Spontaneous Breaking of Spatial Symmetry as a Novel Paradigm for Theoretical Physics

Yuan Liu

liuyuan19850324@gmail.com

October 15th, 2021

Abstract

$E = mc^2$ as a wave equation describes a light speed propagation of the state of symmetry breaking in the space. Time and energy can be concretely defined as measurements of the degree of spatial asymmetry. All the hierarchy problems and the origin of mass and/or mean lifetime of electron and nucleons can be addressed in one shot by assuming the probability of the spontaneous symmetry breaking to be $1/(2.04 \times 10^{21})$. The entity of quarks and hadrons and the mechanism of quark confinement and asymptotic freedom are revealed by calculations supposing that hadrons are rigid body type particles while leptons are mass point type particles, and that in high energy collision the former may either have one or two out of three spatial dimensions collapse into the latter type, or enlarge the spatial expanse of one dimension in a discrete manner. The quantum entanglement can be explained by combining the superluminal phase velocity of de Broglie wave and the relativity of simultaneity, such that both locality and realism remain intact. An updated theory of gravity is proposed, which is not only compatible with quantum mechanics but also has convincingly denied the existence of dark energy and revealed that dark matter is actually the energy that mediates the interactions between Fermions. All the four fundamental interactions saw a super unification, as four different aspects of spontaneous symmetry breaking in the space as a field composed of binary states. Eventually, an astonishing scenario for the birth and evolution of the universe is proposed. Our universe began from two symmetry breakings which had simultaneously occurred 23.1 billion years ago. The probability of spontaneous symmetry breaking decreases, and accordingly do the masses of all elementary particles, as the cosmological event horizon expands at the speed of light.

1. Spontaneous breaking of spatial symmetry

The resemblance between $E = mc^2$ and wave equation

$$\frac{\partial^2 \psi}{\partial t^2} = \frac{\partial^2 \psi}{\partial x^2} v^2$$

is hard to ignore. It strongly suggests that energy and mass might be two different aspects of a unique wave that propagates at the speed of light.

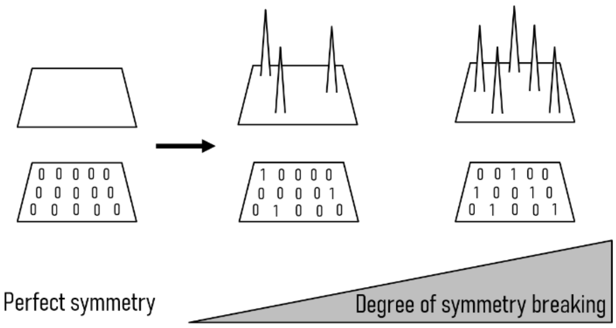
It is not hard to compose a complex exponential function that satisfies the requirement.

$$\Lambda(R, T) = A\, exp\{iB(cT - R)\}$$

$$\frac{\partial^2 \Lambda}{\partial T^2} = \frac{\partial^2 \Lambda}{\partial R^2} c^2$$

What shall this wave convey or describe?

Both energy and mass are linked with certain kind of existence, a concept that only takes meaning in comparison with non-existence as opposition. Therefore, they can be ultimately reduced down to such abstractive binary choices between YES and NO. Suppose a field composed of such binary states (0 and 1 hereafter) spontaneously breaks its symmetry with a consistent stochasticity.



Nothing exists in a perfectly symmetric field, thus no need for physics, let alone physicists. "What if the field does not break its symmetry?" is rather a question of theology, beyond the scope of physics.

Time-independent (we have not defined time yet) formulation of consistent stochasticity should be that the distribution of the length of bilateral symmetry break pair (two ends included) obeys the exponential distribution, in mathematical language. (All multi-lateral configurations can be broken down as a sum of bilateral relationships.)

The probability density function of exponential distribution is

$$f(x) = \lambda e^{-\lambda x} = \frac{e^{-\frac{x}{L}}}{L} \quad \left(L = \frac{1}{\lambda}\right)$$

the expectation of the length of symmetry break pair is

$$E(x) = \frac{1}{\lambda} = L$$

while the probability to find a pair of symmetry breaks with a length not shorter than R is

$$P(x \geq R) = e^{-\lambda R} = e^{-\frac{R}{L}}$$

Define an entropy-like parameter S(R) and a correspondent T(R) as below.

$$S(R) = ln\, P(x \geq R) = -\frac{R}{L}$$

$$T(R) = K|S(R)| = \frac{KR}{L}$$

Let

$$K = \frac{L}{c}$$

Then

$$T(R) = \frac{R}{c}$$

T(R), as a quantification of the degree of symmetry breaking by a specific pair (a longer R means a lower probability to find such a pair out of purely stochastic process, a space that contains such a pair is less likely to be realized, thus more asymmetric), has a character perfectly matches that of "time" in our conventional context. We have been using the notion of time to measure the asymmetry of the space we live in, totally unaware of this profound physical meaning.

The law of entropy increase is therefore rather an axiom from our definition of time. The advent of time is a necessary consequence of spontaneous symmetry breaking, as an inherent property of the space. Time, due to its additive nature (logarithm of multiplied probability), does not need second dimension or more (even in the 11-dimensional M theory).

For the ultimate abstractness, symmetry breaks in the binary field are all identical, and each pair has two symmetry breaks alike. Thus, length is the only variable to distinguish one symmetry break pair with another.

In addition to T(R) which is proportional to the length, another physical property E(R) which is inversely proportional to R shall be naturally conceived or rather requested, such that

$$E(R) = \frac{J}{R}$$

where J is a constant. In other words, E(R) serves as a kind of "line density" of symmetry breaks along the direction and spread over the length of a specific pair.

It can be easily derived that E(R) moves in the same direction (but not linearly) with S (thus with entropy as well), and is inversely proportional to T. As a physical property that satisfies these characteristics, E is nothing but "energy".

Suppose that

$$J = \frac{\hbar c}{2}$$

for Fermions (as we shall see later, $J = \hbar c$ for Bosons), then

$$E(R)T(R) = \frac{\hbar c}{2R}\frac{R}{c} = \frac{\hbar}{2}$$

holds for every symmetry break pair.

Define the energy of a particle as

$$E = \left|\frac{\partial^2 \Lambda}{\partial T^2}\right| = |A|B^2c^2$$

The frequency of wave function Λ is

$$\nu = \frac{|B|c}{2\pi}$$

From the Einstein - de Broglie relationship

$$E = h\nu \quad \rightarrow \quad |A|B^2c^2 = \frac{h|B|c}{2\pi} \quad \rightarrow \quad |AB| = \frac{\hbar}{c}$$

Dimension analysis leads to a general solution in the form of

$$A = \frac{\hbar}{c}\tilde{L} \qquad B = \frac{1}{\tilde{L}}$$

$$\Lambda(R,T) = \frac{\hbar}{c}\tilde{L}\, exp\left(\frac{cT - R}{\tilde{L}}i\right)$$

Define the mass of Fermion as

$$m = \left|\frac{\partial^2 \Lambda}{\partial R^2}\right| = |A|B^2$$

Consider a Fermion with mass $\tilde{M}$, energy $\tilde{E}$.

$$\tilde{R} = \frac{\hbar c}{2\tilde{E}} = \frac{\hbar c}{2\tilde{M}c^2} = \frac{\hbar}{2\tilde{M}c}$$

$$\tilde{E} = \left|\frac{\partial^2 \Lambda}{\partial T^2}\right| = |A|B^2c^2 = \frac{\hbar c}{2\tilde{R}}$$

Dimensional analysis leads to

$$A = \frac{\hbar}{c}2\tilde{R} \qquad B = \frac{1}{2\tilde{R}}$$

$$\Lambda(R,T) = \frac{\hbar}{c}2\tilde{R}\, exp\left(\frac{cT - R}{2\tilde{R}}i\right)$$

as a particular solution. In addition to the wave-particle duality,

$$\frac{1}{\nu} = \frac{2\pi}{Bc} = \frac{4\pi\tilde{R}}{c} = \frac{2\pi\hbar}{\widetilde{M}c^2} = \frac{h}{\tilde{E}} \quad \rightarrow \quad E = h\nu$$

the momentum of the particle, as suggested by its dimension, should be

$$p = \left|\frac{\partial^2 \Lambda}{\partial T \partial R}\right| = |A|B^2 c = \frac{\hbar}{2\tilde{R}} \quad \rightarrow \quad p\tilde{R} = \frac{\hbar}{2}$$

Here appears another conjugate pair in the Heisenberg's uncertainty. It is now convincingly suggested that Λ is a wave function describing the transmission of symmetry breakings in the space.

Einstein could not provide an explanation for why the principle of invariant light speed should hold, but now we have the answer. The speed of light, as an inherent property of space itself with regards to the propagation of symmetry breakings, has good reason to remain invariant for all inertial observers.

Since the binary field serves as the base that underlies all other subsequent fields, what is true in this field must reflect some truths in subsequent layers of reality, directly or indirectly.

$$R = cT \qquad \frac{dR}{dT} = c \qquad \frac{d^2 R}{dT^2} = 0$$

This is the reason why Newton's law of inertia holds, and why forces affect the acceleration of their targets (instead of velocity or higher order derivatives of location by time).

Force, as the spatial derivative of energy, between any two symmetry breaks in the binary field

$$F = \frac{dE}{dR} = \frac{d}{dR}\left(\frac{\hbar c}{2R}\right) = -\frac{\hbar c}{2R^2} < 0$$

is universally attractive and proportional to the inverse square of distance, regardless of the number of spatial dimensions. Since the strength of non-local interactions within an N-dimensional space shall be inversely proportional to the (N-1) th power of distance, the inverse square law in the above implies that the number of spatial dimensions in the binary field has to be three, by reverse reasoning. I will come back to this issue soon, after making a little bit theoretical preparation.

