On the Physics of the Spontaneous Symmetry Breaking in a Binary Field

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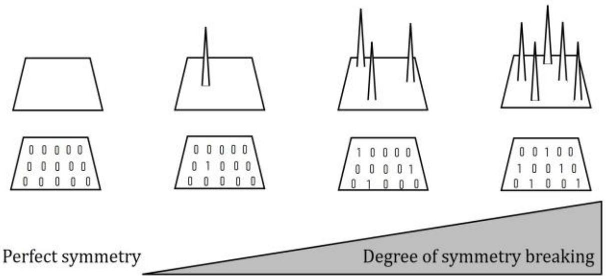
The entity of time and energy have successfully evaded any concrete definition or elucidation for a disproportionately long period despite their pivotal importance in physics. In this paper, we present a novel theoretical scheme in which not only time and energy but all perceivable physical realities can be concretely defined by the degree of asymmetry in a binary digital field. It is made up of spatial quanta with Planck scale properties, and the field has an intrinsic potential to break its symmetry in a totally spontaneous and stochastic manner. The scheme vividly explains the origin of the mass of most of the elementary particles only with fundamental physical constants plus some numbers with universal meaning such as the fractional powers of pi, instead of any artificial parameters. Though it is still in a hatching stage like the old quantum theory, as this paper shows in detail, its capability to provide clear physical images as for why particular Lie groups could rightly describe their corresponding forces is a promising sign that this paradigm shall serve as a powerful guide toward the super-unification of all the fundamental interactions.

Firstly, let us dedicate this 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 had reached exactly the same conclusions of this paper 40 years earlier, and it is no exaggeration to say that this paper is all the way reaffirming the greatness of his insights which 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, thus all physical realities can be reduced down to a collection of ultimate binary choices between 0 and 1 of supreme abstraction. However, it is not the bit information carried by the collection, but the degree of symmetry breaking in such a binary N-dimensional field that gives rise to the 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 such 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 finally broken down to a collection of bilateral relationships between two flipped quanta ("pair" hereafter), regardless of the dimension of the field.

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

The mathematics 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 specific 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.

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

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

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

As we shall shortly see the 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 square of the amplitude of wave function 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.

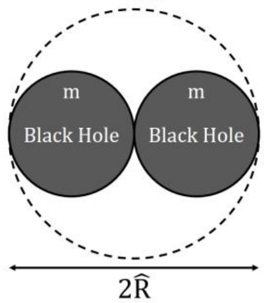
Given that the energy of a pair is defined proportional to the inverse of its length, any force between the quanta, from its definition as the derivative of energy by distance, must be proportional to the inverse square of the length, regardless of the number of spatial dimensions. It is this very nature 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 radius of spatial quanta, which serves as the minimal length unit in the binary field, can be reasonably calculated supposing that it two quanta were brought to that specific distance, each of them would instantly collapse to form a mini-black hole according to our definition of energy.

$$2m = \frac{\hbar}{4\hat{R}c} = \frac{\hat{M}}{2}$$



$$m = \frac{1}{2}\frac{\hbar}{2 \times 2\hat{R}c} = \frac{\hbar}{8\hat{R}c}$$

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

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

$$\hat{M} = \frac{\hbar}{2\hat{R}c} = \frac{m_P}{\sqrt{2}} = 1.54 \times 10^{-8}[\mathrm{kg}]$$

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.

