Variability of Rydberg constant and its implications on particle cosmology

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<Abstract>
Inspired by numbers of hardly-to-be-coincidence relations between the current state of universe and its Planck scaled precursor, we audaciously propose a hypothesis in which the mass of all elementary particles is generally proportional to the inverse cube of the cosmic scale factor, while their electric charge is inversely proportional to the square of scale factor, both of which are due to a scale factor or time-dependent evolution of the Planck constant. It implies that the Rydberg constant may be actually a variable, urges us to re-examine the raw redshift data and our well-established theory of Big Bang nucleosynthesis, which in turn demystifies the delusion that the matter content of the universe is insufficient to let it expand so fast, let alone accelerate.

In spite of its pivotal importance in physics, the entity of time and energy has successfully evaded all attempts for revelation to date. We present a novel theoretical paradigm where all perceivable physical realities can be concretely defined by the degree of asymmetry in a digital field made of Planck scaled spatial quantum. The field has an inherent potential to spontaneously and totally stochastically break its symmetry. Our scheme not only solves numbers of hierarchy problems in one shot but can also theoretically calculate the mass of elementary particles and exotic baryons only with fundamental physical constants and fractional powers of pi or integer or half integer. By providing clearcut physical images for why particular Lie group may rightly characterize its corresponding force, it proves itself as a powerful guide toward the super-unification of all the four fundamental interactions.

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Our observable universe has a radius $\sim 10^{60}$ times of the Planck length, while its energy density is $\sim 10^{-120}$ of the Planck density. Such a relation that energy density being proportional to the inverse square (instead of cube) of the radius applies to black holes as well, thus shall be a general feature of phenomena governed by gravity. Suppose the universe has evolved from a Planck scaled stage to the current state, the above observation strongly implies, according to the Friedmann equations, that the weighted average pressure of the universe shall be negative 1/3 of energy density such that the cosmological event horizon expands at a constant speed. It is rather naïve to believe we are living in a miraculous era when the density of ordinary matter, dark matter and dark energy meet at roughly the same order.

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}(\rho + 3P)$$

$$\rho \propto a^{-3\left(1+\frac{P}{\rho}\right)}$$

Note that the integral powers of $\sim 10^{20}$ repetitively show themselves in hierarchy problems of fundamental physics. Firstly, $\sim 10^{40}$ is the magnitude gap between gravity and electromagnetism (which is actually a consequence of the very fact that $\sim 10^{20}$ itself is the ratio between the Planck mass and the mass of electron or proton). Secondly, $\sim 10^{60}$ is the multiple of the current Hubble radius, mass and time compared with their Planck scaled counterparts. And lastly, $\sim 10^{80}$ is the famous Eddington number.

Instead of asking why the Planck units are so distant from observable realities we are familiar with by those specific magnitudes, or trying to find special reasons for the figures, the right question shall be what kind of a mechanism may assure them to evolve synchronically such that the current figures are not special. There were some physicists, with Sir Paul Dirac as the most renowned, who had sought the possibility that some physical constants might actually be time-dependent variables, unfortunately without success to date. Here we present a hitherto unfalsified hypothesis in which a cosmic scale factor or time-dependent decrease of the Planck "constant" drives an evolution of the scale of the Planck units and the property of elementary particles (mass & electric charge), which can in turn convincingly solve the most profound cosmological conundrums in one shot.

We chose to first present the summary of our conclusions and then gradually unfold the underlying mechanisms, in order not to frustrate our readers in a quite lengthy cruise whose destination may not seem clear until halfway of the journey. As a pivotal figure, 10^{20} (its precise value is 2.67×10^{20} as we will demonstrate later) is exactly the expansion rate of cosmic scale factor from the very Big Bang up until today. The evolution of the key parameters that characterize our universe is shown in below.

Planck constant

$$\hbar \propto a^{-4} \quad : \quad 1 \rightarrow 10^{-80}$$

Gravitational constant

$$G = \text{const.}$$

Speed of light

$$c = \text{const. (so do } \varepsilon_0 \text{ and } \mu_0\text{)}$$

Mass of elementary particles (mass ratio between proton and electron remains constant, $m_p \sim 1836 m_e$)

$$m_{EP} \propto a^{-3} \quad : \quad 1 \rightarrow 10^{-60}$$

Elementary charge

$$e \propto a^{-2} \quad : \quad 1 \rightarrow 10^{-40}$$

Mass-to-charge ratio of electron and proton

$$m_{EP}/e \propto a^{-1} \quad : \quad 1 \rightarrow 10^{-20}$$

Fine structure constant

$$\alpha \propto \frac{e^2}{\varepsilon_0 \hbar} \propto \frac{a^{-4}}{a^{-4}} = \text{const.}$$

Planck length

$$l_{PL} \propto \hbar^{1/2} \propto a^{-2} \quad : \quad 1 \rightarrow 10^{-40}$$

Planck time

$$t_{PL} \propto \hbar^{1/2} \propto a^{-2} \quad : \quad 1 \rightarrow 10^{-40}$$

Planck mass

$$m_{PL} \propto \hbar^{1/2} \propto a^{-2} \quad : \quad 1 \rightarrow 10^{-40}$$

Planck density

$$\rho_{PL} \propto m_{PL}/{l_{PL}}^3 \propto a^4 \quad : \quad 1 \rightarrow 10^{80}$$

Rydberg constant

$$R_\infty \propto \frac{m_e e^4}{{\varepsilon_0}^2 \hbar^3} \propto \frac{m_e}{\hbar} \propto a \quad : \quad 1 \rightarrow 10^{20}$$

A smaller Rydberg "constant" in the past (proportional to cosmic scale factor) implies that the redshift we observe today may not correctly reflect the true expansion of the universe. 1+z has to be re-interpreted downward to its square root. For example, a seemingly 4-fold redshift (raw z=3) is indeed a spectrum emitted when the Hubble radius was 1/2 of the current length (already "redshifted" by two folds judged by today's knowledge of spectrometry), being actually redshifted by two folds (true z=1). For small z, by simple math, true z shall be 1/2 of raw z.

By reducing the Hubble's constant by 1/2 (as it is calculated at $z \ll 1$), our hypothesis drastically downsized the critical density to 1/4 of its current figure. Such an egg of Columbus solution to the dark energy conundrum, of course has a few minor issues to be further addressed.

Firstly, it seems to be rather an overshoot compared with $\Omega_m \sim 0.315$, as the latest estimate by the PLANCK satellite. Note that our above discussion has better affinity with the Cepheids/supernovae-based straightforward measurement of the Hubble's constant, which gives a ~10% larger figure compared with that drawn from the observation of CMB. Should we agree on the matter density (ordinary plus dark) which is confirmed by other methods such as gravitational lensing as well, 10% increase of the Hubble's constant gives 21% larger critical density that is further subject to the 1/4 reduction, and 0.315/1.21=0.26 is close enough to 0.25.

Secondly, if the universe is expanding at a constant velocity, then a non-linear and downward reinterpretation of raw redshift shall result in brighter-than-expected supernovae (instead of dimmer as actually observed) as the raw (fake) redshift increases. For example, raw z=0.1 is equivalent to true z=0.0488, raw z=0.2 equals to true z=0.0954, and 0.0954 is smaller than 2×0.0488. As will be quantitatively explained later, the ~20% (+0.2 in luminosity magnitude) dimmer-than-expected supernovae Ia (compared with the constant velocity expansion) at z~0.5 are actually due to a ~15% underestimate of the Hubble's constant (as will be demonstrated later, the theoretical observable H_0 shall be 85[km/s /Mpc], with half of this figure as the true rate of expansion). At the same time, we will also provide an explanation for how the supernovae of raw redshift $z > 1$ could turn brighter-than-expected, as observed.