The binary field has its shortest indivisible length unit (spatial expanse or diameter of each 0 and 1) which can be calculated as a length that defines a mass whose Schwarzschild diameter equals to the length itself. In other words, if two symmetry breaks occurred in such a close vicinity, they would instantly form a mini black hole.

$$\widehat{m} = \frac{\hbar}{2\hat{R}c}$$

$$\hat{R} = 2 \times \frac{2G\widehat{m}}{c^2} = \frac{2G\hbar}{\hat{R}c^3}$$

$$\rightarrow \quad \hat{R} = \sqrt{\frac{2G\hbar}{c^3}} = \sqrt{2}l_P = 2.29 \times 10^{-35}[m]$$

$$\rightarrow \quad \widehat{m} = \frac{\hbar}{2\sqrt{2}l_P c} = \frac{m_P}{2\sqrt{2}} = 7.69 \times 10^{-9}[kg]$$

This intrinsic discreteness of space is the very source of the Heisenberg's uncertainty (and also what makes the general relativity incompatible with quantum mechanics as explained later). Physical measurements would inevitably involve certain kind of interaction (force) with their target. Hence, when we try to extract certain particle-ness such as mass, energy and momentum out of the wave function Λ by measurements, they should always be pictures through the "lenses of second order differentials".

$$m = \left|\frac{\partial^2 \Lambda}{\partial R^2}\right| \qquad E = \left|\frac{\partial^2 \Lambda}{\partial T^2}\right| \qquad p = \left|\frac{\partial^2 \Lambda}{\partial T \partial R}\right|$$

The concept of infinitesimal on which our mathematical tools (differentials and integrals) heavily rely does not actually exist in reality (purely mathematical notions such as zero distance, infinite density and singularity do not exist either). $\hbar/2$, as the product of conjugate physical properties (inversely proportional to each other by their definition) of every symmetry break pair, is the finest possible "resolution" when we differentiate the Λ function which is no longer smooth but rather discrete in quantum mechanical scale, which sets the theoretical limit on the precision of our knowledge.

Now, let us revisit the issue of the number of spatial dimensions.

$$\left(\frac{dR}{dT}\right)^k = c^k \quad \rightarrow \quad \frac{d^k}{dR^k} = \frac{1}{c^k}\frac{d^k}{dT^k}$$

implies that spatial derivatives are linearly (thus qualitatively) equivalent to temporal derivatives, linked via the powers of c as coefficients.

It explains, as the most famous example, why the behavior of magnetic flux dictates the strength of electromagnetic induction which affects the acceleration of charged particles. The flux, as a reflection of the number of sources of magnetism per unit area of the surface surrounded by the electric circuit in our consideration, which is equivalent to a second order spatial derivative (division by area) of the number of magnets, while the acceleration of charged particles in the circuit is a second order temporal derivative of their location. Hence, a second order spatial derivative decides the behavior of another second order temporal derivative.

A stable N-dimensional binary field shall contain $\propto R^N$ number of the spatial atoms, and therefore $\propto R^N$ number of symmetry breaks in compliance with cosmological principle. The flux of the number of symmetry breaks shall serve as the source for the "gravity" between them to refer to.

$$F \propto \frac{d^2R}{dT^2} \propto \frac{d(R^N)}{dR^2} \propto R^{N-2}$$

$$\frac{d^2R}{dT^2} \propto R^k$$

$$\rightarrow \quad \int \frac{dR}{dT} d\left(\frac{dR}{dT}\right) \propto \int R^k \, dR$$

$$\rightarrow \quad \frac{1}{2}\left(\frac{dR}{dT}\right)^2 \propto \begin{cases} \dfrac{R^{k+1}}{k+1} (k \neq -1) \\ \\ \ln R (k = -1) \end{cases}$$

When and only when k=1 (N=3), the differential equation in above is able to have a solution that complies with the cosmological principle of uniformity and isotropy of space. This is the very reason why there are just three stable spatial dimensions.

2. Origin of electromagnetism, charge and spin

As the largest possible hierarchy gap between the strength of electromagnetism and gravity, in the case of electron-electron interaction, the former is

$$\frac{k_0 e^2}{G m_e^2} = 4.16 \times 10^{42}$$

times stronger than the latter.

For the time being, let us take this hierarchy gap for granted (I will unveil the mechanism of it later), and see how the mass of electron and positron can be theoretically induced instead of being regarded as a god given value, which is nevertheless a great triumph compared with theories to date.

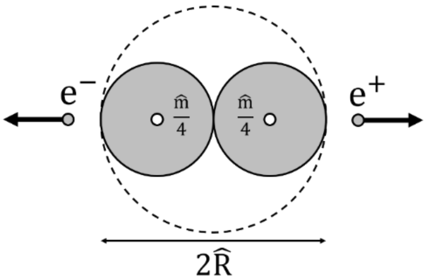
The aforementioned universal attraction between symmetry breaks as a positive feedback would culminate in an equilibrium in which two symmetry breaks are back to back, being confined within a sphere whose diameter is twice of the shortest length unit. Two symmetry breaks collectively have a mass which is 1/2 of the mini black hole (mass is inversely proportional to diameter), thus each shall weigh 1/4 of the black hole.

What if two tiny portions (with a mass of $\widetilde{m_e}$) out of each symmetry break have embodied all the electromagnetism into themselves and counteract with gravitational attraction?

The calculation in below suggests that electron and positron might be the fission products at the turning point where electromagnetic repulsion between the two embodiments overcomes the gravitational attraction between the two symmetry breaks.

$$\frac{G\left(\frac{\widehat{m}}{4}\right)^2}{\hat{R}^2} = \frac{4.16 \times 10^{42} G\widetilde{m_e}^{\,2}}{\hat{R}^2}$$

$$\widetilde{m_e} = \frac{\frac{\widehat{m}}{4}}{\sqrt{4.16 \times 10^{42}}} = 9.41 \times 10^{-31}[kg]$$



The reason why opposite charges repel each other in such a vicinity (otherwise there will be no pair production in which particle and anti-particle fly apart) is not due to the strong interaction. It is rather a purely electromagnetic phenomenon whose mechanism I will unveil later. Moreover, "fission" is not a rigorous expression but only a tentative image, which will be corrected later with its true mechanism.

Astonishingly, the subtle difference between $\widetilde{m_e}$ and the electron mass m_e can be adjusted by

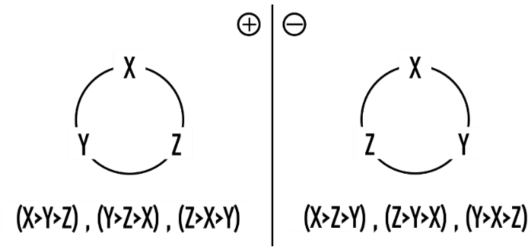
$$\widetilde{m_e} = \frac{m_e}{\sqrt{1 - \left(\frac{1}{4}\right)^2}}$$

$c/4$, as a special velocity, comes from below calculation regarding the two symmetry breaks as a "binary star system", circulating around each other.

$$\frac{G\frac{\widehat{m}}{4}}{\hat{R}^2} = \frac{v^2}{\hat{R}}$$

$$v = \sqrt{\frac{G\widehat{m}}{4\hat{R}}} = \sqrt{\frac{G\hbar}{8\hat{R}^2 c}} = \sqrt{\frac{G\hbar c^3}{16 G\hbar c}} = \frac{c}{4}$$

Electric charge is nothing but a vectorial property generated by this rotation. The existence of two heterogeneous cyclic permutations among three spatial dimensions makes electric charges binary.

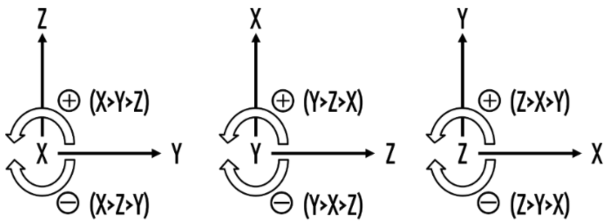


Write down the Λ function in the form of 4-dimensional space time as it should be.

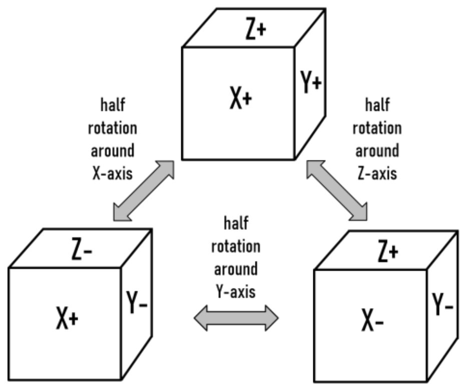
$$\Lambda(X, Y, Z, T) = (\Lambda_X, \Lambda_Y, \Lambda_Z)$$

$$\nabla \times \Lambda = \left(\frac{\partial \Lambda_Z}{\partial Y} - \frac{\partial \Lambda_Y}{\partial Z}, \frac{\partial \Lambda_X}{\partial Z} - \frac{\partial \Lambda_Z}{\partial X}, \frac{\partial \Lambda_Y}{\partial X} - \frac{\partial \Lambda_X}{\partial Y}\right)$$

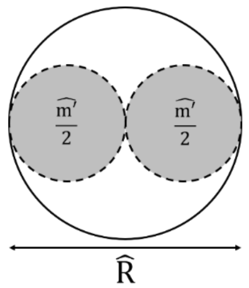
Electric charge is the rotation mode of $\nabla \times \Lambda$, while spin on each axis shall be defined by the mode of each component respectively, denoted as per below for example.



As an even clearer image of quantum spin, consider a cube rotating in 3-D space. It is not hard to find that when we combine three half rotations around all three axes, regardless of the order of manipulation and no matter they are clockwise or anti-clockwise, the final configuration is always identical to the initial one.



Half rotation corresponds to an inversion of two symmetry breaks. Clockwise/anti-clockwise are intuitive metaphors for the two distinct modes of rotation. Spin 1/2 means a combination of two rotations of the same mode and an opposite one, while spin 3/2 means that of three same mode rotations. Spin 1/2 is more stable than spin 3/2 by a similar logic with the superposition of waves. Integer spin Bosons are not made of two symmetry breaks, but a single symmetry break spinning at the speed of light, as if each half of it rotates around the other in a Schwarzschildian manner.



$$\widehat{m}' = \frac{\hbar}{\widehat{R}c}$$

$$\frac{2G\left(\frac{\widehat{m}'}{2}\right)}{\left(\frac{\widehat{R}}{2}\right)^2} = \frac{v^2}{\frac{\widehat{R}}{2}}$$

$$v = \sqrt{\frac{2G\widehat{m}'}{\widehat{R}}} = \sqrt{\frac{2G\hbar}{\widehat{R}^2 c}} = \sqrt{\frac{2G\hbar c^3}{2G\hbar c}} = c$$

3. Quantum entanglement

Having unveiled the entity of quantum spin, let me insert an interlude about quantum entanglement, a phenomenon that has embarrassed so many great physicists but is nonetheless serving as the foundation for quantum computing, cryptography and teleportation.