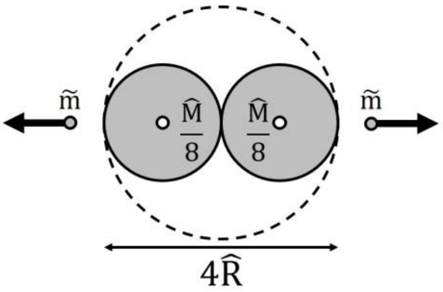
Let us begin to introduce the evidence for the legitimacy of our hypothesis. Firstly, the calculation in below implies that the electron-positron pair production is likely to be a breaking of equilibrium in which the gravitational attraction that holds a mass lump of $\widehat{\mathrm{M}}/4$ together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

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

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

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

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



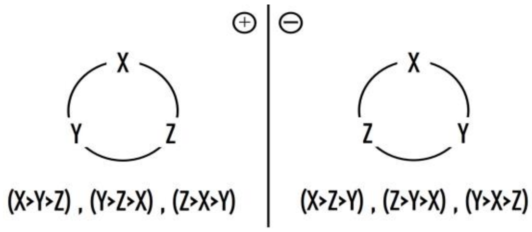
The above illustration is our proposed process. Two pairs of spatial quanta, each with a combined mass of $\widehat{\mathrm{M}}/4$ (since diameter is $4\widehat{\mathrm{R}}$) thus $\widehat{\mathrm{M}}/8$ per quantum, is rotating at a velocity of c/4 (by Newtonian calculation) in which the two quanta 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.

$$\frac{\mathrm{G}\frac{\widehat{\mathrm{M}}}{8}}{(2\widehat{\mathrm{R}})^2} = \frac{\mathrm{v}^2}{2\widehat{\mathrm{R}}}$$

$$\mathrm{v} = \sqrt{\frac{\mathrm{G}\widehat{\mathrm{M}}}{16\widehat{\mathrm{R}}}} = \sqrt{\frac{\mathrm{G}\hbar c^3}{16\mathrm{G}\hbar c}} = \frac{\mathrm{c}}{4}$$

The reason why the rest mass of electron $\mathrm{m_e}$ needs an inverse Lorentz adjustment from $\tilde{\mathrm{m}}$ 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 without the root 2 as the critical divisor.

As proposed in another paper submitted back-to-back with this one, we hypothesized a cosmic scale factor-dependent decrease of the mass of elementary particles, in a manner inversely proportional to the square of scale factor. Here comes the astounding integration of the two hypotheses.

The stochastic flip of the space quanta from 0 to 1, can be alternatively interpreted as the outcome of a Bernoulli trial choosing one out of two opposite states with a 50%:50% probability, where the flips are the surpluses after the trial. According to the well-established theory of random walk, even out of such a perfectly random process, we could still expect a surplus favoring one side over the other, with a magnitude proportional to the square root of the number of trials. Given that our cosmological horizon expands at a constant pace which is exactly the velocity of light, as the other paper of ours suggests, then for each layer of the horizon which has a number of spatial quanta proportional to the square of the cosmic radius, the expected surplus is proportional to the radius. An easy integral along the radius gives a total number of flipped quanta proportional to the square of the radius, thus the average probability density of the flip shall be inversely proportional to the cosmic radius. Note that the increase of the total number of quanta (both flipped and non-flipped) within our cosmological horizon is a gradual process, layer by layer as the cosmological age grows, we should not brutally conclude that the probability density is inversely proportional to the square root of the volume, by simply regarding the cosmological volume as a proportionate measure of the number of total trials.

As proposed in the other paper of ours, given that there only exists 44.4% (4/9) of the conventional critical density in our universe, which is roughly $3.76 \times 10^{-27}[\mathrm{kg} / \mathrm{m}^3]$, the calculations in below almost undoubtedly prove that our universe started from the very breaking of an equilibrium where the probability of two spatial quanta flips occurring simultaneously in close vicinity had surpassed the energy equivalent to such a fractional number of a single nucleon, at that specific cosmic stage.

