Journal of Modern Physics, 2016, 7, 1150-1159
Published Online June 2016 in SciRes. http://www.scirp.org/journal/jmp
http://dx.doi.org/10.4236/jmp.2016.710104

The Integer-Fraction Principle of the Digital Electric Charge for Quarks and Quasiparticles

Ding-Yu Chung

Utica, MI, USA
Email: dy_chung@yahoo.com

Received 8 April 2016; accepted 17 June 2016; published 21 June 2016

Abstract

In the integer-fraction principle of the digital electric charge, individual integral charge and individual fractional charge are the digital representations of the allowance and the disallowance of irreversible kinetic energy, respectively. The disallowance of irreversible kinetic energy for individual fractional charge brings about the confinement of individual fractional charges to restrict irreversible movement resulted from irreversible kinetic energy. Collective fractional charges are confined by the short-distance confinement force field where the sum of the collective fractional charges is integer. As a result, fractional charges are confined and collective. The confinement force field includes gluons in QCD (quantum chromodynamics) for collective fractional charge quarks in hadrons and the magnetic flux quanta for collective fractional charge quasiparticles in the fractional quantum Hall effect (FQHE). The collectivity of fractional charges requires the attachment of energy as flux quanta to bind collective fractional charges. The integer-fraction transformation from integral charges to fractional charges consists of the three steps: 1) the attachment of an even number of flux quanta to individual integral charge fermions to form individual integral charge composite fermions, 2) the attachment of an odd number of flux quanta to individual integral charge composite fermions to form transitional collective integral charge composite bosons, and 3) the conversion of flux quanta into the confinement force field to confine collective fractional charge composite fermions converted from composite bosons. The charges of quarks are fractional, because QCD (the strong force) emerges in the universe that has no irreversible kinetic energy. Kinetic energy emerged in the universe after the emergence of the strong force. The charges of the quasiparticles in the FQHE are fractional because of the confinement by a two-dimensional system, the Landau levels, and an extremely low temperature and the collectivity by high energy magnetic flux quanta. From the integer-fraction transformation from integral charge electrons to fractional charge quarks, the calculated masses of pion, muon and constituent quarks are in excellent agreement with the observed values.

How to cite this paper: Chung, D.-Y. (2016) The Integer-Fraction Principle of the Digital Electric Charge for Quarks and Quasiparticles. *Journal of Modern Physics*, **7**, 1150-1159. http://dx.doi.org/10.4236/jmp.2016.710104

Keywords

Electric Charge, Integral Charge, Fractional Charge, Quarks, Kinetic Energy, Confinement, The Fractional Quantum Hall Effect, The Theory of Everything, The Masses of Quarks, The Mass of Muon, The Mass of Pion, Cosmology

1. Introduction

The elementary charge denoted as e or q is a fundamental physical constant for electric charge. One elementary charge has a measured value of approximately 1.602×10^{-19} coulombs. The electric charge of any isolated object is an integer multiple of e. Quarks and quasiparticles have fractional charges. Quarks have fractional electric charge values 1/3 or 2/3 times the elementary charge. There have been a large number of experiments searching for fractional charge, isolatable, elementary particles using a variety of methods, but no evidence has been found to confirm existence of free fractional charge particles, which leads to the quark confinement concept that the quarks in collective groupings are permanently confined within the hadrons whose charges are integer multiples of e [1]-[4]. Fractional charge quasiparticles in the fractional quantum Hall effect (FQHE) also exist in collective groupings in the confinement of a two-dimensional system, the Landau levels, and an extremely low temperature [5]-[7]. Confinement and collectivity are the common features in fractional charge quarks and quasiparticles. This paper posits that the origin of integral electric charge and fractional electric charge is the integer-fraction principle of digital electric charge. The principle relates to the confinement and collectivity of fractional charges.

Section 2 describes the integer-fraction principle. Section 3 explains the origin of the strong force as the confinement force field for fractional charge quark and the calculations of pion, muon and quark masses. Section 4 describes the fractional quantum Hall effect for fractional charge quasiparticles.