Lastly, as for how the weighted average pressure of the universe can be negative 1/3 of its energy density without the contribution from dark energy. Recall the pressure of photon gas with a fixed volume is 1/3 of the energy density. By reverse logic, the effective pressure at a spatial boundary that is expanding at the speed of light (while the constituents remain virtually static to spatial fabric), shall reasonably be negative 1/3 of energy density, vice versa. A good example that a strikingly simple fact can be overlooked for decades.

With such a cosmic scale factor or age-dependent evolution of the mass of electron and nucleons, chemistry should be quite different in ancient universe. It urges us, above all, to reexamine our well-established theory of the Big Bang nucleosynthesis. According to our hypothesis, the CMB of raw $z \sim 1100$ is equivalent to true $z \sim 32$, which implies a colder or later recombination at ~ 90 Kelvin where the relative strength of gravity compared to electromagnetic force was much stronger than it is today (by ~ 1100 folds). Qualitatively, a weaker electromagnetic capture of electron by proton at least does not contradict with such a colder recombination. However, due to our lack of expertise in the BBN, we would like to rather devote our paper as a priming water for further investigations by qualified professionals.

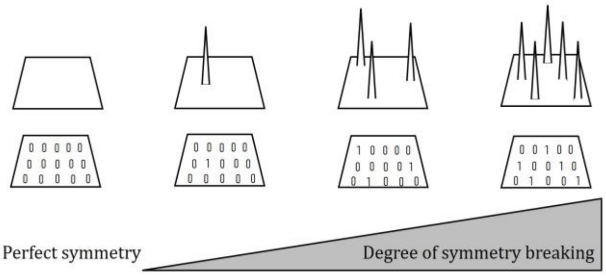
Hopefully an upward revision of the baryon-to-photon ratio could better reproduce the relative abundance among light elements, which may in turn not only solve the so-called cosmic Lithium problem, but also fill the gap between Ω_b and Ω_m which is currently occupied by the dark matter.

Should the mass of elementary particles really evolve with the cosmic age as we have predicted, the validity of those cosmological parameters drawn from the CMB needs to be re-examined from scratch. No matter how elaborate and resilient the current ΛCDM model may look, eventually, precision cosmology is not equal to accurate cosmology.

We would like to ask a favor of experimentalists with great creativity, to design an experiment to either verify or falsify our hypothesis. With billions of years as the current cosmic age, even experiments overarching several decades might not be long enough to detect the slight change in the mass of elementary particles as our hypothesis predicts. It is beyond our imagination as for if there are any smart ideas that can amplify the difference to a detectable magnitude.

Let us sincerely dedicate the following part of our paper to John Wheeler, the man who conceived the slogans of "It from bit" and "Law without law". He was undoubtedly the closest figure who could have reached exactly the same conclusions 40 years ahead of us. It is no exaggeration to say that our paper is all the way reaffirming the greatness of his insights that sharply hit the deepest truths of our mother nature. Wheeler was right to realize that all kinds of existence can only be defined in contrast to non-existence, therefore all physical realities can be reduced down to a collection of binary choices between 0 and 1 of supreme and ultimate abstraction. However, it is not the bit information carried in the collection, but the degree of asymmetry of such a digital field that gives rise to all physical realities.

A field with perfect symmetry, namely all of its constituent quanta take value 0 instead of 1, has nothing existent in it. Physicists do not have to worry about such a deadly quiet world with no subjects of and thus no need for physics at all. We may well take its spontaneous breaking of symmetry as granted, without asking why and how the God gave the primordial stimulation to the universe, once and for all.



The field certainly has an average probability density of the occurrence of the flip from 0 to 1 (no matter how distorted the distribution may be or how large its standard deviation may be), namely per how many quanta on average can we find a 1, when we pick up numerous enough quanta so that the law of large number assures a fairly stable outcome. With such an average in hand, we can now quantitatively define the degree of symmetry breaking in specific areas of the field, using the exponential distribution. Note that no matter how complicated a configuration may be, it can be ultimately broken down to a collection of bilateral pairs of two flipped quanta ("pair" hereafter), regardless of the number of dimensions of the field.

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

The mathematical feature of exponential distributions tells us that the distance ("length" hereafter) between the pair of quanta (measured by multiples of a unit length as will be calculated shortly) has an expectation of

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

and an upside accumulative probability of

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

We can exploit this feature to quantify the rareness of a pair out of the population, as the asymmetry it adds to the field. By taking the natural logarithm of the upside accumulative probability (namely the proportion of pairs that are rarer than the one in question), we obtain a simple exponential function of the length of the pair.

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

The extreme abstractness of the flipped quanta means that all of them equally take the state 1 (there are no values like 1.5 or 2 or pi). Therefore, length is the only variable that can distinguish the pairs since every pair has two quanta alike.

Now with a barometer proportional to the length, next we quite naturally define another barometer which is inversely proportional to the length. Let us assign coefficients to them as below, somehow abruptly but of course they did not come out of nowhere.

$$T(R) = -KS(R) = \frac{R}{c} \qquad \text{let } K = \frac{L}{c}$$

$$E(R) = \frac{J}{R} = \frac{\hbar c}{2R} \qquad \text{let } J = \frac{\hbar c}{2}$$

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

As we shall shortly see pieces of convincing evidence for the legitimacy of our hypothesis, they are exactly the concrete definition of time and energy respectively, unveiled for the very first time in the history of physics. Furthermore, it is exactly this probability density of the flip of spatial quanta that quantum mechanical wave functions actually describe.

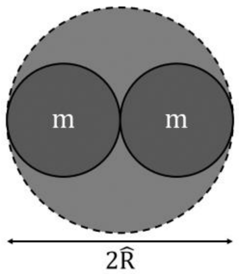
The reason why the amplitude square of the wave functions gives the probability density to find out a Fermion is rightly because Fermions are defined by two flipped quanta, square means two flips simultaneously occur in the vicinity of the locus. After all, we cannot define the degree of asymmetry with only singular spatial quanta, pair is both the minimal and the most reasonable unit for us to focus on.

Given that the energy of a pair is defined proportional to the inverse of its length, any force between the quanta, from its definition as the derivative of energy by distance, must be proportional to the inverse square of the length, regardless of the number of spatial dimensions. It is this very nature of the force being generally proportional to the inverse square of distance that dictates only three-dimensional fields can stably and self-consistently exist, instead of the logic of the contrary as has long been wrongly believed.

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

The sign of the force between quanta shows it is universally attractive. As the final result of such an attraction, we may naturally expect a situation in which two quanta are back-to-back, forming a rotating "binary star system" with a diameter twice the length of a spatial quantum.

The diameter of spatial quanta ($2\hat{R}$), which serves as the minimal length unit in the binary field, can be reasonably calculated supposing that if two spatial quanta are brought to that specific distance, they would instantly form a mini-black hole according to our definition of energy.



$$2m = \frac{E(2\hat{R})}{c^2} = \frac{\hbar}{4\hat{R}c}$$

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

$$\rightarrow \quad \widehat{R} = \sqrt{\frac{G\hbar}{2c^3}} = \frac{l_{PL}}{\sqrt{2}} = 1.14 \times 10^{-35}[m]$$

$$\widehat{M} = \frac{\hbar}{2\widehat{R}c} = \frac{m_{PL}}{\sqrt{2}} = 1.54 \times 10^{-8}[kg]$$

From now on, the Planck length over root 2 will serve as the yardstick in our binary field, together with a series of quantized mass of the Planck scale corresponding to each state that only takes discrete lengths as diameter.