The Hubble's constant from the latest Planck 2018 result is

$$\mathrm{H}_0 = 67.4[\mathrm{km/s\,/Mpc}] = 2.18 \times 10^{-18}[\mathrm{s}^{-1}].$$

The corrected true Hubble's constant ($=2\mathrm{H}_0/3$) is

$$\mathrm{H} = 1.45 \times 10^{-18}[\mathrm{s}^{-1}].$$

The current radius of the cosmological event horizon is

$$\mathrm{R_H} = \mathrm{c/H} = 2.07 \times 10^{26}[\mathrm{m}].$$

The current mass density of the universe (vacuum energy included, non-relativistic matter vs. vacuum energy = 2:1) is

$$\rho = \frac{3\mathrm{H}^2}{8\pi\mathrm{G}} = 3.76 \times 10^{-27}[\mathrm{kg} / \mathrm{m}^3].$$

The current Hubble mass of the universe is

$$\mathrm{M_H} = \frac{4\pi\mathrm{R}^3}{3}\rho = 1.40 \times 10^{53}[\mathrm{kg}],$$

equivalent to 8.36×10^{79} times the mass of neutron (the so-called Eddington number), neutron is as the precursor of a proton and an electron through beta decay.

The Hubble radius has increased from the initial state (a singular spatial quantum) by a factor of

$$\frac{\mathrm{R_H}}{\hat{\mathrm{R}}} = \frac{2.07 \times 10^{26}[\mathrm{m}]}{1.14 \times 10^{-35}[\mathrm{m}]} = 1.82 \times 10^{61},$$

which is the cube of 2.63×10^{20}. According to the other paper of ours, the Eddington number should have increased by a factor of 4.78×10^{81} (4th power of 2.63×10^{20}) from its initial value. Thus, the initial Eddington number was 1.75×10^{-2}. Again, according to the same paper, the inverse of 2.63×10^{20} is the decreasing factor of the probability density of quanta flipping. Its current value is exactly the inverse square root of the magnitude gap between gravity and electromagnetic force in the case of electron-electron interaction, namely the square root of $1/\,4.16 \times 10^{42}$, equals to $1/(2.04 \times 10^{21})$. This means that the initial probability density was 1/7.56.

$$(1.75 \times 10^{-2}) \times (7.56)^2 = 1.00\ !!!$$

What a too-beautiful-to-be-wrong calculation!

Now that we may have to correct our statement that there are structurally twice as much non-relativistic matters as the vacuum energy. The truth shall be that the pressure of non-relativistic matters from the perspective of the cosmological event horizon is exactly negative 1/3 of its energy density. Photon gas with a fixed volume has a pressure 1/3 of its energy density, thus a space whose boundary is expanding with the velocity of light (while its inner contents remain relatively static to it), as the case of the contrary, shall deservedly maintain the relation that $P = -\rho c^2/3$.

As for the logic that the probability density of quanta flips shall be inversely proportional to the cosmic radius, we can also take another approach. Suppose there is a primordial wave function that governs the probability destiny in the entire universe, propagating at the velocity of light, all the way from the singularity (we now should say an activated spatial quantum, not 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 3-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 of the existence of such a wave function later, when the time is ripe.

With our hypothesis has probably gained enough credit in the eyes of its readers, let us show some other interesting calculations that support the hypothesis, but with less clarity for their exact interpretation at this stage, thus are awaiting further investigations.

1) Mean lifetime of free neutrons

Taking the figure $\tau_{\mathrm{nbeam}} \approx 880$ [s] measured by the so-called beam method, it may hardly be a coincidence that

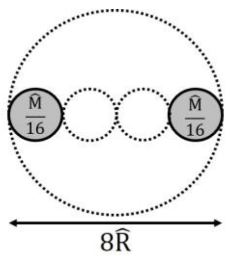
$$\frac{\pi\hat{R}\frac{m_n}{\widetilde{m_e}}}{c\tau_{\mathrm{nbeam}}} \approx \left(\frac{1}{2.04 \times 10^{21}}\right)^2$$

where m_n is the rest mass of neutron, $\widetilde{m_e}$ is the adjusted mass of electron by 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 noted that this gap can be well enough approximated by the Lorentz factor of $c/8$,

