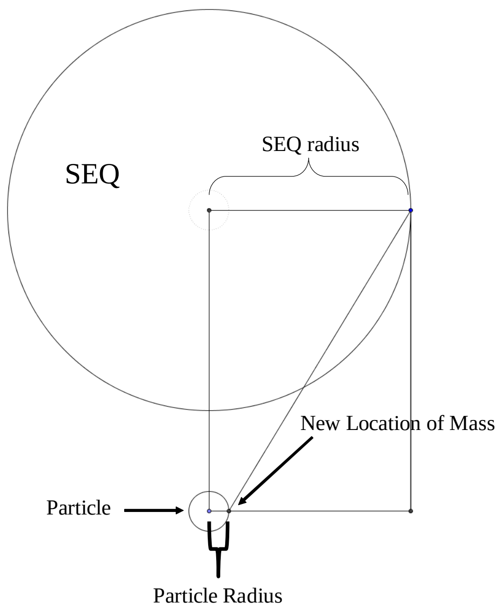

Figure 3. The SEQ Shrinking to the Particle Radius. The upper, large, crcle represents the SEQ. Shrinkage places its mass at a distance of $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ times the shrunken radius, which is the particle radius.

With shrinkage of a small energy quantum, the radius shrinks relative to the mass; mass stays constant. With expansion of the SRQ, mass expands relative to the radius, and the radius is constant. In each case, the mass lies at a distance $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$ times the radius, from the center, so that $k = \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, precisely countering the shrinkage effects. The angular momentum remains at the conserved, initial quantity of $\sqrt{2}\hbar$.

Using the equation of angular momentum, with k being equal to $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$, gives us the conserved angular momentum.

$$L = mrvk = \left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)\left(\sqrt{2}c\right)\left(\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}\right) = \sqrt{2}\hbar \tag{65}$$

We see that the universe is able to produce the conserved angular momentum and centripetal force by creating particles of matter.

6. The Regulation of Particle Size, or Why All Particles of a Kind are Identical

That the universe creates particles of matter 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 and centripetal force of the particle would vary from the target values; all particles collapse to the point that their angular momentum and centripetal force matches the initial, conserved values.

All particles of a kind, everywhere, are identical, and this model tells us why.

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?

7. 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 [4]. The differences 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. The spin of adjacent quanta, within a particle, 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 ideal particle radius is the geometric mean partner of the SEQ radius, the radii of real particles would be the geometric mean partner of the reduced Compton wavelength of the real particles. For example, the true radius of the electron would be:

$$R_e = \frac{4l_p^2}{\frac{\hbar}{m_e c}} = 4\frac{G}{c^2}m_e = 2.705\,218\,242\,135\,866\,147 \times 10^{-57}\,\mathrm{m} \tag{66}$$

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

$$\frac{\text{electron mass}}{\text{electron radius}} = \frac{9.1093897 \times 10^{-31}\,\mathrm{kg}}{2.705\,218\,242\,135\,866\,147 \times 10^{-57}\,\mathrm{m}} = \frac{3.367\,340\,038\,638\,735\,633\,4 \times 10^{26}}{\mathrm{m}}\,\mathrm{kg} \tag{67}$$

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:

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

7.1. 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 [5] showed an amazing relationship between the masses of the electron, muon and tau electron as:

$$(m_e) + (m_\mu) + (m_\tau) = 2/3\left(\sqrt{m_e} + \sqrt{m_\mu} + \sqrt{m_\tau}\right)^2 \tag{68}$$

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

$$\left(4\frac{G}{c^2}m_e\right) + \left(4\frac{G}{c^2}m_\mu\right) + \left(4\frac{G}{c^2}m_\tau\right) = 2/3\left(\sqrt{4\frac{G}{c^2}m_e} + \sqrt{4\frac{G}{c^2}m_\mu} + \sqrt{4\frac{G}{c^2}m_\tau}\right)^2 \tag{69}$$

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,

$$m_e = \frac{c^2}{4G}R_e \tag{70}$$

and inserting this into the Koide formula gives:

$$\left(\frac{c^2}{4G}R_e\right)+\left(\frac{c^2}{4G}R_\mu\right)+\left(\frac{c^2}{4G}R_\tau\right)=\frac{2}{3}\left(\sqrt{\frac{c^2}{4G}R_e}+\sqrt{\frac{c^2}{4G}R_\mu}+\sqrt{\frac{c^2}{4G}R_\tau}\right)^2 \tag{71}$$

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.