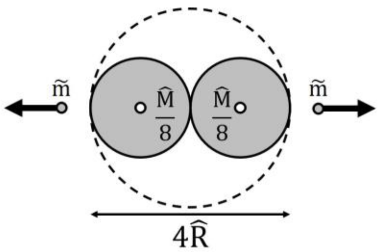
Let us begin to introduce the evidence for the legitimacy of our hypothesis. Firstly, the calculation in below implies that the electron-positron pair production is likely to be a breaking of equilibrium in which the gravitational attraction that holds a mass lump of $\widehat{M}/4$ together is beaten by two competing attractive forces applied on two tiny portions of the lump, whose strength is the same as electromagnetism.

$$\frac{e^2}{4\pi\varepsilon_0} = 4.16 \times 10^{42} G m_e^2$$

$$G\left(\frac{\widehat{M}}{8}\right)^2 = 4.16 \times 10^{42} G\tilde{m}^2$$

$$\rightarrow \quad \tilde{m} = \frac{\widehat{M}/8}{\sqrt{4.16 \times 10^{42}}} = 9.43 \times 10^{-31}[kg]$$

$$\tilde{m} \approx \frac{m_e}{\sqrt{1 - \left(\frac{1}{4}\right)^2}}$$

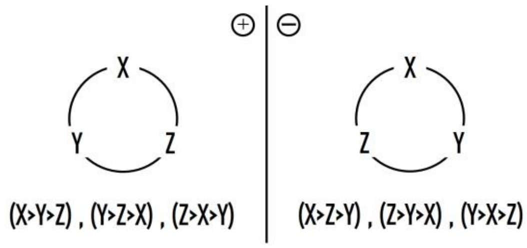


The above illustration is our proposed process. Two pairs of spatial quanta, each with a combined mass of $\widehat{M}/4$ (since diameter is $4\widehat{R}$) thus $\widehat{M}/8$ per quantum, is rotating at a velocity of c/4 (by Newtonian calculation) in which the two quanta rotating in opposite direction. When they come close enough, they would exchange partners, forming two new pairs of quanta with synchronized spins, which shall be the very origin of electric charges. As for why the newly formed pairs will only have half the mass shown in above, to prevent unnecessary confusion at this early stage, please let us clarify later when the time is ripe.

$$\frac{G\frac{\widehat{M}}{8}}{(2\widehat{R})^2} = \frac{v^2}{2\widehat{R}} \qquad v = \sqrt{\frac{G\widehat{M}}{16\widehat{R}}} = \sqrt{\frac{G\hbar c^3}{16G\hbar c}} = \frac{c}{4}$$

The reason why our observable rest mass of electron m_e needs an inverse Lorentz adjustment from $\tilde{m}$ will be also clarified later with persuasive reasoning.

Among the three spatial dimensions, suppose that their characteristics are not homogeneous (as we will see later, this is not only the source of P-symmetry violation but also the origin of the color charges in the QCD and the reason why there are three generations of elementary particles), then there are two heterogeneous permutations. This very fact provides us with a unique way to define two intrinsically different modes of rotation to be assigned to rotations with arbitrarily tilted axis in the three-dimensional space.



As for the reason of the weakness of gravity compared with electromagnetism, it is probably because the former is an interaction based on a scalar, namely energy/mass, which is defined by the stochasticity of the spontaneous symmetry breaking in the binary field, while the latter is an interaction between two rotating pairs of spatial quanta (Fermion) by exchanging singular quantum (Boson), whose strength has good reason to be conserved.

The hierarchy gap between gravity and electromagnetism we adopted here is the extreme case, namely for electron-electron interactions, instead of electron-proton or proton-proton interactions. Similar calculations do hold in the latter two cases, however, as we shall see shortly, the gap between electron-electron interactions is the key figure to unveil the secret behind gravity and electromagnetic force, just as we could never find the above astonishing relation as far as we only pay attention to the electron mass and the Planck mass and Planck length without the root 2 as a critical divisor.

As proposed in the opening of our paper, we hypothesized a scale factor-dependent decrease of the mass of elementary particles, in a manner inversely proportional to the cube of cosmic scale factor. Here comes the astounding integration of the two hypotheses. Recall that there only exists 25% of the conventional critical density in the universe, the calculations in below strongly indicate that the Big Bang was indeed the breaking of an equilibrium in which the probability of two quanta flips simultaneously occur was surpassed by the figure of a fractional number of nucleon mass, which was equivalent to the mass of the entire universe back then.

The Hubble's constant from the latest HST result is

$$H_0 = 73.3[km/s/Mpc] = 2.38 \times 10^{-18}[s^{-1}].$$

The corrected true Hubble's constant ($=H_0/2$) is

$$H = 1.19 \times 10^{-18}[s^{-1}].$$

The current Hubble radius is

$$R_H = c/H = 2.52 \times 10^{26}[m].$$

The current mass density of the universe is

$$\rho = \frac{3H^2}{8\pi G} = 2.54 \times 10^{-27}[kg / m^3].$$

The current Hubble mass is

$$M_H = \frac{4\pi R^3}{3}\rho = 1.70 \times 10^{53}[kg],$$

equivalent to 1.02×10^{80} times of neutron mass (as the precursor of a proton and an electron through beta decay).

Since the Planck length ($\sqrt{2}\widehat{R}$) is itself proportional to the inverse square of cosmic scale factor, the cubic root of the ratio between the current Hubble radius and the current $\widehat{R}$,

$$\frac{R_H}{\widehat{R}} = \frac{2.52 \times 10^{26}[m]}{1.14 \times 10^{-35}[m]} = 2.21 \times 10^{61}$$

which is 2.80×10^{20}, reflects the true increase of the cosmic scale factor.

According to previous discussions, the Eddington number should have increased by a factor of 6.14×10^{81} (fourth power of 2.80×10^{20}) from its initial value, thus the initial Eddington number was 1.66×10^{-2}. On the other hand, the inverse of 2.80×10^{20} is the decreasing factor of the probability density of quanta flip. The current probability density is the inverse square root of the magnitude gap between gravity and electromagnetism of electron-electron interactions, namely the square root of $1/(4.16 \times 10^{42})$, which is equal to $1/(2.04 \times 10^{21})$. This means the initial probability density was 1/7.29.

$$(1.66 \times 10^{-2}) \times (7.29)^2 = 0.88 \approx 1$$

The calculation exactly equals to 1, when

$$H_0 = 85.2[km/s/Mpc] = 2.76 \times 10^{-18}[s^{-1}]$$

$$H = 1.38 \times 10^{-18}[s^{-1}], \quad \rho = 3.41 \times 10^{-27}[kg / m^3]$$

$$R_H = 2.17 \times 10^{26}[m], \quad R_H/\widehat{R} = (2.67 \times 10^{20})^3$$

$$M_H = 1.46 \times 10^{53}[kg] = 8.74 \times 10^{79} m_n$$

$$(8.74 \times 10^{79})/(2.67 \times 10^{20})^4 = 1.72 \times 10^{-2}$$

$$(2.04 \times 10^{21})/(2.67 \times 10^{20}) = 7.64$$

$$(1.72 \times 10^{-2}) \times (7.64)^2 = 1.00$$

Thus, we have earlier mentioned $H_0 = 85[km/s/Mpc]$ as the theoretical observable Hubble's constant. Let us now carry out a quantitative analysis on the luminosity variation of supernovae compared with the theoretical simulation of constant speed expansion of an empty universe (h~0.7).