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

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



$$\frac{G\frac{\hat{M}}{16}}{(4\hat{R})^2} = \frac{v^2}{4\hat{R}}$$

$$v = \sqrt{\frac{G\hat{M}}{64\hat{R}}} = \sqrt{\frac{G\hbar c^3}{64G\hbar c}} = \frac{c}{8}$$

It may have something to do with the participation of the two additional quanta, which cannot get closer than 4D 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, $\tau_{\mathrm{Higgs}} = 2.1(+2.3/-0.9) \times 10^{-22}[\mathrm{s}]$ agrees well enough with the below calculation that has a clear similarity with the case of free neutron.

$$\frac{\frac{\pi\hat{\mathrm{R}}}{\widetilde{\mathrm{m}}} \times 2.04 \times 10^{21}}{\mathrm{c}} = 2.04 \times 10^{21}[\mathrm{s}]$$

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.

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

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 $4\hat{\mathrm{D}}$. 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.

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

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

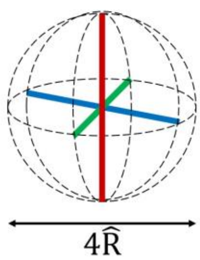
Another implication from that equation is somehow latent or rather stealth, but its profound impact may be far beyond our first impression. The equation shows that

$$\mathrm{k}_0\mathrm{e}^2\left(4\hat{\mathrm{R}}\right)^2 = \mathrm{Gm}^2\left(\frac{\hbar}{4\widetilde{\mathrm{m}}\mathrm{c}}\right)^2 = \mathrm{constant}.$$

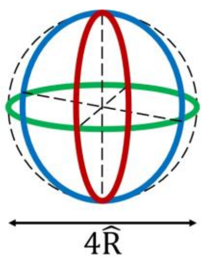
You must have thought, what a trivial fact? Aren't they both constants? Let us explore the possibility that if they are not.

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 the electromagnetism such that proton needs more mass than electron to equally take part in electromagnetic interactions?

As for how the distance part might be variable, the first idea that came up to our mind was the mechanics of rigid bodies were much more abundant 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 $4\hat{\mathrm{R}}$ (as they consist of two quanta). "Point" just means they do not have 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, for the latter is kind of restricted within the diameter of the former.

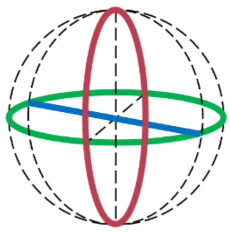


Mass-point-type



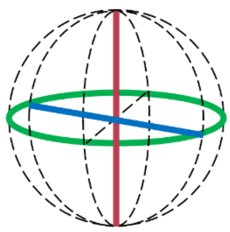
Rigid-body-type

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" still are the partially shrunk rigid-body-type particles, compared with the genuine mass-point type one.



1-dimension shrunk

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



2-dimension shrunk

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

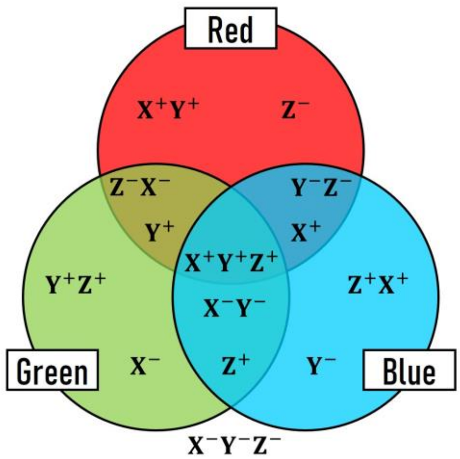
The inversely proportional relation of charge and span shown in our equation implies that a larger effective span shall diminish a mass's responsiveness to electromagnetism. Therefore, the partially shrunk states of mass lump may respectively have inferior electromagnetic responsiveness by factors of

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

Suppose the two spatial quanta evenly contribute to the electromagnetic responsiveness of the Fermion that they collectively define, then each one of them would have an electromagnetic responsiveness further inferior to that of the mass-body-type particle, namely electron, by factors of 1/9.20 and 1/4.30 respectively. A lesser electromagnetic responsiveness means a larger mass is 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 9.20 and 4.30 times of the electron mass respectively, which are exactly the experimentally established theoretical mass of down quark and up quark.