Part II

Gravity

8. Particles and Quanta Are Not Static Entities. The Effects of Doubling the Size of the Hyperverse Radius on Particle Dimensions

In Part One, equations 15-17, we gave the parameters of the ideal particle, repeated here:

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

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

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

They are all functions of the radius of the hyperverse, R_H, meaning the values change with expansion. Let us use the 'now and then' approach, where 'now' refers to the current condition, and 'then' refers to the time when the hyperverse radius was one-half the current size, or $\frac{R_H}{2}$, to see the effects of doubling.

The mass of particles decreases with a doubling:

$$\frac{\text{particle mass now}}{\text{particle mass then}} = \frac{\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}}{\left(\frac{1}{4G}\frac{\hbar^2}{\frac{R_H}{2}}\right)^{\frac{1}{3}}} = \left(\frac{1}{2}\right)^{\frac{1}{3}} = \frac{1}{2}2^{\frac{2}{3}} = 0.793\,700\,525\,984\,100 \tag{72}$$

The radius of particles also decreases with a doubling, and at the same rate as mass:

$$\frac{\text{particle radius now}}{\text{particle radius then}} = \frac{\left(\frac{(2l_p)^4}{R_H}\right)^{\frac{1}{3}}}{\left(\frac{(2l_p)^4}{\frac{R_H}{2}}\right)^{\frac{1}{3}}}\left(\frac{1}{2}\right)^{\frac{1}{3}} = \frac{1}{2}2^{\frac{2}{3}} = 0.793\,700\,525\,984\,100 \tag{73}$$

The number of particles increases with a doubling of the hyperverse radius:

$$\frac{\text{number of particles now}}{\text{number of particles then}} = \frac{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}}{\left(\frac{\frac{R_H}{2}}{2l_p}\right)^{\frac{4}{3}}} = 2\sqrt[3]{2} = 2.\,519\,842\,099\,789\,75 \tag{74}$$

In the geometric mean paper, [3], we gave the effects of doubling on the quanta. Table 2, below, is a combination of the results from Table 6 of that paper, showing quanta, with our particle doubling results. The quanta and particles all change with time.

	observable	SRQ		SEQ		Particle	
Radius	$R_H = 2x\ \uparrow$	$R_{SRQ} = \frac{1}{2}x \downarrow$		$R_{SEQ} = \sqrt[3]{2}x \uparrow$		$R_{particle} = \left(\frac{1}{2}\right)^{\frac{1}{3}} x \downarrow$	
Volume per unit	$V_o = 8x \uparrow$	$V_{SRQ} = \frac{1}{8}x \downarrow$		$V_{SEQ} = 2x \uparrow$		$V_{particle} = \frac{1}{2}x \downarrow$	
Energy per unit	$E_o = 2x \uparrow$	$E_{SRQ} = \frac{1}{32}x \downarrow$		$E_{SEQ} = \frac{1}{2}x \downarrow$		$\left(\frac{1}{2}\right)^{\frac{1}{3}} x \approx 0.7937x \downarrow$	
Number of units	1	$64x \uparrow$		$4x \uparrow$		$2\sqrt[3]{2}x \uparrow$	
Total E = E x #	$2x \uparrow$	$2x \uparrow$		$2x \uparrow$		$2x \uparrow$	
Energy Density	$\frac{1}{4}x \downarrow$	$\frac{1}{4}x \downarrow$		$\frac{1}{4}x \downarrow$		$2^{\frac{2}{3}}x \uparrow$	
Angular Momentum		one	all	one	all	one	all
	$4x \uparrow$	$\frac{1}{64} \downarrow$	1	$\left(\frac{1}{4}\right)^{\frac{1}{3}} \downarrow$	$2\sqrt[3]{2} \uparrow$	1	$2\sqrt[3]{2} \uparrow$

Table 2. Effects of doubling on aspects of the hyperverse. This table is a repeat of Table 6 from [3], with the particle doubling and angular momentum information added.