2. The Integer-Fraction Principle

There are integral electric charge and fractional electric charge. The two types of fractional charge particles are fractional charge quarks in hadron and fractional charge quasiparticles in the FQHE. The origin of integral electric charges and fractional electric charges is unknown. This paper posits that the origin of integral electric charge and fractional electric charge is the integer-fraction principle of digital electric charge. In the integer-fraction principle of the digital electric charge, individual integral charge with irreversible kinetic energy to cause irreversible movement is allowed, while individual fractional charge with irreversible kinetic energy is disallowed. Individual integral charge and individual fractional charge are the digital representations of the allowance and the disallowance of irreversible kinetic energy, respectively. The disallowance of irreversible kinetic energy for individual fractional charge brings about the confinement of individual fractional charges to restrict the irreversible movement resulted from kinetic energy. Collective fractional charges are confined by the short-distance confinement force field where the sum of the collective fractional charges is integer. As a result, fractional charges are confined and collective. The confinement force field includes gluons in QCD (quantum chromodynamics) for collective fractional charge quarks in hadrons and the magnetic flux quanta for collective fractional charge quasiparticles in the fractional quantum Hall effect (FQHE).

The collectivity of fractional charges requires the attachment of energy as flux quanta to bind fractional charges. As a result, the integer-fraction transformation from integral charges to fractional charges involves the integer-fraction transformation to incorporate flux quanta similar to the composite fermion theory for the FQHE [8] [9]. There are two steps in the composite fermion theory for the FQHE. The first step is the formation of composite fermion by the attachment of an even number of magnetic flux quanta to electron. Composite fermions in the Landau levels are the "true particles" to produce the FQHE, while electrons in the Landau level are the true particles to produce the integral quantum Hall effect (IQHE). The IQHE is a manifestation of the Landau level quantization of the electron kinetic energy. The second step is the conversion of integral charges to fractional charges in the collective mode of composite fermions. The IQHE in the collective mode of composite fermions is the FQHE as expressed by the filling factors υ's related to electric charges.

$$
\begin{aligned}
&\text{the composite fermion theory} \\
&\text{the first step:} \\
&\text{electrons} \xrightarrow{\text{even numbers of magnetic flux quanta}} \text{composite fermions} \\
&\text{the second step for the collective mode of composite fermions:} \\
&\nu^* = m \ \text{ for the IQHE} \\
&\nu = \frac{\nu^*}{2n\nu^* \pm 1} = \frac{m}{2mn \pm 1} \ \text{ for the FQHE} \\
&\text{for } \nu^* = 1,\ \nu = \frac{1}{2n+1} \ \text{ for the Laughlin wavefunction of the FQHE}
\end{aligned} \tag{1}
$$

where m and n are integers, and υ and υ^* are the filling factors for electrons and composite fermions, respectively in the Landau levels. The composite fermion theory is used to compute precisely a number of measurable quantities, such as the excitation gaps and exciton dispersions, the phase diagram of composite fermions with spin, the composite fermion mass, etc.

The first step of the integer-fraction transformation from integral charge to fractional charge is same as the first step in the composite fermion theory. The first step is the attachment of an even number of flux quanta to individual integral charge fermions to form individual integral charge composite fermions [6]. Flux quanta are the elementary units which interact with a system of integral charge fermions. The attachment of flux quanta to the fermions transforms them to composite particles. The attached flux quanta change the character of the composite particles from fermions to bosons and back to fermions. Composite particles can be either fermions or bosons, depending on the number of attached flux quanta. A fermion with an even number of flux quanta becomes a composite fermion, while a fermion with an odd number of flux quanta becomes a composite boson. Fermions, such as electrons and protons, follow the Pauli exclusion principle which excludes fermions of the same quantum-mechanical state from being in the same position. Bosons, such as photons or helium atoms, follow the Bose-Einstein statistics which allows bosons of the same quantum-mechanical state being in the same position. As a result, fermions are individualistic, while bosons are collectivistic. Composite fermions are individualistic, while composite bosons are collectivistic. In the first step, the attachment of an even number of flux quanta to each integral charge fermion provides these fermions individual integral charge composite fermions which follow the Pauli exclusion principle.

The second step involves the traditional composite bosons. The second step explains the origin of $1/(2n + 1)$ in Equation (1) in the second step of the composite fermion theory which does not explain the origin of $1/(2n + 1)$. The second step is the attachment of an odd number of flux quanta to individual integral charge composite fermions to form transitional collective integral charge composite bosons [6]. Individual integral charge composite fermions with an odd number $(2n + 1)$ of flux quanta provide collective integral charge composite bosons which allow bosons of the same quantum-mechanical state being in the same position. The collective integral charge composite bosons allow the connection of collective flux quanta from collective integral charge composite bosons. Each flux quantum represents an energy level. In individual integral charge composited fermions, the degenerate energy levels are separated. In collective integral charge composite bosons, the $2n +1$ degenerate energy levels are connected into $2n + 1$ sites in the same energy level.