Apply Lorentz transformation to $\Lambda_0(R,T)$ as the characteristic wave function of a static particle in an inertial frame $K_0(R,T)$, to obtain wave function $\Lambda_{-v}(R',T')$ in another inertial frame $K_{-v}(R',T')$ which is moving at velocity $-v$ against K_0 such that the particle may look like moving at velocity v in the perspective of frame K_{-v}.

$$\begin{pmatrix} cT' \\ R' \end{pmatrix} = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \begin{pmatrix} 1 & \frac{v}{c} \\ \frac{v}{c} & 1 \end{pmatrix} \begin{pmatrix} cT \\ R \end{pmatrix}$$

$$\rightarrow \quad cT' - R' = \sqrt{\frac{c-v}{c+v}}(cT - R)$$

As two trivial projections between Λ_0 and Λ_{-v}

$$\Lambda_{-v}(0,T') \quad \Leftrightarrow \quad \Lambda_0(-vT,T)$$

$$cT' - 0 = \sqrt{\frac{c-v}{c+v}}(cT + vT)$$

$$\rightarrow \quad T' = T\sqrt{1-\left(\frac{v}{c}\right)^2}$$

and

$$\Lambda_{-v}(R',0) \quad \Leftrightarrow \quad \Lambda_0\left(R, -\frac{R}{v}\right)$$

$$0 - R' = \sqrt{\frac{c-v}{c+v}}\left(-\frac{c}{v}R - R\right)$$

$$\rightarrow \quad R' = R\sqrt{\left(\frac{c}{v}\right)^2 - 1}$$

Since the phase velocity of Λ_0 is c, thus Λ_{-v} should have a phase velocity of

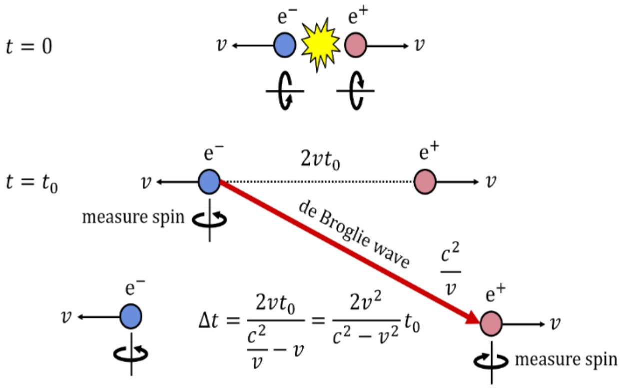
$$u = \frac{R'}{R}\frac{T}{T'}c = \sqrt{\left(\frac{c}{v}\right)^2 - 1} \times \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \times c = \frac{c^2}{v}$$

This is the induction of the superluminal phase velocity of de Broglie wave from the perspective of Λ function.

Quantum entanglement is nothing but a phenomenon that two or more particles occupy symmetric locations with respect to the origin of entanglement (the location of pair production or whatsoever), being characterized by a single wave function but in complementary phases to each other

or one another (recall that Λ may have isotypes depending on the sign of coefficients A and B).
Measurement inevitably involves some kind of interaction with its target and thus leaves indelible traces on its wave function. Interference on one of the entangled particles shall be transmitted to its counterpart(s) in the form of phase alteration, at phase velocity of course.

Consider a set of spin measurements on a pair of entangled electron and positron, carried out simultaneously from the perspective of their center of mass.



From the inertial frame moving together with electron, due to the relativity of simultaneity found by Einstein (the very person who called quantum entanglement a "spooky action"), the measurement of electron shall be prior to that of positron by a time difference exactly equals to Δt in the frame of mass center being further converted into the time in electron's frame.

$$\left(\frac{vt_0}{c-v} - \frac{vt_0}{c+v}\right)\sqrt{1-\left(\frac{v}{c}\right)^2}$$

$$= \frac{2v^2}{c^2 - v^2}\sqrt{1-\left(\frac{v}{c}\right)^2}\, t_0$$

The relativity of simultaneity leaves a window just enough for the superluminal transmission of phase alteration, which is true in the perspective of positron of course. Neither the measurer in electron's frame nor the one in positron's frame is able to tell whether the detected spin is interfered by the measurement of their counterpart or not. The measurer at mass center's frame has no way to circumvent the superluminal interaction either. Thus, "hidden parameter" does exist (phase of Λ function), but is truly hidden from us.

Furthermore, it can be proved by easy math that "simultaneous" measurements in all other frames moving asymmetrically with respect to the entangled particles will only leave a time gap more than enough for the superluminal interaction. In other words, disentanglement is strictly prohibited by the laws of physics. As quantum observables are subject to the Heisenberg's uncertainty, they are uncontrollable to the measurer, which assures that superluminal transmission of information is still impossible. Hereby, the underlying mechanism of quantum entanglement is perfectly explained, with both locality and realism remain intact.

4. Solution of hierarchy problems

Now the time is ripe to tackle the hierarchy gap between electromagnetism and gravity. Gravity takes energy and mass (scalars) as its source for reference, is a "scalar force", whereas electromagnetic force takes electric charges (vectors) as its source for reference, is a "vector force".

Therefore, it is reasonable to assume that gravity should be characterized by the stochasticity of spontaneous symmetry breaking (as an inherent property of space to generate energy and mass), while electromagnetic force should be characterized by the indivisible length unit (as electric charge is born out of the final equilibrium).

Their characteristic wave functions shall look like

$$\Lambda_G = \frac{\hbar}{c} L \, exp\left(\frac{cT - R}{L} i\right)$$

$$\Lambda_{EM} = \frac{\hbar}{c} \hat{R} \, exp\left(\frac{cT - R}{\hat{R}} i\right)$$

respectively, where L is the expectation of the length of symmetry break pair.

Since forces are spatial derivatives of energy,

$$E_G = \left|\frac{\partial^2 \Lambda_G}{\partial T^2}\right| = \frac{\hbar c}{L} \quad \rightarrow \quad F_G \propto \left|\frac{\partial^3 \Lambda_G}{\partial T^2 \partial R}\right| = \frac{\hbar c}{L^2}$$

$$E_{EM} = \left|\frac{\partial^2 \Lambda_{EM}}{\partial T^2}\right| = \frac{\hbar c}{\hat{R}} \quad \rightarrow \quad F_{EM} \propto \left|\frac{\partial^3 \Lambda_{EM}}{\partial T^2 \partial R}\right| = \frac{\hbar c}{\hat{R}^2}$$

If

$$\frac{L^2}{\hat{R}^2} = 4.16 \times 10^{42}$$
$$\rightarrow L = \sqrt{4.16 \times 10^{42}}\hat{R} = 4.65 \times 10^{-14}[\mathrm{m}]$$

the hierarchy gap can be perfectly explained.

As I will get back later, the mean lifetime of free neutron and the baryonic density in our universe collectively provide strong supports to the validity of this value of L.

Now that $\mathrm{E_G}$ is $6.77 \times 10^{-13}[\mathrm{J}]$, equivalent to a mass of $7.52 \times 10^{-30}[\mathrm{kg}]$ which is exactly $8\widetilde{m_e}$. This eight-fold relationship may seem trivial considering the calculations were

$$E_G = \frac{\hbar c}{\sqrt{4.16 \times 10^{42}}\hat{R}}$$
$$\rightarrow m_G = \frac{\hbar}{\sqrt{4.16 \times 10^{42}}\hat{R}c}$$

$$\widetilde{m_e} = \frac{\frac{\hat{m}}{4}}{\sqrt{4.16 \times 10^{42}}}$$
$$= \frac{\frac{\hbar}{8\hat{R}c}}{\sqrt{4.16 \times 10^{42}}} = \frac{\hbar}{8\sqrt{4.16 \times 10^{42}}\hat{R}c}$$

However, the equation presented in below may shed light to a much more profound secret of the relationship between electromagnetism and gravity.

$$\frac{k_0 e^2}{\left(\frac{\hbar}{2 \times 2\widetilde{m_e}c}\right)^2} = \frac{G m_e^2}{\left(2\hat{R}\right)^2}$$

It shows that electromagnetic repulsion between two unit charges of opposite signs at a distance correspondent to the energy required for a pair production of two "dynamic masses" (rest mass adjusted by Lorentz factor of $c/4$) always balances with gravitational attraction between the rest masses at a distance of $2\hat{R}$. It can be further simplified as

$$k_0 \left(\frac{e}{\sqrt{1-\left(\frac{1}{4}\right)^2}}\right)^2 = \frac{\hbar c}{128}$$

$$\Leftrightarrow \quad k_0 \left(\frac{8e}{\sqrt{1-\left(\frac{1}{4}\right)^2}}\right)^2 = \frac{\hbar c}{2}$$

$$\Leftrightarrow \quad \frac{1}{\sqrt{\varepsilon_0}} \left(\frac{8e}{\sqrt{1-\left(\frac{1}{4}\right)^2}}\right)^2 = \frac{h}{\sqrt{\mu_0}}$$

which implies that the interactions between Fermions are generally mediated via waves that are eight times energetic as the particles themselves (I will revisit this eight-fold relationship and unveil its origin later).

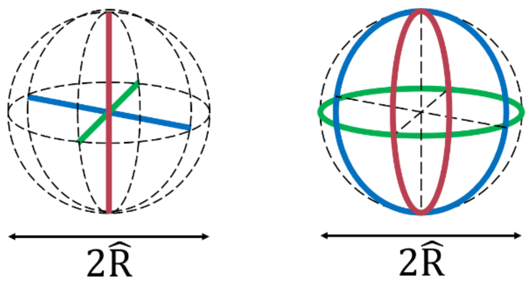
Note that by regarding gravity and electromagnetic force as third partial derivatives of the wave function Λ, it follows that the velocity of their transmission equals to the speed of light.