Firstly, the Chandrasekhar limit remains unchanged in our hypothesis, which assures the mass and absolute luminosity of type Ia supernovae should be basically time-independent.

$$M_{limit} \propto \frac{{m_{PL}}^3}{{m_{Helium}}^2} \propto \frac{a^{-6}}{a^{-6}} = const.$$

For those SN Ia with raw redshift z~0.5 (true z~0.225 and h~0.85), the luminosity curve we have actually compared them with as theoretical standard is equivalent to that of effective z~0.25 & raw h~0.7, or raw z~0.5 & effective h~0.35 (half of the observable h~0.7). Note that we have to reduce either the raw z or the raw h by 1/2 to prevent a "double count" caused by the illusive redshift. The apparent flux is proportional to the inverse square of h×z. Thus, the observed luminosity is ~83.7% of the theoretical standard.

$$\left(\frac{0.85 \times 0.225}{0.35 \times 0.5}\right)^{-2} \approx 0.837$$

The dimmer-than-expected luminosity shall end at z~1 where the effect of the non-linear revision of raw z down to true z balances with that of the ~15% underestimate of H_0.

$$\left(\frac{0.85 \times 0.414}{0.35 \times 1.0}\right)^{-2} \approx 1.005^{-2} \approx 1$$

The ~15% underestimate of the Hubble's constant by the supernovae-based measurement shall be largely due to the intrinsic non-linearity of raw z against true z even for $z \ll 1$.

The stochastic flip of spatial quantum from 0 to 1, can be interpreted as the outcome of Bernoulli trial choosing one out of two opposite states with 50%:50% probability, with the flip as the surplus after the trial. According to the well-established theory of random walk, even out of such a perfectly and evenly random process, we could still expect a surplus favoring one side over the other, with a magnitude proportional to the square root of the total number of trials. For each layer of the cosmological event horizon (which constantly expands at the speed of light), it should have a number of spatial quanta proportional to the square of its radius, thus the expected surplus should be proportional to its radius. An easy integral along the radius gives us a total number of flipped quanta proportional to the square of the cosmic radius, therefore the average probability density of quanta flip shall be inversely proportional to cosmic radius (square divided by cube).

Note that the increase of the number of spatial quanta within our cosmological event horizon is a step-by-step process in accordance with the growth of cosmic age, we cannot brutally conclude that the probability density shall be inversely proportional to the square root of the Hubble's volume, by simply regarding the volume as a measure of the total number of Bernoulli trials.

We may take another approach as well. Suppose there is a primordial wave function that governs the probability destiny in the entire universe, propagating at the speed of light, all the way from the singularity (we now should say a spatial quantum with a diameter of 1.63×10^{6}[m] which was the root 2 times the initial Planck length, instead of a point with no volume) and literally pioneers the frontier of the universe. Whichever explanation may you prefer, either by the conservation of energy or the mathematical property of three-dimensional Laplacian, the amplitude of the wave function shall attenuate inversely proportional to the distance from its origin. If we take the extension of its outer boundary as an expansion of space itself, we may find that the effect of space expansion to reduce the amplitude of waves equivalently makes ends meet such that the probability density settles to exactly the same magnitude everywhere in the universe. This wave can be regarded as the master or mighty or mother wave for the subsequent wave functions of all specific particles. We shall revisit the essence and the implications by the existence of such a wave function later, when the time is ripe.

Note that our model predicts that for a spatial region whose scale is macroscopic enough, the energy enclosed within it (generated out of it via spontaneous symmetry breaking) shall always be proportional to its diameter (or radius). It may well explain why the rotating velocity in galactic arms tends to form a plateau in the outer shells of galaxies, since the inner mass is roughly proportional to the radius so that the gravitational acceleration is inversely proportional to the radius itself instead of its square.

Let us present some interesting calculations which support our hypothesis, with less clarity for exact interpretations at this stage, thus remain to be further elucidated.

1) Mean lifetime of free neutrons

Taking the figure τ_{beam} ≈880 [s] measured by the so-called beam method, it may hardly be a coincidence that

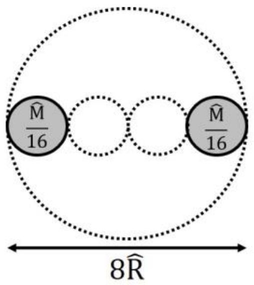
$$\frac{\pi \hat{R} \frac{m_n}{\widetilde{m_e}}}{c\tau_{beam}} \approx \left(\frac{1}{2.04 \times 10^{21}}\right)^{2}$$

where m_n is neutron's rest mass, $\widetilde{m_e}$ is the relativistic electron mass with the Lorentz factor of c/4. Though the physical image for the exact meaning of the coefficient π and the ratio between the two masses remain unclear, this calculation implies that beta-decay (and maybe the weak interaction in general) may be a phenomenon that is deeply related with the stochasticity of the spontaneous symmetry breaking in the binary field. We could reasonably guess that the release of an anti-neutrino in the beta-decay (which is equivalent to an absorption of a neutrino) might be the participation of two additional flipped quanta that are needed for the fission of a stand-by neutron (made of two quanta) into an electron and a proton (need four quanta collectively). The two quanta, on their way to the neutron, shrinking the distance between them, thus the seemingly unfixed mass of neutrinos.

Moreover, there is a well-known conundrum that the mean lifetime of free neutrons measured by the so-called bottle method is $\tau_{\mathrm{nbottle}} \approx 887$ [s], which is inexplicable within the range of experimental error. We noticed that this gap can be well enough approximated by the Lorentz factor of c/8,

$$\frac{\tau_{\mathrm{bottle}}}{\tau_{\mathrm{beam}}} \approx \frac{1}{\sqrt{1-\left(\frac{1}{8}\right)^2}}$$

a velocity we may obtain supposing two quanta are rotating with a diameter of $8\hat{R}$ instead of $4\hat{R}$.



$$\frac{G\frac{\hat{M}}{16}}{(4\hat{R})^2} = \frac{v^2}{4\hat{R}} \qquad v = \sqrt{\frac{G\hat{M}}{64\hat{R}}} = \sqrt{\frac{G\hbar c^3}{64G\hbar c}} = \frac{c}{8}$$

It may have something to do with the participation of the two additional quanta, which cannot get closer than $8\hat{R}$ due to the existing stand-by free neutron. The case may be that in the bottle method, our focus is those undecayed stand-by neutrons without the additional quanta, while in the beam method, we focus on the decayed neutrons thus with the disturbance from the two additional quanta with a velocity of c/8, which may in turn contribute an extra mass to the system and prolong the lifetime. In short, the mysterious discrepancy may be caused by the fact that we were actually observing two slightly but intrinsically different phenomena.

2) Mean lifetime of the Higgs Boson

As the latest figure, $\tau_{\mathrm{Higgs}} = 2.1(+2.3/-0.9) \times 10^{-22}$[s] agrees well enough with the below calculation that has a clear similarity with the case of free neutron.

$$\frac{\pi\hat{R} \times 2.04 \times 10^{21}}{c} = 2.43 \times 10^{-22}[s]$$

This calculation suggests that the Higgs field and the Higgs mechanism could be exactly a rephrase of the spontaneous symmetry breaking of the binary field.

Next, let us move on to the implications of our hypothesis on the strong force. In particular, we will first mathematically calculate of the mass of up quark and down quark, and then reveal the physics behind the color charges, together with the true mechanism of the asymptotic freedom and the so-called quark confinement.