With this 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. Thus, each half of the rotating mass lump did not have a mass of $\widehat{M}/8$ and a unit charge, but was actually giving up half of its mass (maintaining the other as its mass) to acquire 1/2 of a unit charge. It was rightly 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 one of the two spatial quanta within a partially shrunk rigid-body-type particle, namely hadron, in high energy collisions. It interacts with one of the two spatial quanta that define the incoming lepton and let it scatter. The form of quark, as a singular quantum in a transiently shrunk hadron, can only exist together with its spatial quantum partner, therefore, it does not make sense outside of hadrons. The 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 ultimate 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 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 ($X^-Y^-Z^-$)

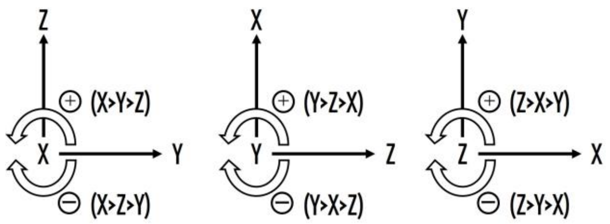
	CYAN	MAGENTA	YELLOW
$\overline{uud}$	X^-Y^-	Y^-Z^-	Y^+
$\overline{udu}$	X^-Y^-	X^+	Z^-X^-
$\overline{duu}$	Z^+	Y^-Z^-	Z^-X^-

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^-

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 $\pm 2/3$ accordingly. Down quark (one dimension shrunk) has a larger geometric mean of spatial span compared with up quark (two dimensions shrunk). It explains why nucleons have their respective charge radius and mass radius, since the superposition of mass and electric charges offset in their respective, independent manner.

Signs of charge may depend on the rotation mode of the shrunk particle on each dimension. Note that by the aforementioned definition of rotation mode, we may not only define the mode of the entire particle, but also the mode seen from each axis of spatial dimensions. 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 the quantum mechanical wave must be defined as complex functions. The necessity to use complex numbers in describing the dynamics of the spatial quanta might be just due to the historical inevitability since we have chosen real numbers to build the physics of the superficial particles with which we are much more familiar. Furthermore, the mathematics of complex numbers, or we should particularly say imaginary numbers, turns out to be the final sentence to the theory of QCD, as we have found a strikingly beautiful solution as to how protons and neutrons are bound 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 $1/\pi^2$ (since 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 up quark and down quark might 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 the spans over all the three dimensions) between rigid-body-type particles and mass-point-type ones. It is interesting that the theoretical mass of s 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 uniform positive charge density, as a good approximation of atomic nuclei. 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 0, as the utmost 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 seems nonsense in the conventional context, since the square of the velocity is negative. However, being free from all kinds of prejudice, if an imaginary number velocity is allowed, what will happen? A direct consequence shall be that the Lorentz factor turns out to be bigger than 1. Having paved the way for quite long, we believe that an idea such that this imaginary number velocity represents the motion of the spatial quanta may not sound too abrupt. And which 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 the nucleus, into the equation. Then multiply the resulted “Hubble constant” of atomic nuclei with $\sim 10^{15}$ [m] as the order of their radii. Surprisingly, it can be found that the imaginary velocity falls to exactly the same order with the velocity of light. At such a non-negligible velocity, the aforementioned bigger-than-one Lorentz factor would rightly reduce the relativistic mass by roughly 1~2% (instead of becoming heavier!), which shall be exactly the binding energy per nucleon for the elements with double digit atomic number. Our approximation may not work well enough for the nuclei of light elements as their charge density shall be far from homogeneous. Note that the imaginary velocities are theoretically proportional to the distance of nucleons from the center of atomic nuclei, thus the effect of relativistic reduction of mass (which is nothing but the magnitude of the binding energy) increases with the 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 this sharing of spatial quanta that nucleons could to reach a less massive and thus more stable complex. Due to the limitation of space, we will not go any further into too much detailed quantitative discussions on specific atomic nuclei. However, it may not diminish the persuasiveness of our hypothesis even by a little bit, we believe.