Proton has a mass about 1836 times of the electron mass. How comes this hierarchy gap (though much modest)? It is a well-known fact that

$$6\pi^5 \approx 1836$$

which hints that proton (hadrons in general) might be a "rigid body type" particle, while electron (leptons in general) might be a "mass point type" particle, which turns out to be exactly the case. Note that even for mass point type particles, $2\hat{R}$ serves as the shortest possible spatial expanse (there is no zero distance in reality) or the length of each degree of freedom.

Mass point type　　　　Rigid body type

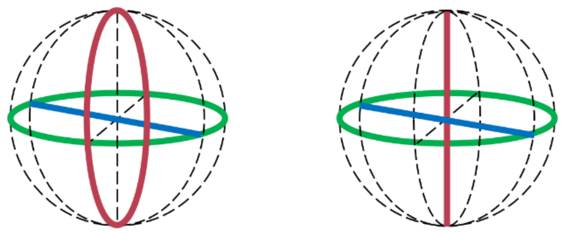


Revisit the equation in the previous chapter,

$$\frac{k_0 e^2}{\left(\frac{\hbar}{2\times 2\widetilde{m}_e c}\right)^2} = \frac{G m_e^2}{(2\hat{R})^2}$$

$$\rightarrow k_0 e^2 (2\hat{R})^2 = G m_e^2 \left(\frac{\hbar}{4\widetilde{m}_e c}\right)^2 = constant.$$

It implies that $k_0 e^2$ ("strength of electromagnetism" hereafter) is inversely proportional to the square of $2\hat{R}$, while e ("strength as electric charge" hereafter) is inversely proportional to $2\hat{R}$. In a 3-dimensional rigid body type particle, if one or two of the three dimensions (expanse $2\pi\hat{R}$) have transiently collapsed into mass point type (expanse $2\hat{R}$), the geometric mean of spatial expanse over three dimensions should be respectively (numbers are relative to that of electron)



1-dimension collapse　　　　2-dimension collapse

$$\sqrt[3]{\frac{(2\pi\hat{R})^2 2\hat{R}}{(2\hat{R})^3}} = \pi^{\frac{2}{3}} \qquad \sqrt[3]{\frac{2\pi\hat{R}(2\hat{R})^2}{(2\hat{R})^3}} = \pi^{\frac{1}{3}}$$

Therefore, the strength of electromagnetism (not the strength as electric charge, for a reason I will explain later) of the collapsed particles shall be inferior to that of electron by factors of

$$1/\left(\pi^{\frac{2}{3}}\right)^2 = 1/4.60 \qquad 1/\left(\pi^{\frac{1}{3}}\right)^2 = 1/2.15$$

Suppose the two symmetry breaks evenly contribute to the strength of electromagnetism of the particle they collectively define, then each one of them would have a strength of electromagnetism which is further inferior to that of electron by factors of $1/9.20$ and $1/4.30$ respectively.

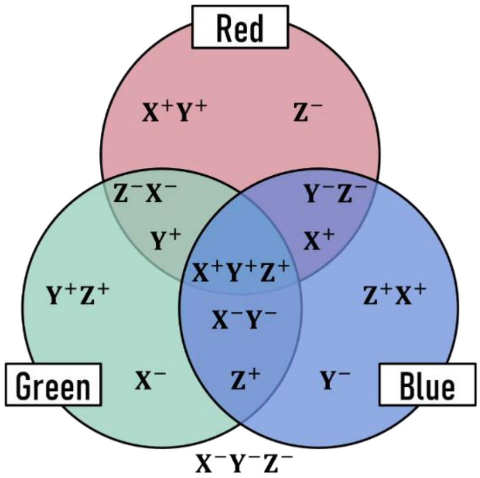
In the aforementioned fission, a less efficient embodiment of electromagnetism would need larger mass to collect enough repulsion that overcomes gravitational attraction. Therefore, the theoretical mass of a single symmetry break in these collapsed particles shall be 9.20 and 4.30 times of the electron mass respectively, which are exactly the theoretical mass of down quark and up quark.

Calculations so far undoubtedly suggest that the entity of quark is one of the two symmetry breaks within a partially collapsed hadron in high energy collision, which interacts with one of the two symmetry breaks within the incoming lepton and let it scatter. Quark only appears transiently as a single symmetry break in a collapsed hadron together with its counterpart, which does not make sense outside of hadrons, thus cannot independently exist. This is the secret of quark confinement.

If one dimension has collapsed, the transient state would have electric charge $\pm 1/3$, reflecting the fact that one out of three dimensions is mass point type (electron type), if two have collapsed, the charge would be $\pm 2/3$ accordingly. Signs of charge depend on the mode of collapsed dimension(s).

Down quarks (one dimension collapsed) have a larger geometric mean of spatial expanse over three dimensions compared to up quarks (two dimensions collapsed), which explains why nucleons have their respective charge radius and why it is larger than the mass radius (superposition of mass does not offset as that of electric charge).

Color charge of quark is a reflection of the details of collapsed dimension(s) as per below schematic figure and tables for an example.



Proton ($X^+Y^+Z^+$)

	RED	GREEN	BLUE
uud	X^+Y^+	Y^+Z^+	Y^-
udu	X^+Y^+	X^-	Z^+X^+
duu	Z^-	Y^+Z^+	Z^+X^+

Neutron ($X^0Y^0Z^0$)

	RED	GREEN	BLUE
udd	X^+Y^+	X^-	Y^-
dud	Z^-	Y^+Z^+	Y^-
ddu	Z^-	X^-	Z^+X^+

Anti-proton ($X^-Y^-Z^-$)

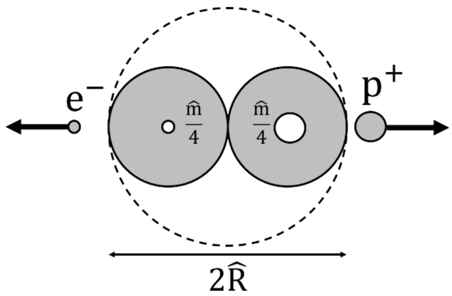
	CYAN	MAGENTA	YELLOW
$\overline{uud}$	X^-Y^-	Y^-Z^-	Y^+
$\overline{udu}$	X^-Y^-	X^+	Z^-X^-
$\overline{duu}$	Z^+	Y^-Z^-	Z^-X^-

Anti-neutron ($X^0Y^0Z^0$)

	CYAN	MAGENTA	YELLOW
$\overline{udd}$	X^-Y^-	X^+	Y^+
$\overline{dud}$	Z^+	Y^-Z^-	Y^+
$\overline{ddu}$	Z^+	X^+	Z^-X^-

Out of the $6\pi^5$, proton as a genuine rigid body type particle, shall be an inferior embodiment of electromagnetism than electron by a factor of $1/\pi^2$ (all three dimensions are rigid body type). The remaining $1/6\pi^3$ may be a factor reflecting the qualitative leap from mass point to rigid body. In other words, the logic in our calculation of theoretical mass of up quark and down quark may only apply for particles that have at least one mass point type dimension. Although its mechanism needs to be further elucidated, the assumption sounds quite reasonable since 6 is the degree of freedom in 3-dimensional space, while π^3 is the ratio of effective volume (the product of spatial expanses over all three dimensions) between rigid body type and mass point type particles. It is interesting that the theoretical mass of strange quark is about 186 times of the electron mass, 186 is a good approximation of $6\pi^3$.

If the rigid body type proton is indeed an inferior carrier of electromagnetism compared to electron by a factor of $1/1836$ or $1/6\pi^5$, it can be generated by fission similar to the pair production of electron and positron, with a mass that is 1836 times as heavy as electron.



Some readers may have wondered how such a lump of mass defined by two symmetry breaks can break apart to form two Fermions which theoretically require four symmetry breaks in total.

Good questions always lead us to great discoveries. It is clear that such a fission can take place only when there are two additional symmetry breaks occurring next to a stand-by state, which is a stochastic process. The stand-by particle is nothing but neutron (or anti-neutron), and the fission is β decay. We may further notice that it cannot be the case that a tiny portion of mass spinning off from a symmetry break as per the schematic illustrations so far, but should instead be a loss of mass in return for the acquisition of electromagnetism by rotation. It is actually the aforementioned universal attraction between symmetry breaks (similar to gravity but not exactly the one in our conventional sense) that electromagnetism has to overcome.

As mentioned earlier, the mean lifetime of free neutron can be calculated from the stochasticity of spontaneous symmetry breaking in the binary field. Recall that I have assumed the expectation of the length of symmetry break pair to be

$$L = \sqrt{4.16 \times 10^{42}}\hat{R} = 2.04 \times 10^{21}\hat{R}$$

in order to solve the hierarchy gap between electromagnetism and gravity. It means that there will be one symmetry break in every 2.04×10^{21} spatial atoms on average, or in other words, the probability of each spatial atom to take "1" instead of "0" is $1/2.04 \times 10^{21}$. In the framework of spontaneous symmetry breaking, time can be converted to a correspondent length via the light speed.

Now it cannot be a coincidence that

$$\frac{\frac{\pi}{2}\frac{m_n}{\widetilde{m}}\hat{R}}{887c} \approx \left(\frac{1}{2.04 \times 10^{21}}\right)^2$$

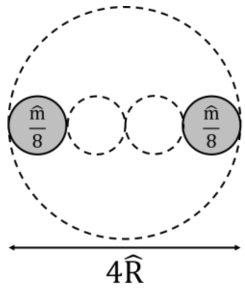
$887[s]$ is the mean lifetime of free neutron measured by the beam method, while m_n is the rest mass of neutron. Another interesting fact is that $880[s]$, the mean lifetime of neutron measured by the bottle method, can be linked with $887[s]$ by the Lorentz factor of $c/8$.

$$\frac{887}{880} \approx \frac{1}{\sqrt{1-\left(\frac{1}{8}\right)^2}}$$

$c/8$ is the velocity when two symmetry breaks circulate at the equator of a sphere whose diameter is four times of the indivisible length unit.

$$\frac{G\frac{\widehat{m}}{8}}{(2\hat{R})^2} = \frac{v^2}{2\hat{R}}$$

$$\rightarrow v = \sqrt{\frac{G\widehat{m}}{16\hat{R}}} = \sqrt{\frac{G\hbar}{32\hat{R}^2 c}} = \sqrt{\frac{G\hbar c^3}{64G\hbar c}} = \frac{c}{8}$$



These calculations strongly suggest that the mean lifetime of free neutron is correlated with the probability that two additional symmetry breaks stochastically occur next to the stand-by state.