The third step is the conversion of collective flux quanta into the confinement force field to confine collective fractional charge composite fermions converted from the collective integral charge composite bosons. In collective fractional charge fermions, each site in the same energy level has $\pm 1/(2n + 1)$ fractional charge.

$$
\text{fractional charge per site in the same energy level} = \frac{\pm 1}{2n+1} \tag{2}
$$

Fractional charges are the integer multiples of $\pm 1/(2n + 1)$ fractional charge to explain the origin of $1/(2n + 1)$ in Equation (1) for the composite fermion theory. The products in the third step also include individual integral charge fermions to conserve electric charge. The sum of all collective fractional charges and individual integral charges is integer. The integer-fraction transformation from individual integral charge fermions to collective fractional charge fermions is as follows.

$$\begin{aligned}&\text{individual IC fermions} \xrightarrow{\text{even number of flux quanta}} \text{individual IC composite fermions}\\&\xrightarrow{\text{odd number of flux quanta}} \text{tramsitional collective IC composite bosons} \xrightarrow{\text{confinement force field}}\\&\text{collective FC composite fermions} + \text{individual IC fermions}\end{aligned} \quad (3)$$

where IC is integral charge and FC is fractional charge.

3. The Origin of the Strong Force and the Calculations of Pion, Muon and Quark Masses

The charges of quarks are fractional, because QCD (the strong force) emerged in the universe that had no irreversible kinetic energy. Kinetic energy emerged in the universe after the emergence of the strong force as described in the cyclic dual universe model previously [10] [11]. As described previously [10] [11], there are three postulates in the dynamic and reversible theory of everything. The first postulate of the dynamic and reversible theory of everything is the oscillating M-theory as the oscillating membrane-string-particle whose space-time dimension number oscillates between 11D and 10D and between 10D and 4D dimension by dimension reversibly. There is no compactization. Matters in oscillating M-theory include 11D membrane (2_{11}) as membrane (denoted as 2 for 2 space dimensions) in 11D, 10D string (1_{10}) as string (denoted as 1 for 1 space dimension) in 10D, and variable D particle ($0_{4\text{ to }11}$) as particle (denoted as 0 for 0 space dimension) in 4D to 11D. Space-time dimension number between 10 and 4 decreases with decreasing speed of light, decreasing vacuum energy, and increasing rest mass. The second postulate is the digital transitional Higgs-reversed Higgs fields postulate as the digital attachment-detachment spaces postulate. Attachment space (denoted as 1) attaches matter, and relates to rest mass and reversible movement. Detachment space (denoted as 0) detaches matter, and relates to irreversible kinetic energy. The combination of *n* units of attachment space as 1 and *n* units of detachment space as 0 brings about three different digital space structures: binary partition space, miscible space, or binary lattice space as below.

$$\underset{\text{attachment space}}{(1)_n} + \underset{\text{detachment space}}{(0)_n} \xrightarrow{\text{combination}} \underset{\text{binary partition space}}{(1)_n(0)_n}, \underset{\text{miscible space}}{(1+0)_n}, \text{ or } \underset{\text{binary lattice space}}{(1\,0)_n} \quad (4)$$

Binary partition space, $(1)_n(0)_n$, consists of two separated continuous phases of multiple quantized units of attachment space and detachment space. In miscible space, $(1 + 0)_n$, attachment space is miscible to detachment space, and there is no separation of attachment space and detachment space. Binary lattice space, $(1\ 0)_n$, consists of repetitive units of alternative attachment space and detachment space. Binary partition space $(1)_n(0)_n$, miscible space $(1 + 0)_n$, and binary lattice space $(1\ 0)_n$ account for quantum mechanics, special relativity, and the force fields, respectively. In this paper, the integer-fraction principle is an extension of the digital space structure consisting of attachment space for rest mass and reversible movement and detachment space for irreversible kinetic energy.