9. The Fractional Increase in Particle Energy Equals the Hubble Constant

From [1]. the Hubble constant, H, can be expressed as:

$$H = \frac{\Delta E_o}{E_o} \tag{75}$$

where E_o is the energy of the observable universe, and ΔE_o is the change in energy of the observable universe. Thus, the Hubble constant is a measure of the change of energy in the universe. From [3], delta energy of the observable universe, ΔE_o is equal to $\frac{c^5}{2G}$.

We can calculate delta E for a particle, by dividing the rate of change of energy of the observable universe, ΔE_o, by the number of particles. We find that about 1.1×10^{-29} joules of energy are added to a particle each second:

$$\frac{\Delta E_o}{\text{number of particles}} = \frac{\frac{c^5}{2G}}{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}} = \Delta E_{particle} = 1.112\,106\,810\,712\,833\,910\,4 \times 10^{-29}\,\frac{\mathrm{m}^2}{\mathrm{s}^3}\,\mathrm{kg} \tag{76}$$

To find the fractional increase of energy of a particle, we can take the ratio of $\Delta E_{particle}$ to $E_{particle}$:

$$\frac{\Delta E_{particle}}{E_{particle}} = \frac{\frac{\frac{c^5}{2G}}{\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}}}{\frac{c\hbar}{R_H} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}} = \frac{2c}{R_H} = 2.285\,027\,734\,440\,597\,113\,7 \times 10^{-18}\,\mathrm{m/\,s/\,m} \tag{77}$$

The amazing result is the Hubble constant. The fractional, or at each point, increase in the energy of a particle is the same as for the observable universe. Particles and the observable universe have identical growth in their energies. This may seem odd at first for a couple of reasons. The standard use of the Hubble constant is a measure of the rate of the separation of galaxies. But we saw in [1], that the Hubble constant is actually a measure of the addition of energy to the universe. Secondly, the idea that the rate of growth of the observable universe, the Hubble constant, if scaled down to the size of a particle, gives us the growth rate of particles of matter, is quite a surprising realization.

10. Particles Continuously Accrete the Quanta of Space

As discussed in the first part of this paper, particles are not static over time; they are accreting quanta with expansion, apparently doing so to conserve angular momentum and centripetal force.

Table 2 shows us that particle energy decreases with time. But particles are composed of quanta, and the energy of quanta shrinks with time, at a FASTER rate, than does a particle. Plus, the angular momentum of the observable universe continually increases.

The concept of frame advances was developed in [2] and [3], the idea being that space is radially advancing in increments of one hypervortex radius. Each radial advancement of a vortex radius is called a 'frame advance'.

The number of SEQ within one particle is $\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}$. There have been $\left(\frac{R_H}{2l_p}\right)^2$ frame advances since expansion started. Dividing the number of SEQ within a particle, by the number of frame advances, gives us the number of SEQ absorbed per frame advance per particle:

$$\frac{\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}}{\left(\frac{R_H}{2l_p}\right)^2} = \left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} = 6.128\,686\,714\,971\,424\,166\,1 \times 10^{-82} \text{ SEQ/frame/particle} \tag{78}$$

The volume absorbed per particle per frame is $\frac{\text{number of SEQ}}{\text{frame advances}} \times \frac{\text{volume}}{\text{SEQ}} = \frac{\text{volume}}{\text{frame advance}}$:

$$\left(\frac{2l_p}{R_H}\right)^{\frac{4}{3}} \times 2\pi^2 \left(R_H 4l_p^2\right) = 2\pi^2 \left(\frac{(2l_p)^{10}}{R_H}\right)^{\frac{1}{3}} = 3.316\,087\,367\,219\,182\,637\,8 \times 10^{-123} \frac{\text{m}^3}{\text{frame}} \tag{79}$$

This is the volume of 'raw', full radius SEQ absorbed per frame advance. Logic, and calculations (unpublished data), indicate that the quanta shrink as they approach the absorbing matter.