With the discovery of imaginary velocity, we have to slightly correct our previous equations. Instead of multiplying the Lorentz factor of c/4 or c/8, we should have 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 the fine structure constant.)

We intentionally let the slight difference go, as the time for such a correction will only be ripe at this stage. After all, the rest mass of elementary particles needs a reverse adjustment from pure theoretical calculations, because the rest mass to us is actually 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 origin of so many exotic baryons and mesons, our hypothesis may 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,

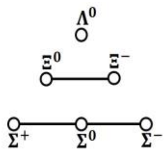
$$\dot{m} = m_p\sqrt{1 + \left(\frac{1}{4}\right)^2} \approx 967[\mathrm{MeV} / c^2]$$

we may find with great surprise that the mass of the 16 baryons (other than proton and neutron) that 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)

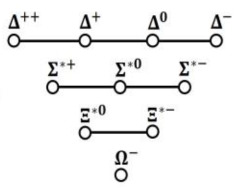


$\sqrt[3]{2}\dot{m} \approx 1218 \rightarrow \Delta^{++}, \Delta^+, \Delta^0, \Delta^-$ (1232)

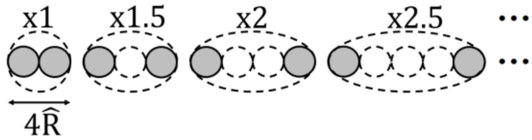
$\sqrt[3]{3}\dot{m} \approx 1395 \rightarrow \Sigma^{*+}, \Sigma^{*0}, \Sigma^{*-}$ (1383~1387)

$\sqrt[3]{4}\dot{m} \approx 1535 \rightarrow \Xi^{*0}, \Xi^{*-}$ (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 experiment, where we could just indirectly assume that nucleons have deeper structure from the scattering pattern of electrons (we could never actually observe any independent quark), hadron collider experiments do churn out numerous detectable exotic baryons and mesons. The difference is, exotic baryons, though very short-lived, are nonetheless made of spatial quanta pair, therefore are genuine rigid-body-type Fermions as carriers of electric charge. Compared with proton, the electromagnetic responsiveness of each excitation state shall be, by some unknown mechanisms, 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 the square root of 1.5 gives rise to the sigma baryons remains to be further examined. The case might be one of the three dimensions had collapsed first, then the two-dimensional "disk" expands one of its two dimensions.) 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 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 investigation.

In summary, quarks are one of the two quanta that make up a partially shrunk nucleon in where one or two of its three spatial dimensions transiently changes from rigid-body-type to mass-point-type degree of freedom. Gluons are thus the energy exchanged in transitions among these different states of shrinkage. Exotic baryons are nucleons that transiently expanded along one of its three dimensions, mesons are thus the energy exchanged during the transition among these different expansion states. The dazzling patterns of the cascade in hadron decays are probably the reflections of probable transitions among all possible states, which should be explained without problem in the context of our model.

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 supposed to be made of only u/d/s quarks. It implies that nucleons have three intrinsically distinctive modes upon the transient expansion of spatial dimensions, namely which one of the three to be expanded. One natural explanation could be that compared with the first and the easiest choice of expansion that gives rise to the 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 factors of ~1/8 and ~1/125 (or 1/137?) respectively, which in turn generate baryons that are roughly twice and five times massive as those generated by the first mode of expansion. It may not be useless to point out that the ratio between the mass of tauon and muon is roughly 136:8, though we cannot further figure out where does the residual ~8π (when we divide the mass of tauon by 8 times of electron's) come from.