Our universe is in the reversible multiverse. In the third postulate for reversible multiverse, all physical laws and phenomena are permanently reversible, and temporary irreversibility of entropy increase is allowed through reversibility breaking, symmetry violation, and low entropy beginning. One irreversible phenomenon which is not allowed is the collision of expanding universes. The collision of expanding universes which have the inexhaustible resource of space-time to expand is permanently irreversible due to the impossibility to reverse the collision of expanding universes. To prevent the collision of expanding universes, every universe is surrounded by the interuniversal void that is functioned as the permanent gap among universes. The space in the interuniversal void is detachment space [10] which detaches matter and relates to kinetic energy. The interuniversal void has zero-energy, zero space-time, and zero vacuum energy, and detachment space only, while universe has non-zero-energy, the inexhaustible resource of space-time to expand, zero or/and non-zero vacuum energy, and attachment space with or without detachment space. Attachment space attaches matter and relates to rest mass. The detachment space of the interuniversal void has no space-time, so it cannot couple to particles with space-time in universes, but it prevents the advance of expanding universes to the interuniversal void to avoid the collision of expanding universes.

A zero-sum energy dual universe of positive-energy universe and negative-energy universe can be created in the zero-energy interuniversal void, and the new dual universe is again surrounded by the interuniversal void to avoid the collision of universes. Under symmetry, the new positive-energy universe and the new negative-energy universe undergo mutual annihilation to reverse to the interuniversal void immediately. Our universe is the dual asymmetrical positive-energy-negative-energy universe where the positive-energy universe on attachment space absorbed the interuniversal void on detachment space to result in the combination of attachment space and detachment space, and the negative-energy universe did not absorb the interuniversal void. Within the positive-energy universe, the absorbed detachment space with space-time can couple to particles in the positive-energy universe to result in massless particles with irreversible kinetic energy. The formation of our universe involves symmetry violation between the positive-energy universe and the negative energy universe. Irreversible kinetic energy from detachment space is the source of irreversible entropy increase, so the positive-energy universe is locally irreversible, while the negative-energy universe without irreversible kinetic energy from detachment space is locally reversible. The locally reversible negative-energy universe guides the reversible process of the dual universe. As a result, our whole dual universe is globally reversible. Our dual universe is the globally reversible cyclic dual universe as shown in **Figure 1** for the evolution of our universe as described previously [10] [11].

The four reversible steps in the globally reversible cyclic dual universe are 1) the formation of the 11D membrane dual universe, 2) the formation of the 10D string dual universe, 3) the formation of the 10D particle dual universe, and 4) the formation of the asymmetrical dual universe.

1) The formation of the 11D membrane dual universe

As described previously [10] [11], the reversible cyclic universe starts in the zero-energy interuniversal void, which produces the dual universe of the positive-energy 11D membrane universe and the negative-energy 11D membrane universe as in **Figure 1**. In some dual 11D membrane universes, the 11D positive-energy membrane universe and the negative-energy 11D membrane universe coalesce to undergo annihilation and to return to the interuniversal void as in **Figure 1**.

2) The formation of the 10D string dual universe

Under the reversible oscillation between 11D and 10D, the positive-energy 11D membrane universe and the negative-energy 11D membrane universe are transformed to the positive-energy 10D string universe and the negative-energy 10D string universe, respectively, as in **Figure 1**. The positive-energy 11D membrane universe is transformed to the positive-energy 10D string universe as in Equations (5a) and (5b).

The RS1 Membrane Transformation

$$\text{step 1}: 2_{11} \xrightarrow{\text{from 11D membrane to 10D string}} 1_{10} \text{ in the 11D AdS space} \tag{5a}$$

$$\text{step 2}: 2(1_{10}) \xrightarrow{\text{the close string vibration}} 1_{10}\, 0_{10} = 1_{10}\ g_e \quad \text{in the 11D AdS space}$$

$$2(2_{11}) \xleftrightarrow{\text{the close string and the open string vibrations}} (s1_{10})\, g_e \tag{5b}$$