As mentioned earlier, the calculation that has implied the possible mechanism of electron-positron pair production applies to proton-antiproton pair production as well, just by adopting the hierarchy gap of proton-proton interactions, which is a fact that implies a general relationship. We found that it could be put into the below equation with a good enough approximation.

$$\frac{e^2}{4\pi\varepsilon_0\left(\frac{\hbar}{2 \times 2\widetilde{m}_e c}\right)^2} \approx \frac{Gm_e^2}{(4\hat{R})^2}$$

It implies that the electromagnetic repulsion between two unit-charges of opposite signs at a distance corresponding the energy required for a pair production of two Lorentz adjusted masses (by the factor of c/4) generally balances with the gravitational attraction between the rest masses at a distance of $4\hat{R}$. It nicely matches with our proposal for the underlying mechanism behind the origin of electron mass.

This mass-independent relationship can be simplified to a more familiar form, which may have strikingly reveled the secret behind the fine structure constant α.

$$\frac{e^2}{4\pi\varepsilon_0} \approx \frac{\hbar c}{128}\left(1-\left(\frac{1}{4}\right)^2\right)$$
$$128\alpha \approx 1-\left(\frac{1}{4}\right)^2$$

137.036 might be 128 adjusted with the square of Lorentz factor of c/4, plus some higher order refinements.

Another implication from that equation is somehow latent or rather stealth, but its profound impact may be far beyond our first impression. The equation shows that

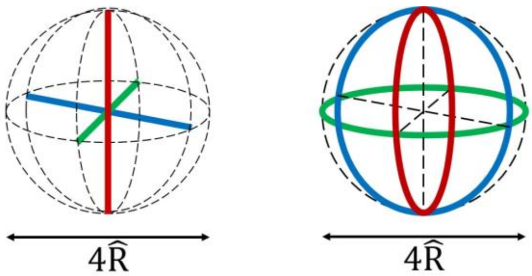
$$k_0 e^2\left(4\hat{R}\right)^2 = Gm^2\left(\frac{\hbar}{4\tilde{m}c}\right)^2 = \text{constant.}$$

You may want to ask, aren't the figures on the left-most side all constants? Let us explore the possibility that if they are not.

Electrons and protons have different mass-charge ratios, but how sure are we about the identity or uniformity of electric charges? In other words, what if the real case is that the mass carried by protons, by some unknown mechanisms, has a lesser responsiveness to electromagnetic force such that protons need more mass than electrons to take part in electromagnetic interactions equally?

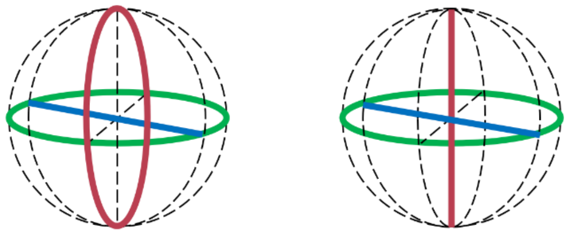
As for how the part of $4\hat{R}$ might be variable, the first idea that came up to our mind was that the mechanics of rigid bodies are much richer than that of mass points. What if proton and neutron are a kind of rigid-body-type particles whereas electron is a mass-point-type particle?

Note that we have already excluded the concept of zero distance in our binary field, thus even for mass points, they still have a minimal diameter of $4\hat{R}$ (as they consist of two quanta). "Point" just means it does not have any rotational degree of freedom. Moreover, we may reasonably postulate that the length of spatial "span" of a rigid-body-type degree of freedom is π times that of a mass-point-type one, as the latter is kind of restricted within the diameter of the former.



mass-point-type rigid-body-type

Next, let us suppose that in the high energy hadron collision experiments, the smashed nucleons may instantly reduce one or two of its three rigid-body-type degrees of freedom down to the mass-point-type. If we define an "effective span" of degrees of freedom by taking the geometric average of the span on all the three dimensions, we shall obtain the below figures expressed with fractional powers of pi, indicating how "bulgy" the partially shrunk rigid-body-type particles still are, compared with the genuine mass-point type one.



one dimension shrank two dimensions shrank

$$\sqrt[3]{\frac{\left(4\pi\hat{R}\right)^2 4\hat{R}}{\left(4\hat{R}\right)^3}} = \pi^{\frac{2}{3}} \qquad \sqrt[3]{\frac{4\pi\hat{R}\left(4\hat{R}\right)^2}{\left(4\hat{R}\right)^3}} = \pi^{\frac{1}{3}}$$

The inversely proportional relation of charge and span shown in our equation implies that a larger effective span shall diminish a mass's responsiveness to electromagnetism. Therefore, each partially shrunk state of the mass lump shall have an inferior electromagnetic responsiveness by factors of

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

respectively, compared with the mass-point-type electron.

Suppose the two spatial quanta evenly contribute to the electromagnetic responsiveness of the Fermion that they collectively define, then each spatial quantum would have an electromagnetic responsiveness further inferior to that of electron, by factors of 1/9.2 and 1/4.3 respectively.

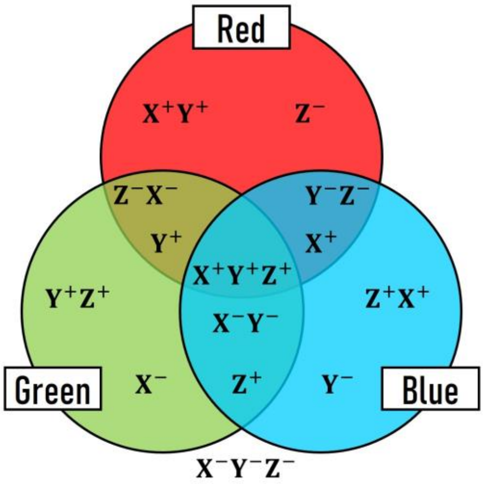
A lesser electromagnetic responsiveness means a larger mass required to behave as an electric charge, therefore, the theoretical mass of a singular spatial quantum in the partially shrunk rigid-body-type particles shall be 9.2 and 4.3 times of the mass of electron, respectively. They are exactly the experimentally established theoretical mass of down quark and up quark.

With the convincing calculation of the mass of up quark and down quark, our hypothesis of the concept "electromagnetic responsiveness" shall have gained sufficient credibility. Now the time is ripe to reveal the reason why the mass of electron and positron is not twice of our illustrated fission product. In short, electric charges are obtained in exchange with mass. Each half of the rotating mass lump did no longer have a mass of $\widehat{M}/8$ and a unit charge, but was actually giving up half of its mass (reserving the other half as its mass) to acquire 1/2 of a unit charge. It was in this way that the combined particles had exactly the mass of electron and a unit charge. In other words, electromagnetic responsiveness shall be regarded as a conversion factor between mass and electric charge, or the efficiency of a specific type (mass point or rigid body) of mass to acquire and maintain a unit charge.

Our discussions so far strongly suggest that the entity of quark is rather one of the two spatial quanta within a partially shrunk rigid-body-type particle, namely hadron, in high energy collisions. It only transiently interacts with one of the two spatial quanta that collectively define the incoming leptons, and let them scatter.

The form of quark, as a singular quantum in a transiently shrunk hadron, can only exist together with its partner quantum, therefore, it does not make sense outside of hadrons. Detectable Fermions are, after all, defined by a pair of quanta, thus the visionary state of "quark" does not independently exist. This shall be the secret of the so-called quark confinement.