The number of frame advances per second, is the number of frame advances, divided by the age of the universe, $\frac{\text{number of frame advances}}{\text{age of the universe}}$:

$$\frac{\left(\frac{R_H}{2l_p}\right)^2}{\frac{R_H}{2c}} = 2c\frac{R_H}{4l_p^2} = \frac{1.506\,053\,303\,548\,235\,063\,6 \times 10^{104}}{\text{s}} \tag{80}$$

Note that the inverse of this number is $6.639\,859\,798\,408\,221\,496\,7 \times 10^{-105}$ seconds, which is the value of 'small time', from [3].

The number of SEQ absorbed per second per particle is the number of SEQ within a particle, divided by the age of the universe, $\frac{\text{number of SEQ absorbed}}{\text{second / particle}}$:

$$\frac{\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}}{\frac{R_H}{2c}} = \frac{2c}{R_H}\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} = \frac{9.\,242\,124\,709\,274\,213\,200\,4 \times 10^{22}}{\text{s}} \tag{81}$$

The volume of SEQ absorbed per particle per second is the volume absorbed per particle per frame, times the number of SEQ absorbed per second per particle, $\frac{\text{volume absorbed}}{\text{s}}$:

$$2\pi^2\left(\frac{(2l_p)^{10}}{R_H}\right)^{\frac{1}{3}} \times 2c\left(\frac{R_H}{4l_p^2}\right) = 2\pi^2 2c\left(R_H^2 16 l_p^4\right)^{\frac{1}{3}} = 4.\,994\,204\,334\,255\,019\,305\,4 \times 10^{-19}\,\frac{\text{m}^3}{\text{s}} \tag{82}$$

The energy absorbed per second, is the number of SEQ absorbed per second per particle, times the energy per SEQ, $\frac{\text{energy absorbed}}{\text{s}}$:

matching (76) above:

$$\frac{2c}{R_H}\left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}} \times \frac{c\hbar}{R_H} = \frac{2c}{R_H}E_{particle} = 1.\,112\,104\,896\,164\,221\,812\,6 \times 10^{-29}\,\frac{\text{m}^2}{\text{s}^3}\,\text{kg} \tag{83}$$

The percentage increase in energy is, again, the Hubble constant: $\frac{2c}{R_H}\frac{c\hbar}{\sqrt[3]{R_H 4l_p^2}} = \frac{2c}{R_H}\frac{c\hbar}{R_{SEQ}} =$

$$\frac{\text{energy absorbed per second}}{\text{energy of a particle}} = \frac{\frac{2c}{R_H}\frac{c\hbar}{\sqrt[3]{R_H 4l_p^2}}}{\frac{c\hbar}{R_H} \times \left(\frac{R_H}{2l_p}\right)^{\frac{2}{3}}} = \frac{2c}{R_H} \tag{84}$$

Dividing the mass of the universe by the number of particles by the age of the universe also gives us the energy absorbed per particle:

$$\left(\frac{R_H c^4}{4G}\right) / \left(\left(\frac{R_H}{2l_p}\right)^{\frac{4}{3}}\right) / \left(\frac{R_H}{2c}\right) = \frac{c^3}{R_H}\left(\frac{2}{G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} = 1.\,112\,105\,534\,346\,726\,290\,1 \times 10^{-29}\,\frac{\text{m}^2}{\text{s}^3}\,\text{kg} \tag{85}$$

Our rate of addition of energy to particles, divided by the particle energy, is the Hubble constant:

$$\frac{1.1121048961642218126\times10^{-29}\,\frac{\mathrm{m}^2}{\mathrm{s}^3}\,\mathrm{kg}}{4.8669235720195028597\times10^{-12}\,\frac{\mathrm{m}^2}{\mathrm{s}^2}\,\mathrm{kg}}=2.2850264231759038554\times10^{-18}\ \text{per second}\ =H \tag{86}$$

Particles are accreting energy, or quanta of space, at a rate equal to the Hubble constant.