The left side of the equation is to calculate the ratio between an adjusted spatial expanse and the distance correspondent to the mean lifetime of neutron. The physical meaning of the coefficients $\pi / 2$ and $m_n / \widetilde{m}$ in front of $\hat{R}$ remains to be studied (the former is equivalent to a conversion from diameter to half circumference), however, they are far from random arbitrary numbers, thus sound meaningful.

Note that the bottle method focuses on undecayed neutrons (without two additional symmetry breaks) while the beam method counts decayed ones (with the two symmetry breaks, thus diameter $4\hat{R}$). The Lorentz factor of $c/8$ suggests that m_n may indeed be a dynamic mass of neutron, instead of its rest mass.

In this context, the release of anti-neutrino in β^- decay, which is equivalent to an absorption of neutrino by neutron, might be exactly the additional pair of symmetry breaks that triggers the decay. The entity of neutrino might be a transition state in which two symmetry breaks are rotating around and approaching to each other due to the universal attraction between them, and the binary modes of heterogeneous rotation in 3-D space may correspond to neutrino and anti-neutrino.

Imagine a point circulating on an inclined orbit whose center overlaps with the origin of a Cartesian coordinate system. The distance from the point to each axis shall change periodically according to its coordinate (x, y, z), making it possible to define a predominant axis of rotation at every moment. If the rotation around x, y and z axis differ with one another by their nature, there could be three different modes of theoretical mass accordingly. The mass of neutrino should be realized as a superposition of the three modes with respective weights, changing periodically as the imaginary point circulates on the orbit, which is a possible explanation for the mechanism of neutrino oscillation.

Since the distance between two symmetry breaks shall be shrinking during the rotation, and mass is inversely proportional to the distance, this transition hypothesis may explain why it is difficult to determine the exact figures of neutrino mass, while only the differences among generations seem to be conserved. The fact that neutrinos do not have electric charge might be a reflection that the rotation velocity of the two symmetry breaks is always slower than $c/4$ in the process of shrinking, thus unable to form a stable electric charge that only comes out from the final equilibrium.

The revelation of the entity of neutron and the mechanism of β decay may shed light to the origin of the asymmetry of matter/anti-matter abundance in our universe. Since proton/anti-proton and neutron/anti-neutron pair productions are mainly observed in high energy collisions so far, way rarer than β^- or β^+ decay, nucleons and anti-nucleons should be generated overwhelmingly by β decays than by pair productions.

Assume that stable neutrons in atomic nuclei are all generated from protons by β^+ decay at some point in the past, while every newborn stand-by particle as a candidate of neutron or anti-neutron is inherently neutral. After N rounds of such Bernoulli trial, a deviation in favor of one side over the other with a magnitude of root N shall be mathematically expected. The surplus particles cannot find their partners for annihilation. Therefore, the overwhelmingly abundance of matter in our universe could be a purely probabilistic outcome. In this sense, our definition of "matter" and "anti-matter" could be totally arbitrary.

5. Quantum gravity

Being inspired by the thought experiment of freefalling elevator, let us consider the behavior of light in a flat and homogeneous space filled with the critical mass density ρ. It is a good approximation of our universe whose extreme flatness (in the large scale) is strongly supported by observations.

Set the observer as standard point with zero gravity, the relative strength of gravitational field in such a spherically symmetrical environment is an increasing function of distance R.

$$\frac{G\frac{4}{3}\pi R^3\rho}{R^2} = \frac{4\pi G\rho}{3}R$$

As an observational fact, light in a gravitational field bends toward the stronger side of it with an angle (thus gravitational acceleration) twice of Fermion's. Therefore, the trajectory of a horizontal light beam would have a centrifugal curvature in the eyes of the observer.

$$\frac{d^2R}{dt^2} = \frac{8\pi G\rho}{3}R$$

Emphasizing that gravitational lensing is nowadays rather an observational fact was to remind the readers that the triumph by the general relativity to have successfully predicted the phenomenon before its observation does not guarantee that regarding gravity as the expression of space-time curvature is the only feasible and correct approach. As far as the predictions of an alternative mathematical model do not contradict with all relativistic phenomena, we have no reason to dismiss it as false or inferior to the general relativity.

Moreover, its deep-rooted incompatibility with the quantum mechanical view of the world implies that the general relativity might be at best a fine approximation of a better theory. It may function well enough in macro scale but cannot be an almighty approach that leads us to the truth of gravity.

One the other hand, light running toward the observer would be subject to a reciprocal gravitational redshift. Reciprocal means the redshift is universal to every set of light source and observer, or in other words, light passing through a space filled with a certain mass density consistently reaches to distant observers with a longer wave length.

$$1 + z = \frac{1}{\sqrt{1 - \frac{2GM}{c^2 R}}}$$
$$= \frac{1}{\sqrt{1 - \frac{8\pi G\rho}{3}\frac{R^2}{c^2}}} = \frac{1}{\sqrt{1 - \left(\frac{HR}{c}\right)^2}}$$

We may notice that the implication from the former of our thought experiments is an equivalent formulation of the Friedmann equations for a flat universe (k=0), if we regard the bending of light as the very expression of space expansion or contraction.

$$H^2 = \left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G\rho}{3} - \frac{kc^2}{a^2}$$

In this context, the so-called universal gravitation should be re-interpreted as a universal repulsion between Fermions (one unit, motion against space) being overwhelmed by a contraction of space (two units, dynamics of space itself) so that a centripetal acceleration (one unit) will be perceived as the net result. The contraction of space, as the dominant factor which dictates the nature of gravity, is rather a consequence of symmetry breaking in the spatial mass distribution.

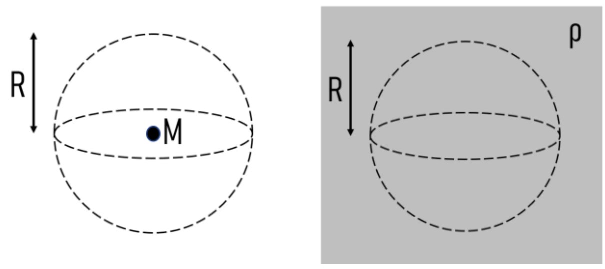
As a simple fact that has been overlooked for decades, what the Friedmann equations describe is rather the dynamics of space, not the net motion of celestial bodies. In a space with homogeneous mass distribution, such a linear relationship between recession velocity and distance is incompatible with relativistic velocity addition in the first place. An additional motion of Fermions against space is rather necessarily requested.

For spherically symmetric mass distributions, we may notice that the alternative model described in below is mostly equivalent to the Riemann geometry in the general relativity, more specifically the Schwarzschild metric and the Robertson-Walker metric in centralized and homogeneous distribution respectively. (Not exactly equivalent, because it is an approximated version in which gravity is not as a third derivative of Λ, thus can instantly affect its target.)

Firstly, define mass flux as

$$F(R) = \frac{Enclosed\ mass\ in\ sphere\ of\ radius\ R}{4\pi R^2}$$

Space expansion or contraction occur in the direction that can maximize $F(R)$ with an acceleration of $8\pi GF(R)$, while motion of Fermions against space is universally repulsive with acceleration $4\pi GF(R)$. The two accelerations shall be further added according to the special relativity, to obtain a proper acceleration.



	Centralized	Homogeneous
F(R)	$\frac{M}{4\pi R^2} \propto R^{-2}$	$\frac{\rho}{3} R \propto R^1$
$\frac{dF}{dR}$	$-\frac{M}{2\pi R^3} < 0$	$\frac{\rho}{3} > 0$
Space stretch	$-\frac{2GM}{R^2}$	$\frac{8\pi G\rho}{3} R$
Motion in space	$\frac{GM}{R^2}$	$\frac{4\pi G\rho}{3} R$

As a better approximation of the reality, for a hybridized distribution where a mass core M is surrounded by thin and homogeneous mass density ρ, there should be a critical radius such that

$$\frac{dF(R_c)}{dR} = 0 \quad \rightarrow \quad R_c = \sqrt[3]{\frac{3M}{2\pi\rho}}$$

It is a striking implication that gravity may change its direction from attractive (R < Rc) to repulsive (R > Rc). The repulsive gravity could be a driver to form the large-scale structure in our universe, much larger than theoretical predictions only assuming positive feedback by attractive gravity.

Discussions so far suggest that the light from distant stars should be subject to redshift of three types.