The color charge of quark may highly likely to be a reflection of the details of the shrunk dimension(s) as shown in the schematic figure and tables in below, just 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 ($X^-Y^-Z^-$)

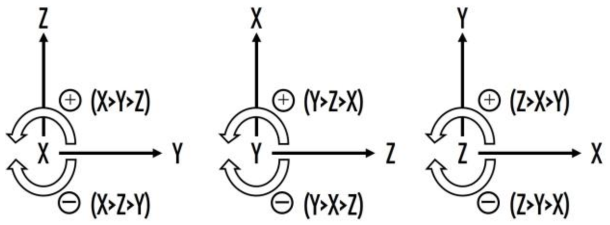
	CYAN	MAGENTA	YELLOW
$\overline{uud}$	X^-Y^-	Y^-Z^-	Y^+
$\overline{udu}$	X^-Y^-	X^+	$Z^- X^-$
$\overline{duu}$	Z^+	Y^-Z^-	$Z^- X^-$

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^+	$Z^- X^-$

If one dimension has shrunk, the transient state would have an imaginary electric charge of $\pm 1/3$, reflecting the fact that one out of three dimensions is mass-point-type (same with electrons). If two dimensions have shrunk, the charge would be $\pm 2/3$ by similar logic. Down quark (one dimension shrunk) has a larger geometric mean of spatial span than that of up quark (two dimensions shrunk). It may well explain why nucleons have their respective charge radii and mass radii, as the superposition of mass and the offset of electric charges take place respectively, in an independent manner deservedly as our model predicts.

The sign of the fractional charge of quarks may reflect the mode of rotation of the shrunk particle seen from each dimension. By the aforementioned definition of the rotation mode, we can define not only the mode of the entire particle, but also the mode seen from each axis of spatial dimension. The illustration in below is for an example.



Now that it is almost needless to say that the information about the rotation modes is conveyed by the wave function of particles for sure. And more importantly, this rotation of spatial quanta beneath the detectable particle they actually define, is exactly the reason why quantum mechanical waves must be defined as complex functions. The necessity to use complex numbers in describing the dynamics of the spatial quanta might be due to the historical inevitability that we had chosen (of course not by accident) real numbers to construct the physics of the detectable particles with which we are much more familiar. Furthermore, the properties of complex number, or imaginary number in particular, turns out to be the final sentence to the theory of QCD, as we have found a strikingly simple solution for how could protons be held harmonically together within atomic nuclei.

Before moving on to the highlight of this paper, let us add some complemental comments about the mass of proton. Proton has a mass about 1836 times that of electron. It is a well-known fact that $6\pi^5$ is a good approximation of 1836. Out of the $6\pi^5$, proton as a genuine rigid-body-type particle shall be an inferior reactor to the electromagnetic force than electron by a factor of $1/\pi^2$ (as all three dimensions are rigid-body-type). The remaining $1/6\pi^3$ might be a factor reflecting a qualitative leap from mass-point-type to rigid-body-type. In other words, the logic of our calculation of theoretical mass of u quark and d quark compared with electron may only apply for particles that have at least one mass-point-type dimension. Although its mechanism needs to be further elucidated, the assumption does not sound so unreasonable either, as 6 is the degree of freedom of a three-dimensional rigid body, while π^3 could be the ratio of "effective volume" (the product of spans over all the three dimensions) between rigid-body-type and mass-point-type particles. It is interesting to note that the theoretical mass of strange quark is about 186 times of the electron mass, and 186 is a good enough approximation of $6\pi^3$.

Next, let us unveil the secret of the asymptotic freedom. Suppose a homogeneous sphere with a uniformly positive charge density, as a good approximation of atomic nucleus. The below equation of radial motion, with a fairly simple integration, gives us an equation about the velocity. Let the constant of integration be zero, which is equivalent to the conserved mechanical energy is zero, as the most simplified situation for our thought experiment.

$$m\frac{d^2r}{dt^2} = \frac{1}{4\pi\varepsilon_0}\frac{4}{3}\pi r^3\frac{\rho e}{r^2} = \frac{\rho_0 r_0^3 e}{3\varepsilon_0 r^2} \qquad (\rho r^3 = \rho_0 r_0^3)$$

$$\rightarrow \quad \frac{m}{2}v^2 = -\frac{\rho_0 r_0^3 e}{3\varepsilon_0 r} = -\frac{\rho e}{3\varepsilon_0}r^2 \quad \rightarrow \quad \frac{v}{r} = \sqrt{\frac{2\rho e}{3\varepsilon_0 m}}\,i$$

The equation looks nonsense in the conventional context, since the square of the velocity is negative. However, being free from all kinds of prejudice, if imaginary velocities are allowed, what will happen? A direct consequence shall be that the Lorentz factor turns out to be smaller than one. Having paved the way for quite a while, we believe that now an idea that this imaginary number velocity represents the motion of the spatial quanta may not sound too abrupt. And it is highly likely to be the case.

Substitute the actual figures of the unit charge, the mass of nucleon, the permittivity of vacuum, the charge density of proton as the average charge density of atomic nuclei, into the equation. Then multiply the resulted "Hubble constant" of atomic nuclei with $\sim 10^{-15}$ [m] as the order of their radii. Surprisingly, we may notice that the imaginary velocity falls to exactly the same order with the velocity of light. At such a non-negligible velocity, the aforementioned smaller-than-one Lorentz factor would rightly reduce the relativistic mass by roughly 1~2%, which matches well enough with the binding energy per nucleon for the elements with double digit atomic number.

Our approximation may not work well enough for the atomic nuclei of light elements since their charge density shall be far from homogeneous. Note that the imaginary velocities are theoretically proportional to the distance of the nucleons from the center of atomic nucleus, thus the magnitude of the relativistic mass reduction (or the level of binding energy) increases with the growth of radius. This is exactly the underlying mechanism of the so-called asymptotic freedom.

As for the motion of the spatial quanta within atomic nuclei, the most reasonable explanation should be that they switch their "owners" just like the free electrons in metals. It is by such a sharing of spatial quanta that nucleons can reach a less massive and thus more stable state.

Due to limitation of space, we will not go any further into detailed quantitative discussions on specific atomic nucleus. However, it may not diminish the persuasiveness of our hypothesis by a little bit, we firmly believe.

The discovery of imaginary velocities urges us to slightly correct our previous equations. Instead of multiplying the Lorentz factor of c/4 or c/8, we should divide that of ci/4 or ci/8, which do not make too much difference except we may obtain a closer approximation of the fine structure constant. Note that

$$128 \times \left(1 + \left(\frac{1}{4}\right)^2\right)\sqrt{1 + \left(\frac{1}{8}\right)^2} = 137.058381721 \ldots$$

is very close to the inverse of α. We have intentionally ignored the slight difference, since the time for such a correction would only be ripe at this stage. After all, the rest mass of elementary particles needs an inverse adjustment from pure theoretical calculations rightly because the rest mass in our perspectives is the relativistic mass from the view point of spatial quanta, and the former is always lighter than the rest mass in the perspective of spatial quanta.

Our discussions have almost reveled all the major secrets of the strong force. However, without explaining the origins of so many exotic baryons and mesons, our hypothesis might not acquire full credit for sure. So, now let us cope with it. Adopting the Lorentz factor adjusted proton mass as one unit of the standard nucleon mass in collision experiments,

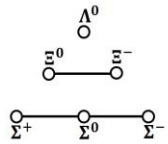
$$\dot{m} = m_p\sqrt{1 + \left(\frac{1}{4}\right)^2} \approx 967[\mathrm{MeV} / c^2]$$

we may find with great surprise that the mass of the 16 baryons (other than proton and neutron) that supposedly to consist of only u, d or s quarks align in an extremely elegant pattern.