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 completely homogeneous, we may no longer be able to define the two intrinsically distinctive modes of rotation as we have proposed. From this point of view, it is rather deservedly that right-handed spin and left-handed spin should 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 is rather a phenomenon being noticed rightly because of the addition of newly flipped spatial quanta to the pre-existing physical system that we had been observing. The reason why only the Bosons for the weak interaction possess mass, may highly 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 culminated by the universal attraction between them. The strong force can be separated 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. The motion of spatial quanta at imaginary velocities contributes to a relativistic reduction of mass, stabilizing the atomic nucleus in the form of binding energy. The phenomena that imply any inner structures of hadrons are indeed watching the transient snapshots of the hadrons, which should not have been even noticed unless the hadrons were smashed to each other in those extra high energy colliders. The theory of QCD rightly reflects the fact that the three rigid-body-type dimensions of nucleons may randomly change its type or extend its span under high energy conditions. The weak interaction can be seen as an inevitable consequence of the spontaneous symmetry breaking of the binary field, which occurs whenever two additional spatial quanta are stochastically flipped and brought closer by the universal attraction to the vicinity of an existing particle.

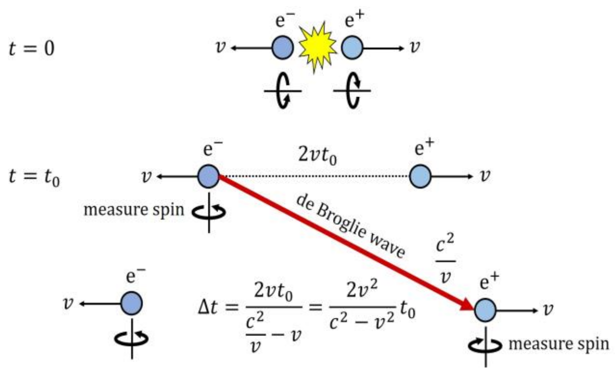
Our theory vividly explained, with clearcut physical images, why electromagnetism, weak force and strong force are respectively linked with U(1), SU(2) and SU(3) Lie group in the Yang-Mills theory. The groups have to be defined in complex space because of the necessity to describe the motion of the spatial quanta living in another layer that is deeper than that of the real number based detectable particles. The meaning of dimension number in each of the Lie group is now trivial to the readers, 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 outcomes of "newly" designed experiments, which are actually nothing but reaffirming its reproductivity by thousands of minorly tinkered versions of similar conditions, without really challenging the credibility of the model. Luckily enough, 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 21st century 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 (though already too close to the finale), we would like to 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 and the relativity of simultaneity. Fairly simple mathematics can prove that the seemingly instant transmission of quantum states over light years is indeed a totally lawful propagation of the phase change at the super-luminal phase velocity of the de Broglie wave.



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

The 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.

In the end, 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. We guess that most of you may have reached your own conclusion which should not be too far from ours. Our answer is, in the deepest layer of our 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 any 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 itself, but because it is the only language that human can use to describe the nature. Some theories of mathematics are proven to be extremely powerful in physics, since they happened to share certain similarities in their structure with the phenomenon in our question, nothing more, nothing less.

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 the definition of time. As we have unveiled in this paper, the velocity of light, as the converting coefficient between the spatial separation and the temporal progression (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 or concept 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 was the basic constants that are always wandering, vice versa. After all, it is a matter of subjective decision as for how to understand the nature.

The uncertainty principle tells us that only when we have collected enough number of samples may we obtain some results 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 of no 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 of no law".

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

Lastly, let us make a final declaration. Having read our paper, some of you may wonder if we were traversers from a world 300 hundred years from now, telling the progress of physics in these years. We can responsibly and sadly tell you, in spite of our painstaking effort, we could not find even the tiniest possibility that time travel to the past is allowed by physics.

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