1) Cosmological redshift

$$\frac{d^2R}{dt^2} = \frac{8\pi G\rho}{3} R = H^2 R \quad \rightarrow \quad R = R_0 e^{Ht}$$

$$v_0 = \frac{dR}{dt} = HR_0 = \sqrt{\frac{8\pi G\rho}{3}} R_0$$

Let $\phi(t)$ be the proportion out of the initial comoving distance being covered by the star light, then it can be expressed as an integral as below,

$$\phi(t) = \int_0^t \frac{c}{R_0\, exp(H\tau)} d\tau = \frac{c}{HR_0}\left(1 - \frac{1}{e^{Ht}}\right)$$

When the light reaches us,

$$\phi(T) = 1 \quad \rightarrow \quad T = -\frac{ln\left(1 - \frac{HR_0}{c}\right)}{H}$$

$$1 + z = \frac{a_T}{a_0} = \frac{R_0 e^{HT}}{R_0} = e^{-ln\left(1 - \frac{HR_0}{c}\right)}$$

$$= \frac{1}{1 - \frac{HR_0}{c}} \approx 1 + \frac{HR_0}{c} = 1 + \frac{v_0}{c}$$

2) Doppler redshift

$$u_0 = H' R_0 = \sqrt{\frac{4\pi G\rho}{3}} R_0 = \frac{v_0}{\sqrt{2}}$$

$$1 + z = \sqrt{\frac{1 + \frac{u_0}{c}}{1 - \frac{u_0}{c}}} \approx 1 + \frac{u_0}{c} = 1 + \frac{1}{\sqrt{2}}\frac{v_0}{c}$$

3) Gravitational redshift

$$1 + z = \frac{1}{\sqrt{1 - \left(\frac{HR_0}{c}\right)^2}} = \frac{1}{\sqrt{1 - \left(\frac{v_0}{c}\right)^2}} \approx 1 + \frac{1}{2}\left(\frac{v_0}{c}\right)^2$$

Taken together.

$$1 + z \approx \left(1 + \frac{v_0}{c}\right)\left(1 + \frac{1}{\sqrt{2}}\frac{v_0}{c}\right)\left\{1 + \frac{1}{2}\left(\frac{v_0}{c}\right)^2\right\}$$
$$\approx 1 + \left(1 + \frac{1}{\sqrt{2}}\right)\frac{v_0}{c} \approx 1 + \frac{\sqrt{3}v_0}{c}$$

Since the Hubble's constant is proportional to the square root of mass density, the root 3 in above is exactly the reason why there seems to be roughly three times of total energy while we can only detect one (visible matter plus dark matter).

Dark energy might be an illusion due to mis-interpretation of redshift by the Λ CDM model (overlook of the Doppler redshift). The striking mechanism of the accelerating expansion of our universe will be unveiled later.

The denial of dark energy inevitably urges us a revision of the CMB as well. For radiations from the vicinity of our cosmological event horizon,

$$v_0 \approx c \quad \rightarrow \quad u_0 \approx \frac{c}{\sqrt{2}}$$

$$1 + z = \sqrt{\frac{1 + \frac{1}{\sqrt{2}}}{1 - \frac{1}{\sqrt{2}}}} \frac{1}{1 - \frac{v_0}{c}} \frac{1}{\sqrt{1 - \left(\frac{v_0}{c}\right)^2}}$$

$$z \approx 10^3 \rightarrow v_0 \approx 0.985c$$

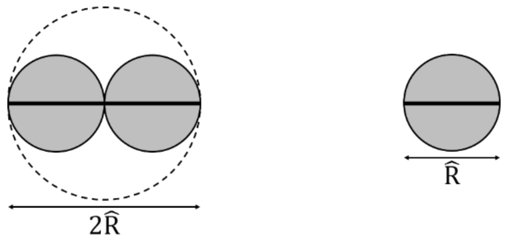
$$\frac{a_T}{a_0} = \frac{1}{1 - \frac{v_0}{c}} \approx 67 \rightarrow T_0 \approx 2.725 \times 67 \approx 183[K]$$

It suggests a possibility that CMB might be a relic of radiation whose average temperature at emission was roughly minus 90 degree Celsius. It is interesting that the inverse cube of scale factor ratio settles to the same order with CMB anisotropy.

$$10^5 < \left(\frac{a_T}{a_0}\right)^3 \approx 3 \times 10^5 < 10^6$$

I will revisit this issue at the end of my thesis.

To further investigate the eight-fold energetic wave that mediates the interactions between Fermions, I have invented a concept of "extreme line density" for both Fermions and Bosons as per below.



$$m = \frac{\hbar}{4\hat{R}c} = \frac{\hbar}{4\sqrt{2}l_P c} = \frac{m_P}{4\sqrt{2}} \qquad E = \frac{\hbar c}{\hat{R}} = \frac{\hbar c}{\sqrt{2}l_P} = \frac{E_P}{\sqrt{2}}$$

$$\rho_F = \frac{m}{2\hat{R}} = \frac{\frac{m_P}{4\sqrt{2}}}{2\sqrt{2}l_P} = \frac{m_P}{16 l_P} \qquad \rho_B = \frac{\frac{E}{c^2}}{\hat{R}} = \frac{\frac{m_P}{\sqrt{2}}}{\sqrt{2}l_P} = \frac{m_P}{2 l_P}$$

Recall that the mutual recession of Fermions can be formulated with an alternative Hubble's constant

$$H' = \sqrt{\frac{4\pi G\rho}{3}}$$

Suppose the extreme line density of Boson is seamlessly spread along Hubble diameter, we may surprisingly notice that the dilution of this energy into the entire Hubble volume always results in the hypothesized ρ in our calculation of H'.

$$\frac{2\frac{c}{H'}\rho_B}{\frac{4}{3}\pi\left(\frac{c}{H'}\right)^3} = \frac{2\rho_B}{\frac{4}{3}\pi\left(\frac{c}{H'}\right)^2} = \frac{2\frac{m_P}{2l_P}}{\frac{4}{3}\pi\frac{3c^2}{4\pi G\rho}} = \frac{\frac{c^2}{G}}{\frac{c^2}{G\rho}} = \rho$$

It indicates that the universal repulsion between Fermions is a homeostasis to maintain the extreme line density ρ_B along the Hubble diameter.

Furthermore, this law of dilution implies that for a region that is macroscopic enough, the enclosed mass and energy should be proportional to its diameter instead of volume. It is consistent with the fact that energy, by definition, can be alternatively expressed as a flux of a linear amount (proportional to radius) penetrating a spherical surface.

$$E = \frac{\hbar c}{2R} = \frac{hc}{4\pi R} = \frac{hcR}{4\pi R^2}$$

The calculation in below exactly explains the anomaly found in the rotation velocity of galactic arms.

$$\frac{v^2}{R} = \frac{d^2R}{dt^2} \propto F(R) \propto \frac{2R}{4\pi R^2} \propto \frac{1}{R}$$

Discussions so far strongly suggest that dark matter is indeed the energy of Λ wave function which accompanies its correspondent Fermion. Dark matter and visible matter collectively have a total energy that is eight times as massive as the latter.

Rewrite G with Planck units and c,

$$G = \frac{c^2 l_P}{m_P}$$

Gravitational acceleration of Fermions (motion against space) and Bosons (dynamics of space) proposed in my alternative model for gravity can be revised as

$$G_F = \frac{Gm}{R^2} = \frac{\frac{c^2 l_P}{m_P}m}{R^2} = \frac{m \,/\, \frac{m_P}{16 l_P}}{R^2 \,/\, \frac{c^2}{16}} = \frac{m \,/\, \rho_F}{\left(R \,/\, \frac{c}{4}\right)^2}$$

$$G_B = -\frac{2Gm}{R^2} = -\frac{mc^2 / \frac{m_P c^2}{2 l_P}}{R^2/c^2}$$

$$= -\frac{E/\tilde{\rho}_B}{(R/c)^2} \qquad (\tilde{\rho}_B = c^2\rho_B)$$

Gravity is a synergistic phenomenon as a sum of the motion of Fermion and the dynamics of space (accelerations to be added in a relativistic manner). The former is universally repulsive, while the latter is universally attractive. The implications are quite clear. Fermions take the source of gravity in the form of mass. Translate the mass into its correspondent length with the extreme line density of Fermions, while convert the distance to its correspondent time with $c/4$ as the special velocity for Fermions, then divide the former by the square of the latter, which is just in compliance with the dimension of acceleration. For Bosons, just substitute "energy" for "mass" in above sentence, and use c instead of $c/4$. The global expansion of space (contraction only occurs locally) is a necessary outcome of spontaneous symmetry breaking in the binary field, while the repulsion between Fermions is a homeostasis to maintain a constant line density of energy along Hubble's diameter.

Distance can only be in multiples of the indivisible length unit (except zero), the updated formulation of gravity is a discrete version, thus compatible with quantum mechanics. The Riemann geometry is a mathematical tool rightly suitable for the calculation of gravitational phenomenon as a collective sum of countless numbers of the aforementioned synergistic actions. It functions well enough in describing phenomena in macro scale where the intrinsic discreteness of nature is mostly smoothed out. However, for gravity between two or among just a few elementary particles, it is rather simple math (somehow Newtonian) that actually works.

It is no coincidence that the general solutions for Fermions and Bosons can be rewritten with their respective quantized angular momentum and special velocity as below.

$$\begin{aligned} \Lambda_F(R,T) &= \frac{\hbar}{c} 2R_F\, exp\left(\frac{cT-R}{2R_F} i\right) \\ &= \frac{\hbar}{2} \frac{R_F}{\frac{c}{4}} exp\left(\frac{cT-R}{2R_F} i\right) \end{aligned}$$

$$\begin{aligned} \Lambda_B(R,T) &= \frac{\hbar}{c} R_B\, exp\left(\frac{cT-R}{R_B} i\right) \\ &= \hbar \frac{R_B}{c} exp\left(\frac{cT-R}{R_B} i\right) \end{aligned}$$

In the newly proposed framework of spontaneous breaking of spatial symmetry, quantization of angular momentum is no longer mysterious at all. The mass of a particle can be defined in an inversely proportional manner with its virtual diameter (thus radius), while the rotation speed of symmetry breaks that define the particle is always $c/4$ for Fermions and c for Bosons. Therefore, angular momentum, as the product of mass and radius and velocity, shall naturally be conserved among particles of the same category.

It is also noteworthy that the temporal periodicity of Λ function that defines a Fermion with mass $\tilde{M}$ and virtual diameter $\tilde{R}$ can be rewritten in the form as below.

$$\frac{1}{\nu} = \frac{2\pi}{Bc} = \frac{4\pi\tilde{R}}{c} = \frac{\pi\tilde{R}}{c/4}$$

In classical mechanics, the velocity of wave can be calculated from the tension and line density of its medium.

$$v = \sqrt{\frac{T}{\rho}}$$

Substitute

$$v = c$$

$$\rho = \rho_B = \frac{c^2}{2G}$$

then

$$T = \frac{c^4}{2G} = 6.07 \times 10^{43} [kg \cdot m\, /\, s^2]$$

As an extension of our Schwarzschildian equation of motion for the imaginary binary star system within

Bosons, the gravitational pull within a single symmetry break as the extreme case should be

$$\widehat{m}' = \frac{\hbar}{\widehat{R}c}$$

$$\frac{2G\left(\frac{\widehat{m}'}{2}\right)^2}{\left(\frac{\widehat{R}}{2}\right)^2} = \frac{2G\widehat{m}'^2}{\widehat{R}^2} = \frac{2G\hbar^2}{\widehat{R}^4 c^2} = \frac{2G\hbar^2}{\frac{4G^2\hbar^2}{c^6}c^2} = \frac{c^4}{2G} = T$$

On the other hand, in our arguments to tackle the hierarchy gap between electromagnetism and gravity, we have supposed that the magnitude of electromagnetism should be governed by

$$F_{EM} \propto \left|\frac{\partial^3 \Lambda_F}{\partial R^2 \partial T}\right| = \frac{\hbar c}{\widehat{R}^2} = \frac{\hbar c}{\frac{2G\hbar}{c^3}} = \frac{c^4}{2G} = T$$

These calculations collectively imply that the space can be alternatively regarded as a fabric in which each spatial atom has an intrinsic tension of T.