$\sqrt[3]{1.5}\dot{m} \approx 1107 \rightarrow \Lambda^0$ (1116)

$\sqrt[3]{2.5}\dot{m} \approx 1312 \rightarrow \Xi^0, \Xi^-$ (1315~1322)

$\sqrt{1.5}\dot{m} \approx 1184 \rightarrow \Sigma^+, \Sigma^0, \Sigma^-$ (1189~1197)

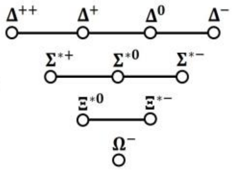


$\sqrt[3]{2}\dot{m} \approx 1218 \rightarrow \Delta^{++}, \Delta^+, \Delta^0, \Delta^-$ (1232)

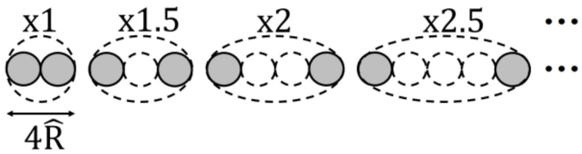
$\sqrt[3]{3}\dot{m} \approx 1395 \rightarrow \Sigma^{*+}, \Sigma^{*0}, \Sigma^{*-}$ (1383~1387)

$\sqrt[3]{4}\dot{m} \approx 1535 \rightarrow \Xi^{*0}, \Xi^{*-}$ (1532~1535)

$\sqrt[3]{5}\dot{m} \approx 1654 \rightarrow \Omega^-$ (1672)



It strongly suggests that exotic baryons are actually transient figures of nucleons during high energy collision, expanding one of its three spatial dimensions in a discrete manner.



In contrast to the deep inelastic scattering in which we can just indirectly assume that nucleons have inner structures from the scattering pattern of electrons, hadron collision experiments do actually churn out numerous detectable baryons and mesons. The difference is that, exotic hadrons, though very short-lived, are nonetheless made of spatial quanta pair, and are genuine rigid-body-type particles as carriers of electric charge. Compared with proton, the electromagnetic responsiveness of each excitation state should be, by the same logic with the calculation of quark mass, inversely proportional to their effective span, to explain their increased mass. The effective span shall be reasonably calculated by equally distributing the span of the expanded dimension onto all three dimensions, therefore the cubic roots of half-integers or integers. (The reason why square root of 1.5 gives rise to sigma baryons remains to be studied. The case might be one of the three dimensions had collapsed first, then the two-dimensional "disk" expands one of the remaining two.) The reason why the cubic roots of integers correspond to spin 3/2 baryons while the cubic roots of half-integers give rise to spin 1/2 baryons may due to the fact that the former are expansions in multiples of $4\hat{R}$, which may render the baryons an additional integral spin by a mechanism that awaits further study.

In summary, quark is one of the two quanta that define a partially shrunk nucleon in which one or two of its three spatial dimensions transiently collapse from rigid-body-type to mass-point-type degree of freedom. Gluon is the spatial quantum exchanged in the transitions between the different states of shrinkage. Exotic baryons are nucleons transiently expanded along one of its three dimensions, while mesons are the energy exchanged during the transition between these different states of expansion. The dazzling varieties of the cascades in hadron decay are probably the reflections of the probable transitions among all possible states, which shall be explained with no big problem in the context of our model, as a matter of time.

Moreover, it is interesting to note that the mass of baryons with c quark substitution and b quark substitution are generally and roughly twice and five times heavier than their counterparts made of only u/d/s quarks, respectively. It implies that nucleons may have three intrinsically distinctive modes for the transient expansion of its spatial dimensions, namely which one of the three dimensions to be expanded. One natural explanation could be that compared with the first and the easiest choice that gives rise to those baryons supposed to be made of u/d/s quarks, the second and third harder choices may, for some unknown reason, result in a much weaker electromagnetic responsiveness by a factor of ~1/8 and ~1/125 respectively, which in turn generate baryons roughly twice and five times massive than those generated by the first mode. It may not be meaningless to point out that the ratio between the mass of tauon and muon is roughly 136:8, though we have no idea where comes the residual ~8π (after we divide the mass of muon by $8m_e$).

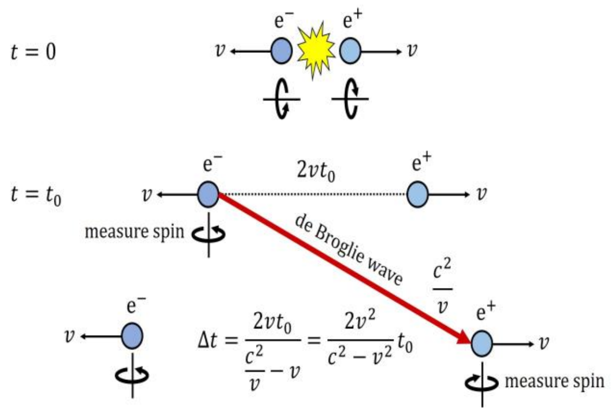
The heterogeneity among the three spatial dimensions is highly likely to be the reason why P symmetry is broken in the weak interaction. If the three spatial dimensions are homogeneous, we may no longer be able to define the two intrinsically distinctive modes of rotation as we have proposed in this paper. From this point of view, it is rather natural that right-handed spin and left-handed spin shall differ to each other in an inherently distinguishable fashion. Note that the weak force is the only interaction in which the number of participating spatial quanta does not conserve before and after the process. In other words, it could rather be a phenomenon which is noticeable to us rightly because of the addition of newly flipped spatial quanta to the pre-existing physical system we had been observing. The reason why only the Bosons of the weak interaction possess mass, may be the very reflection of this non-conservation of the number of flipped quanta before and after the process.

After all, electric charge is a vectorial property generated out of the rotation of spatial quanta as a culmination of the universal attraction between them. The strong force can be bisected into two parts. The binding of nucleons within atomic nuclei can be explained by their sharing of spatial quanta just like the free electrons in metals, where the motion of spatial quanta with imaginary velocities contributes to a relativistic mass reduction, stabilizing the atomic nucleus in the form of binding energy. Those phenomena that imply any inner structures of hadrons are indeed the transient snapshots of them, which should not have been even noticed unless they were smashed to each other in the ultra-high energy colliders. The mathematical structure of QCD exactly reflects the fact that the three rigid-body-type dimensions of nucleons may randomly change their type or extend their spatial span under high energy conditions. The weak interaction shall be rather regarded as an inevitable consequence of the spontaneous symmetry breaking of the binary field, which occurs whenever two additional flipped spatial quanta are brought by the universal attraction to the vicinity of an existing particle.

Our theory vividly explains, with clearcut physical images, why electromagnetism, weak force and strong force are respectively linked with U(1), SU(2) and SU(3) Lie group in the Yang-Mills gauge theory. The groups correspondent to rotations in complex space is rightly the reflection that they describe the motion of spatial quanta that live in another layer which is deeper than that of the real number based detectable particles. The meaning of dimension number in each of the Lie group is now rather trivial, we believe, after the revelation of the underlying physics behind each force. Hereby, all the four fundamental interactions are unified as four aspects of a singular story based on a self-consistent theoretical paradigm, namely the spontaneous symmetry breaking in the space as a binary field.

As for why there are certain errors, though very slight, between the experimental data of baryon masses and our simple calculation, the main contributor should be some minor disturbances by those factors we are not yet able to fully take into consideration at this stage. It is well known that the construction process of the standard model of particle physics was indeed a series of hindsight, through which tens of artificial parameters have been added for the fine tuning with existing experimental data. Therefore, it has good reason to "predict" the outcome of "newly" designed experiments, which are actually nothing but reaffirming the model's reproductivity by thousands of minorly tinkered versions of similar conditions, without harshly challenging the credibility of it. Luckily enough though, more and more clues have been piling up recently, indicating that the model is far from complete or even correct. Shall we satisfy with a 21st century version of the Ptolemaic epicycle theory, or had we better pursue the possibility of a Copernican revolution (even though not yet sophisticated as Newton or Einstein)? In front us is a vital choice between a self-satisfaction with blind precision and an aesthetic/philosophical awakening.