11. Gravitational Potential Energy Accumulated per Second is the Accreted Energy

The general equation of gravitational potential energy of mass m is:

$$U=G\frac{Mm}{d} \tag{87}$$

where M is the attracting mass and d is the distance between the centers of the masses. Recall that particle energy is $\left(\frac{c^6}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}$. Let both masses be the particle mass, and the distance between the centers of the two masses be two times the particle radius (the particles are just touching), so that:

$$U=G\frac{M_{particle}^2}{2r}=G\frac{\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)^2}{2\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)}=\frac{1}{8}\left(\frac{c^6}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}=\frac{1}{8}E_{particle} \tag{88}$$

The value of $\frac{1}{8}E_{particle}$ is the gravitational potential energy for two adjacent particles. To get the gravitational potential energy for the full volume around a mass, not just the adjacent mass, we need to cube the distance, which is an increase of eight times. The gravitational potential energy of the adjacent volume of mass is eight times a particle mass. Thus U, the gravitational potential energy, matches the particle energy:

$$U=G\frac{M_{particle}\left(8M_{particle}\right)}{2r}=G\frac{\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(8\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\right)}{2\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)}=\left(\frac{c^6}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}=E_{particle} \tag{89}$$

Taking this gravitational potential energy of a particle, and dividing it by the age of the universe, we get a value for the rate of addition of gravitational potential energy per second, to a particle:

$$\frac{U}{T} = \frac{G\frac{M_{particle}\left(8M_{particle}\right)}{2R}}{\frac{R_H}{2c}} = \left(\frac{2c}{R_H}\right)\left(\frac{c^6}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}} = 1.112\,105\,534\,346\,726\,290\,2 \times 10^{-29}\,\frac{\mathrm{m}^2}{\mathrm{s}^3}\,\mathrm{kg} \tag{90}$$

where T is the age of the universe.

This value matches our value of energy accreted per second by a particle. The potential energy added per second is identical to the accreted energy.

$$\frac{U}{T} = \text{accreted energy per unit time} \tag{91}$$

The gravitational potential energy of a particle is the accreted energy.

12. Gravitational Force is the Extension of the Centripetal Force Beyond the Particle Radius

In order for a vortex to spin, an inward, or centripetal, force must exist. Centripetal force, F_C, was defined as $\frac{c^4}{2G}$.

Looking at the gravitational force between two particles in direct contact, so that the distance between their centers is two times their radii, we have:

$$F_G = G\frac{m(8m)}{d^2} = G\frac{\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(8\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)}{\left(2\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)^2} = \frac{1}{4} \times \frac{c^4}{2G} \tag{92}$$

At a distance of two radii, the gravitational force is very close to the centripetal force of a particle, off by a factor of 4. This distance of two times the radius is outside the particle, and we would expect any centripetal force that existed there to be less. Since the distance, in this case, is twice the distance of a radius, and given that force drops by the inverse square law, we would expect a doubling of the distance to produce a reduction in the force by 1/4, just as we have calculated.

If the distance between the particles was one radius (the particles are overlapping), the gravitational force equals the centripetal force:

$$F_G = G\frac{m\left(8m\right)}{r^2} = G\frac{\left(\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)\left(8\left(\frac{1}{4G}\frac{\hbar^2}{R_H}\right)^{\frac{1}{3}}\right)}{\left(\left(\frac{16l_p^4}{R_H}\right)^{\frac{1}{3}}\right)^2} = \frac{c^4}{2G} \tag{93}$$

At a distance of one radius, the centers of the masses are at a distance from one another that is equal to the radius of a particle.

We can conclude that the gravitational force, and the centripetal force of the particle, are identical forces, forming a continuum of force, so that the centripetal force can be said to be the force at the particle boundary, but centripetal force also extends beyond the particle boundary, where it is experienced as the gravitational force. Or we can say that the centripetal force is the force of gravity. The two forces are the same force, simplifying the situation, leaving us with just one force.

13. Quantum Gravity is the Accretion of the Quanta of Space by Particles of Matter

Elementary particles are not static, unchanging entities; they are dynamical, formed as a means for the expanding hyperverse to conserve angular momentum, while maintaining centripetal force. The energy of the quanta decrease with expansion. To preserve angular momentum, particles must continually accrete energy; that is, they must keep absorbing the quanta of space. It is an ongoing process, driven by expansion, and this is gravity.

The absorbed space pulls along the matter embedded in it. The closer to the absorbing matter, the faster space moves, just like water near a drain moves faster towards the drain the closer the water is to the drain. Matter does not curve space; matter absorbs space, incorporating the quanta of space into the necessary mass and volume to conserve angular momentum and centripetal force.

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