Lastly, let me present two calculations that will be revisited later with profound implications.

$$\frac{G\left(\frac{\widehat{m}'}{2}\right)^2}{\widehat{R}^2} = \frac{1}{8} \times \frac{2G\left(\frac{\widehat{m}'}{2}\right)^2}{\left(\frac{\widehat{R}}{2}\right)^2} = \frac{1}{8}T$$

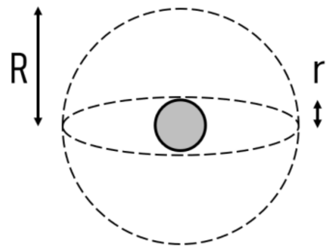
$$\frac{k_0 e^2}{\widehat{R}^2} = \frac{\left\{1-\left(\frac{1}{4}\right)^2\right\}\frac{\hbar c}{128}}{\frac{2G\hbar}{c^3}} = \frac{15}{16}\frac{1}{128}\frac{c^4}{2G} = \frac{15}{2048}T$$

6. Super unification of fundamental interactions

Apply the flux model to electromagnetism (of course its underlying mechanism is line density homeostasis as well, but practically this mathematical model gives precise result for spherically symmetric distributions), in a case where an idealized "charge core" with homogeneous charge density is surrounded by a virtually vacant space. We have to keep in mind that there are two differences with gravity.

1) No homeostatic mechanism by the dynamics of space, since the total charge is structurally conserved at zero (unlike the positive density of mass and energy being spontaneously generated out of nothing). Charge density shall quickly converge to zero as radius increases.

2) Interaction between charges should be sign-dependent, instead of universally repulsive or attractive.



$$F(R) = \begin{cases} \frac{|\rho|}{3}R & (R \le r) \\ \frac{|\rho|}{3}\frac{r^3}{R^2} & (R > r) \end{cases}$$

$$\frac{dF(R)}{dR} = \begin{cases} \frac{|\rho|}{3} > 0 (R \le r) \\ -\frac{2|\rho|}{3}\frac{r^3}{R^3} (R > r) \end{cases}$$

Similar to the critical radius in gravity, the radius of charge core ($|\rho| > 0$) serves as the watershed where electromagnetism changes its direction from conventional one to the contrary, which is nothing but the direction of strong interaction. As predicted by flux model, the attraction between charges of the same sign (and the repulsion between opposite charges) within the charge core shall be proportional to distance, a feature that can be found again in strong interaction, namely the asymptotic freedom. The idealized charge core is nothing but an approximation of atomic nucleus. Therefore, our conventional understanding of electromagnetic force is just one side of electromagnetism, and strong interaction is the other.

If the strong interaction is just a hidden aspect of electromagnetism and quarks do not really exist, then how come the various exotic baryons and mesons?

As the most widely used particle in collision experiments to produce exotic hadrons, let us denote the dynamic mass of proton as

$$\dot{m} = \frac{m_p}{\sqrt{1-\left(\frac{1}{4}\right)^2}} \approx 969[MeV\ /\ c^2]$$

A periodic table for the 16 baryons composed of u/d/s quarks (except proton and neutron) shockingly shows up in front of us.

$\sqrt[3]{1.5}\dot{m} \approx 1109 \ \rightarrow\ \Lambda^0\ (1116)$

$\sqrt[3]{2.5}\dot{m} \approx 1315 \ \rightarrow\ \Xi^0, \Xi^-\ (1315\sim1322)$

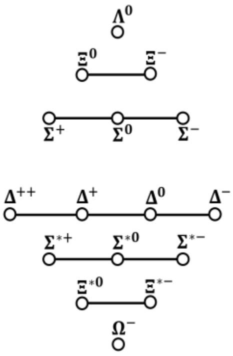
$\sqrt{1.5}\dot{m} \approx 1187 \ \rightarrow\ \Sigma^+, \Sigma^0, \Sigma^-\ (1189\sim1197)$

$\sqrt[3]{2}\dot{m} \approx 1221 \ \rightarrow\ \Delta^{++}, \Delta^+, \Delta^0, \Delta^-\ (1232)$

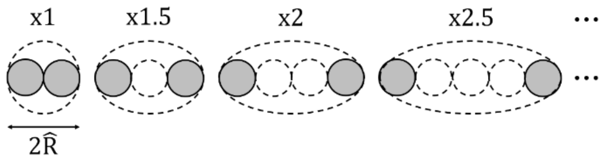
$\sqrt[3]{3}\dot{m} \approx 1398 \ \rightarrow\ \Sigma^{*+}, \Sigma^{*0}, \Sigma^{*-}\ (1383\sim1387)$

$\sqrt[3]{4}\dot{m} \approx 1538 \ \rightarrow\ \Xi^{*0}, \Xi^{*-}\ (1532\sim1535)$

$\sqrt[3]{5}\dot{m} \approx 1657 \ \rightarrow\ \Omega^-\ (1672)$



It is strongly suggested that exotic baryons are transient figures of nucleons in high energy collision, expanding one of the three dimensions in a discrete manner. Compared with proton, the strength as electric charge (not the strength of electromagnetism) of each excitation state shall be inversely proportional to their effective diameter, which can be calculated by equally distributing the enlarged volume into three dimensions, thus cubic roots of half-integers and integers. (The only square root that gives rise to sigma baryons might be a rare case in which one of the dimensions has collapsed first, then the 2-dimensional "disk" expands one of the two remaining dimensions.)



Exotic baryon, though very short-lived, is nonetheless composed of a symmetry break pair, thus is a genuine Fermion as carrier of electric charge. Whereas in inelastic scattering, both electron and collapsed nucleon behave as massive (energetic) particles, therefore the magnitude of scattering shall be understandably determined by the strength of electromagnetism confined within those particles, instead of their electric charge. This is the reason why theoretical mass of quark is decided by its strength of electromagnetism while that of exotic baryon is dictated by its strength as electric charge. In our definition, the strength of electromagnetism is proportional to the square of the strength as electric charge, which is consistent with the experimental fact that the cross section of electron scattering by nucleons is proportional to the square sum of quark's fractional charge.

The reason why cubic roots of integers correspond to spin 3/2 baryons while cubic roots of half-integers give rise to spin 1/2 baryons may have something to do with the fact that the former group are multiples of $2\hat{R}$, which may render the baryons an additional integral spin by a mechanism that awaits further study.

As for why there are certain errors, though very slight, between the experimental data of baryon masses and my calculation, the main contributor should be disturbances from some minor factors I have not considered at this stage.

Another possible contributor to the error could be the intrinsic discreteness of nature. Just like there is no infinitesimal in reality, irrational number shall also be a notion that is limited in the mathematical and imaginary world. Thus, theoretical calculation such as "root two times of proton mass" shall inevitably deviate from actual measurement.

Moreover, it is interesting that the mass of baryons of c quark substitution and b quark substitution series are generally and roughly twice and five times as heavy as their counterparts that are supposed to be made of u/d/s quarks.

It indicates that nucleons may have three different modes to expand its spatial dimension in high energy collision. One possible explanation could be that, compared with the first mode of expansion that gives rise to the baryons supposed to be made of u/d/s quarks, the second and third mode might result in much weaker carrier of electric charge by factors of $\sim 1/8$ and $\sim 1/125$ respectively, which may in turn generate baryons that are twice and five times as massive as those in the basic series.

The $\sim 1/8$ and $\sim 1/125$ might be actually $1/8$ and $15/2048$ (recall the calculations in the end of the last chapter) from aesthetic point of view, which implies that the first mode of expansion may be related with the universal gravitation between symmetry breaks, while the second and third mode may have something to do with gravity (conventional) and electromagnetism respectively.

It is profoundly interesting that the mass of Higgs Boson, $125[GeV / c^2]$ is roughly 128 times of $969[MeV / c^2]$, the dynamic mass of proton. Recall that $15/2048$ was $1/128$ before the refinement by $15/16$. What shall the $1/128$ mean? I believe that the discussions so far should have cast a great doubt on the Higgs mechanism in which the God particle renders mass to others.

To summarize the conclusions, quark is one of the two symmetry breaks that make up a partially collapsed nucleon in which one or two of the three dimensions have shrunk from rigid body type to mass point type degree of freedom. Gluons are thus the energy exchanged in transitions among different collapse states. Exotic baryons are transient expansion of nucleons in one of the three dimensions, mesons are the energy exchanged during transition among different expansion states. The dazzling patterns of cascade in hadron decay are nothing but reflections of probable transitions among those states, which should be explained in the framework of my theory without problem.

Let me add some comments about weak interaction. It is interesting that all the basic symmetries violated in weak interaction involve parity. Some physicists believe that CPT symmetry shall be conserved in weak interaction as the last resort, but its consequence that T symmetry should be broken to make ends meet sounds ugly to me. A hypothesis that the weak interaction is the very consequence of parity symmetry violation sounds more elegant.

There is yet another possibility that may rescue the P and CP violations in week interaction. Recall that quantum spin is redefined as a triplet vector, and that the Wu's experiment was later confirmed to have achieved the maximum possible polarization, which was 0.6 Gamma anisotropy.
These facts indicate that the spin inversion experiments so far might have just inverted one third of the true parity, at best. Thus, an experiment inverting the direction of magnetic field along three mutually orthogonal axes to see if the parity symmetry recovers in weak interaction, is highly recommended.