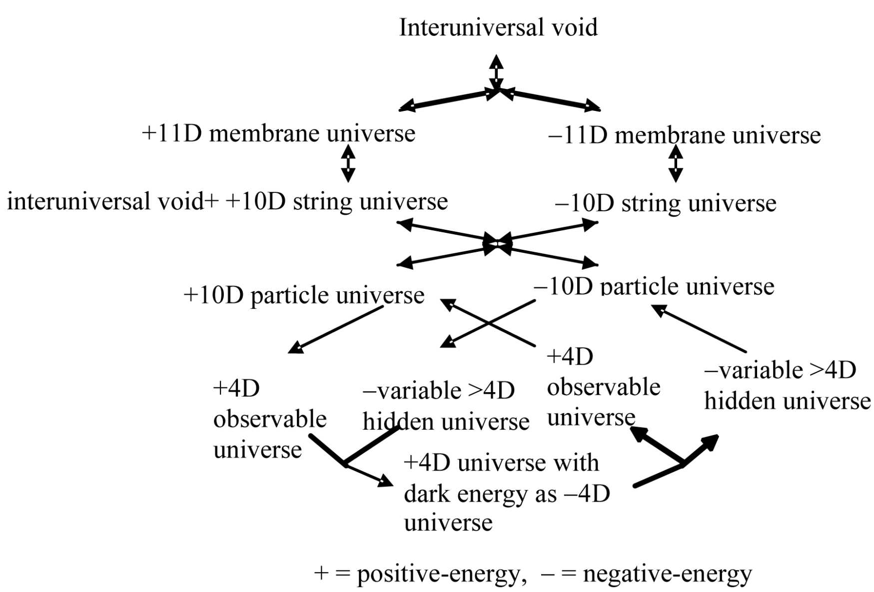

Figure 1. The globally reversible cyclic dual universe.

where 2_{11} is membrane (denoted as 2) in 11D, s is the pre-strong force, 1_{10} is string (denoted as 1) in 10D, 0_{10} is particle (denoted as 0) in 10D, AdS is anti-de Sitter, and g_e is the external graviton.

According Randall and Sundrum, the RS1 (Randall-Sundrum model 1) in an anti-de Sitter (AdS) space consists of one brane with extremely low graviton's probability function and another brane with extreme high graviton's probability function [12] [13]. The formation of the 10D string dual universe involves the RS1. As shown in Equation (5a), one of the possible membrane transformations from the 11D membrane to the 10D string is the RS1 membrane transformation which involves two steps. In the Step 1, the extra spatial dimension of the 11D membrane in the transformation from the 11D membrane to the 10D string becomes the spatial dimension transverse to the string brane in the bulk 11D anti-de Sitter space [12]. This transformation is derived from the transformation from membrane to string. In the transformation from the two-dimensional membrane to the one-dimensional string, the extra spatial dimension of the two-dimensional membrane on the x-y plane becomes the x-axis transverse to the one-dimensional string on the y-axis in the two-dimensional x-y space. In the Step 2, for the RS1 membrane transformation, two string branes are combined to the combined string brane. The external 10D particles generated by the close string vibration of the combined string brane are the 10D external gravitons which form the external graviton brane as the Gravitybrane (Planck Plane) in the RS1 of the Randall-Sundrum model [12] [13]. As in the RS1 of the Randall-Sundrum model, the two branes with equal mass-energy in the 11D anti-de Sitter space are the string brane with weak gravity and the external graviton brane with strong gravity. The weak gravity in the string brane is the predecessor of the observed weak gravity generated during the Big Bang [14] [15]. The external graviton in the external graviton brane is the predecessor of a part of the observed dark energy [16]. The 10D string brane and the 10D external graviton brane correspond to the predecessors of the observed universe (without dark energy) and a part of observed dark energy, respectively [14] [15]. The reverse transformation from 10D to 11D is the RS1 string transformation.

In Equation (5b), the particles generated from the 10D open string vibration are the 10D particles for the pre-strong force (denoted as *s*) in addition to the external graviton from the close string vibration in the 11D AdS. The pre-strong force is the same for all strings without positive or negative sign. This pre-strong force is the prototype of the observed strong force for fractional charge quarks generated during the Big Bang [14] [15].

In the negative universe through symmetry, the 11D anti-membrane (2_{-11}) is transformed to 10D antistring (1_{-10}) with external anti-graviton $\overline{g_e}$ and the pre-strong force s as follows.

$$2\left(2_{-11}\right) \longleftrightarrow \left(s1_{-10}\right)\overline{g_e} \tag{6}$$

The dual universe of the positive-energy 10D string universe with *n* units of $(1_{10})_n$ and the negative-energy 10D string universe with *n* units of $(1_{-10})_n$ is as follows.

$$\left(\left(s1_{10}\right) g_e\right)_n \left(\overline{g_e}\left(s1_{-10}\right)\right)_n \tag{7}$$

There are four equal regions: the positive-energy 10D string universe, the external graviton, the external antigraviton, and the negative-energy 10D string universe [16].