As an interlude, let us by the way point out that the "spooky action of distance", namely the quantum entanglement, has nothing mysterious. The key is the super-luminal phase velocity of the de Broglie wave, plus the relativity of simultaneity.



$$\left(\frac{vt_0}{c-v}-\frac{vt_0}{c+v}\right)\sqrt{1-\left(\frac{v}{c}\right)^2}=\frac{2v^2}{c^2-v^2}\sqrt{1-\left(\frac{v}{c}\right)^2}\,t_0$$

Fairly simple mathematics can prove that the seemingly instant transmission of quantum states over light years is indeed a totally legal propagation of the phase change at the super-luminal phase velocity of the de Broglie wave.

The causal relationship was simply hidden by a strangely overlooked fact that there is actually a time window exactly sufficient for the transmission from one particle to the other. In the comoving reference frame with the "influencer", the "influenced" receives the phase change with no wonder, and no violation of any physical laws.

Now, let us address the pending question we have raised earlier in this paper, namely the entity of the master wave function that governs the entire universe. Our answer is, in the deepest layer of mother nature, there are no laws at all.

All regularities or physical laws are nothing but statistically correct patterns or statements. The law of large number and the central limit theorem tell us that even out of a complete randomness, we may still expect certain patterns to appear as far as our sampling procedures are consistent. In other words, order comes not from the nature itself, but instead from the ordered actions of its observers.

It is not abstract mathematics that ultimately governs the universe. "The unreasonable effectiveness of mathematics in the natural sciences", as admired by Eugene Wigner, in our view, is not because of any divine power of mathematics, but because it is the only language that human can make use of to describe the nature. Some theories of mathematics are proven to be extremely powerful in physical studies, since they happened to share some similarities in their structures with that of the phenomenon in our question.

All successful scientific theories are nothing but a set of self-consistent logical statements, including but not limited to our definition of time and energy. Any theory that first seemed perfect but was later proven to be incomplete, for example the Newtonian mechanics, is because its seemingly perfect logical structure had not met with a test for the hardest challenge yet. For the case of Newtonian mechanics, the problem was that the Galilean transform was not consistent with our definition of time (whereas Lorentz transform was). The invariance of the speed of light rightly complies with our definition of time. As we have reveled in this paper, the velocity of light, as the conversion coefficient between spatial separations and temporal progressions (namely the degree of spatial asymmetry), deservedly has to be constant.

Back to the entity of the master wave of probability density, it is probably no more than an imaginary construct that can best explain, without self-contradiction, all the phenomena that happen on a macroscopic enough scale. In this sense, even the fundamental physical constants may only seem to be invariant as we always measure them with huge enough number of trials. The completely random and stochastic nature of the quantum mechanical world can be alternatively interpreted as if it were the basic constants that are always wandering, vice versa. After all, it is a matter of subjective decision as for how to interpret the nature.

The uncertainty principle tells us that only when we have carried out enough number of trials may we obtain a result with a higher certainty. In his famous book "What is Life", Erwin Schrodinger had sharply pointed out that all physical laws become reliable only when they are judged by the average behavior of a huge enough number of atoms, which is the very reason why all living creatures have to acquire a certain macroscopic size. A search for the ultimate law of the nature will necessarily end up with "law without law". It is a conclusion that can be drawn from repetitive rounds of logical reasoning. If we worship a deterministic rule to be the final destination of scientific explorations, then what renders the deterministic character to the rule? The only way to escape from such an endless rat race is to admit Wheeler's slogan, "law without law".

Eventually, our newly proposed theoretical paradigm may rephrase the almighty principle of least action as a principle of most probability, which is equivalent to least asymmetry in the space. Physical action has a unit of angular momentum whose conjugate unit in Heisenberg's uncertainty principle is dimensionless, which could be understood either as an angle or as a probability. In the latter context, the existence of a larger quantum angular momentum is equivalent to a lesser probability of occurrence of such a situation. Thus, the principle of least action is a rephrase of a trivial fact that it is always the event with the highest probability to be the most likely to happen (What a statement with 0 bit information). As the scale of our observation grows up to macroscopic, the predominance of the highest probability becomes more and more overwhelming compared to the second highest in an exponential manner due to the multiplicative nature of probability. Therefore, even a mere probabilistic pattern may well look like a virtually deterministic law.

Unlike the speed of light, and the gravitational constant, the Planck "constant" as a decisive rate limiting factor between deterministic classical physics and probabilistic quantum mechanical world, now has good reasons to be a variable dependent on the size of the universe. A cosmological event horizon that encloses a larger volume may contain more spatial quanta within it (even without the scale factor dependent decrease of the diameter of quanta), thus quite understandably corresponds to a much more deterministic universe. It is rather natural that the Planck scale is a set of evolving standards instead of rigid rulers. Its evolution in accordance with the size or age of the observable universe gratefully frees us from the "mission impossible" to draw specific meaning from the current values of many physical constants or to "glimpse the mind of God" who governs the entire universe.

In response to Einstein's famous quote "God does not throw dice", Bohr warned him "Don't tell the God what to do, Einstein." Today, we have found a better reply: "Yes, you are right, Einstein, but in the sense that the dicey character of the nature is the very proof that there is no God."

In the end, let us present an alternative breakdown of the Riemannian geometry of the general relativity into two Newtonian mechanic Poisson equations for gravitational potential, which act in synergy to reproduce the outputs of the Einstein equations.

<First layer of gravitational attraction>

$$\nabla^2 \phi = 4\pi G(\rho + P)$$

(Take both ρ and P as inversely proportional to the cube of the radius.)

<Second layer of gravitational attraction>

$$\nabla^2 \phi = 4\pi G(2P)$$

(Take P as constant regardless of the radius.)

It is not hard to check that this alternative formulation reproduces exactly the same outcomes for both the FLRW metric and Schwarzschild metric. Interestingly, the critical pressure that results in zero acceleration in the first layer ($P = -\rho$) is the condition in the Friemann equations that ensures a space expansion with its energy density remains constant, while that of the second layer ($P = 0$) is the very condition for an expansion of space with energy density inversely proportional to the volume. Such a cross-over relation strongly implies that gravitational interaction may be a kind of homeostatic response to alteration of energy distribution from the preceding configuration.

The concept of space-time curvature in response to energy momentum tensor is a convenient mathematical tool or a sophisticated analytical language that neatly describes the culminated synergistic outcomes of the two gravitational accelerations contributed from myriads of energy/mass quanta (both static & moving), which is applicable for any arbitrary energy momentum dynamics. On the other hand, our newly proposed formulation may not provide with us closed form expressions for all kinds of mass distribution. However, as far as the practicability is concerned, the case is not anyhow better for the general relativity either, which celebrates its centennial with only a handful of rigorous solutions for highly symmetric conditions. Most importantly, unveiling the Newtonian structure beneath the general relativity, in other words, becoming free from the fetters of the continuous space-time dogma, is a critical step toward the unified understanding of gravity with other forces.

It seems to us the first Poisson equation is unable to be translated into Maxwellian language of fields, which further leads to obviously Lorentz invariant tensor equations and can directly predict the existence of gravitational waves. However, as long as it is equivalent to general relativity, its incompatibility with Maxwellian electromagnetism shall not be a lethal defect that definitively ruins the completeness of our newly proposed formulation. We believe that it is now needless to say that superficial mathematical disunity does not necessarily mean the inconsistence of our understanding of the fundamental interactions. since mathematics is no more than a convenient tool to approximate the intrinsically random behavior of the nature.

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