After all, gravity is a combination of the dynamics of space and the motion of Fermions, the former as a consequence of the inherent nature of the space to generate energy out of nothing by spontaneous symmetry breaking, while the latter is a homeostasis to maintain a constant line density of energy.

Electric charge is a vectorial property generated by rotation in the final equilibrium as a culmination of symmetry break condensation by the universal attraction between them. Electromagnetism is a sign-dependent motion of electrically charged Fermions, as a homeostasis of the line density of electric charge.

Strong interaction is another aspect of electromagnetism appears within a largely homogeneous charge core such that both the direction and intensity of electromagnetism turn to be unconventional. The illusive existence of quark is a reflection that the rigid body type dimension(s) of a particle may collapse in 3-D space.

Weak interaction is a consequence that two additional symmetry breaks have stochastically occurred next to an existing particle and let it decay.

This theory explains, with sharp physical images, why electromagnetism, weak interaction and strong interaction are linked with U(1), SU(2) and SU(3) group respectively in the Yang-Mills theory.

Hereby, all the four fundamental forces have come to a super unification as four parts of a consistent story based on the powerful paradigm of spontaneous symmetry breaking in the space.

7. Evolution of the universe

As the grand finale, let me unveil the secret about the average density in our universe. As shown in below, energy density is inversely proportional to the square of Hubble radius.

$$R = \frac{c}{H} \quad R' = \frac{c}{H'} \quad H = \sqrt{2}H' \quad \rightarrow \quad R' = \sqrt{2}R$$

$$\frac{2R'\rho_B}{\frac{4}{3}\pi R'^3} = \rho \quad \rightarrow \quad \frac{\frac{c^2}{G}}{\frac{8}{3}\pi R^2} = \rho$$

$$R^2\rho = \frac{3c^2}{8\pi G} = 1.61 \times 10^{26}[kg\ /\ m] \qquad \rho \propto \frac{1}{R^2}$$

For a spatial region that is largely homogeneous in terms of energy and mass distribution, its local Hubble constant is proportional to the square root of average density. Recall that the dilution of extreme line density ρ_B along Hubble diameter into Hubble volume does not prefer any particular density ρ, which implies that the farther we observe, the thinner average density we would obtain. Thus, the recession velocity of stars relatively close to us shall be disproportionately faster than that of distant ones. In other words, the local Hubble constant varies in a distance-dependent manner.

However, this mechanism alone cannot fully explain the accelerating expansion of our universe, since the acceleration should be far more aggressive than what is actually observed.

Theoretically, the average energy density in our universe shall converge to zero as the radius of our observation goes to infinity. Then, how was the latest figure of $4.2 \times 10^{-28}[kg\ /\ m^3]$ specifically chosen as our observable baryonic density? Is it simply due to the technical limitation that our telescopes cannot look out far enough? The calculation in below tells us it is not the case.

The eight-fold relationship predicts a total energy density of

$$\rho = 8 \times 4.2 \times 10^{-28} = 3.36 \times 10^{-27}[kg\ /\ m^3]$$

which is fairly close to the latest estimate as the sum of visible matter and dark matter in our universe.

Correspondent to this energy density,

$$R = 2.19 \times 10^{26}[m]$$

$$H = 1.37 \times 10^{-18}[s^{-1}]$$

It is astonishing that

$$\frac{2R}{L} = \frac{2 \times 2.19 \times 10^{26}[m]}{4.65 \times 10^{-14}[m]} = 9.41 \times 10^{39}$$

$$\frac{\frac{4}{3}\pi R^3\rho}{m_p} = \frac{1.48 \times 10^{53}[kg]}{1.67 \times 10^{-27}[kg]} = 8.86 \times 10^{79}$$
$$= (9.41 \times 10^{39})^2$$

9.41×10^{39} is not only the expectation of the number of symmetry breakings along the Hubble diameter (a newly introduced concept by this paper), but also the square root of the so-called Eddington number that measures the total energy in our universe as multiples of proton mass.

The rationality of such an arrangement, in which the enclosed energy shall be proportional to the square of radius, might be due to the fact that the energy flux penetrating the cosmological event horizon remains constant so that there is no further acceleration of space expansion, thus the event horizon consistently recedes from us at the speed of light.

Let

$$M = 2.04 \times 10^{21}$$

$$N = 9.41 \times 10^{39}$$

It can be derived that

$$m_p = 6\pi^5 \sqrt{1 - \left(\frac{1}{4}\right)^2} \frac{\hbar}{8\hat{R}cM} \propto M^{-1}$$

$$\rho = \frac{27c^5\pi^9\left\{1 - \left(\frac{1}{4}\right)^2\right\}}{16G^2\hbar M^6} \propto M^{-6}$$

$$H = \sqrt{\frac{8\pi G\rho}{3}} \propto M^{-3}$$

$$R = \frac{c}{H} \propto M^3$$

$$N = \frac{2R}{M\hat{R}} \propto \frac{M^3}{M} = M^2$$

$$N^2 = \frac{\frac{4}{3}\pi R^3\rho}{m_P} \propto \frac{M^9M^{-6}}{M^{-1}} = M^4$$

The precise relationship between M and N can be calculated as

$$N = \frac{2}{3\pi^5\sqrt{1 - \left(\frac{1}{4}\right)^2}} M^2 \approx \frac{M^2}{444}$$

These calculations indicate that in a space spontaneously breaking its symmetry with a non-zero probability (otherwise it will be deadly quiet), both its size and energy density will be uniquely determined by that probability ($1/M$).

Then, why do M and N take the current values instead of all other possible combinations?

It is again astonishing that when we take

$$M_0N_0 = 1$$

as an extreme case, or in other words, the probability of the field to give rise of a Fermion by two symmetry breakings occurring simultaneously ($1/\ {M_0}^2$) exactly equals to the total energy contained in the space as multiple of the mass of a rigid-body-type elementary particle (${N_0}^2$).

$$\frac{{M_0}^3}{444} = 1 \quad \rightarrow \quad M_0 = 7.63 \qquad N_0 = 1.31 \times 10^{-1}$$

$$2R_0 = 2R \times \left(\frac{7.63}{2.04 \times 10^{21}}\right)^3 = \frac{4.38 \times 10^{26}[m]}{1.91 \times 10^{61}}$$

$$= 2.29 \times 10^{-35}[m] = \hat{R}$$

It undoubtedly suggests that our universe exactly began from a pair of symmetry breaks that arose spontaneously and broke the perfect symmetry of the space. Moreover,

$$\frac{R}{c} = \frac{2.19 \times 10^{26}[m]}{3 \times 10^8[m/s]}$$

$$= 7.29 \times 10^{17}[s] = 2.31 \times 10^{10}[y]$$

$$\frac{\frac{2R}{c}}{\frac{\hat{R}}{c}} = \frac{1.46 \times 10^{18}[s]}{7.63 \times 10^{-44}[s]} = 1.91 \times 10^{61}$$

$$= (2.67 \times 10^{20})^3 = \left(\frac{M}{M_0}\right)^3$$

which demonstrates that the event horizon of our universe is expanding exactly at the speed of light ever since its birth 23.1 billion years ago.

$$t \propto ct = R \propto M^3$$

The cube of M is proportional to the age of our universe. M, N and other variables take their current values exactly because our universe has been expanding for 23.1 billion years.

Now, we have successfully eradicated all god given parameters other than G, c and $\hbar$.

After all, the seemingly accelerating expansion of our universe is a net effect of a distance-dependent decrease of local Hubble constant (stars closer to us may recede at a disproportionately faster velocity than distant ones, as if the expansion is accelerating over time) and a time-dependent decrease of global Hubble constant. Hereby, the raison d'être of dark energy has completely disappeared.

Arguments so far have convincingly denied the long-believed dogma that the CMB was emitted at around 13.8 billion years ago, or 380,000 years after the Big Bang. Instead, it should be revised to 2.28×10^{10} ($66/67$ of 2.31×10^{10}) years ago, with a much lower temperature (183K).

Since the Hubble radius is proportional to the cube of M, the M at the emission of CMB was

$$M_{CMB} = \sqrt[3]{\frac{1}{67}} M \approx \frac{M}{4}$$

therefore,

$$\rho_{CMB} \approx 4^6 \rho \approx 4000\rho$$

$$m_{pCMB} \approx 4m_p \qquad m_{eCMB} \approx 4m_e$$

The gravity between proton and electron was roughly 16 times stronger than it is now, while the electromagnetic attraction between them remains unchanged ($\hat{R}$ is constant, but L is proportional to M). In an environment where both the strength of gravity (relative to electromagnetism) and density of energy decrease as the space expands, the recombination should have occurred at some point where electromagnetism became the dominant force to form atoms. The detailed conditions of such a recombination remain to be further examined by chemists, which shall explain why the recombination did occur when the Hubble radius was $1/67$ of its current length, or in other words, when our universe had expanded for roughly 3.45×10^8 ($1/67$ of 2.31×10^{10}) years.

An extension of the age of our universe by 9.3 billion years may solve the mysteries such as why there are many giant galaxies found in the deep universe (which should be too young for galactic formation) and the so-called Lithium problem. In a universe without a hot recombination and the subsequent Big Bang nucleosynthesis, all elements heavier than Hydrogen could only be produced by nuclear fusion in stars, for a prolonged period (for example, an extension from 5 billion years to 14.3 billion years, as the time since the first stars were born).

According to the relativistic velocity subtraction, a point that recedes from us at the speed of light would do so in the eyes of all other observers who are receding from us at subluminal velocity. Our cosmological event horizon shall serve as the event horizon for all observers in the universe.

Some may have noticed the striking implication from all those stories. We are living in a universe whose radius is finite and increasing, which is practically infinite in the sense that all of its residents share an identical cosmological event horizon that remains unreachable to all of them forever. The countless number of stars and creatures on them, if any, were all born of stochastic fluctuations in the binary field. They are largely negligible from the perspective of the entire universe, which becomes even truer as both the mass of elementary particles and the average energy density decrease in accordance with the expansion of space.

<End of Article>