Some dual 10D string universes return to the dual 11D membrane universes under the reversible oscillation between 11D and 10D. Alternatively, under symmetry violation as in the case of our universe, the positive-energy 10D string universe absorbs the interuniversal void, while the negative-energy 10D string universe does not absorb the interuniversal void. The interuniversal void has zero vacuum energy. In our universe, the absorption of the interuniversal void by the positive-energy 10D string universe forced the positive-energy 10D universe with high vacuum energy to be transformed to the universe with zero vacuum energy that was the vacuum energy of the 4D universe. However, the transformation from 10D to 4D was not immediate, because the strings had to be 10D, and it could not be transformed to 4D, therefore, strings had to be transformed to particles that allowed the change of its dimension number freely to accommodate the transformation from the 10D universe to the 4D universe driven by the absorption of the inter universal void.

1) The formation of the 10D particle dual universe

As described previously [15], the transformation from strings to particles came from the emergence of positive charge and negative charge that allowed the mutual annihilation of positively charge 10D strings and negatively charge 10D antistrings in the 10D string universes to produce positively charge 10D particles and negatively pre-charge 10D antiparticles in the 10D particle universes as follows.

$$\left(\left(s\,0_{10}\,e^{+}e^{-}\;0_{-10}\;s\right)g_{e}\right)_{n}\left(\overline{g_{e}}\left(s\,0_{10}\,e^{+}e^{-}\;0_{-10}\,s\right)\right)_{n}, \tag{8}$$

where *s* and *e* are the pre-strong force and the pre-charge force in the flat space, g_e is the external graviton, $\overline{g_e}$ is the external graviton, and $0_{10}0_{-10}$ is the particle-antiparticle. There are four equal regions: the 10D positive-energy particle universe, the external graviton, the 10D negative-energy particle universe, and the external anti-graviton. The emergence of positive charge and negative charge provides the prototype of the observed electromagnetic force with charge generated during the Big Bang [14] [15].

2) The formation of the asymmetrical dual universe

The formation of our current universe follows immediately after the formation of the 10D particle dual universe through the asymmetrical dimensional oscillations, leading to the asymmetrical dual universe. The 10D positive-energy universe was transformed immediately to the 4D positive-energy particle universe with zero vacuum energy. The 10D negative-energy particle universe undergoes the stepwise dimension number oscillation between 10D and 4D. Without absorbing the inter universal void, the external graviton and the anti-graviton also undergo the stepwise dimension number oscillation between 10D and 4D. The result is the asymmetrical dual universe consisting of the four equal regions of the 4D positive-energy particle universe, the variable D external graviton, the variable D negative-energy particle universe, and the variable D external anti-graviton. The asymmetrical dual universe is manifested as the asymmetry in the weak interaction in our observable universe as follows.

$$\begin{array}{l}\text{the 4D positive-energy particle universe and the external graviton}\\ \left(\left(s\,0_{4}\,e^{+}w^{+}\,e^{-}w^{-}\;0_{-4}\,s\right)g_{e}\right)_{n}\\ \text{the variable D negative-energy particle universe and the external anti-graviton}\\ \left(\overline{g_{e}}\left(s\,0_{4\text{ to }10}\,e^{+}w^{+}\,e^{-}w^{-}\,0_{-4\text{ to }-10}\,s\right)\right)_{n}\end{array} \tag{9}$$

where *s*, g_e, $\overline{g_e}$ *e*, and w are the strong force, external graviton, external anti-graviton, electromagnetism, and weak interaction, respectively for the observable universe, and where $0_4 0_{-4}$ and $0_{4\text{ to }10}\ 0_{-4\text{ to }-10}$ are 4D particle-antiparticle for the 4D positive-energy particle universe and variable D particle-antiparticle for the variable D negative-energy particle universe, respectively. For our asymmetrical dual universe, the step 3 for the transformation from 10D string to 10D particle had to be followed by the step 4, so the electromagnetic interaction from the step 3 was unified with the weak interaction from the step 4 to become the electroweak interaction, which was generated during the Big Bang [14] [15].

In the reversible cyclic dual universe, the strong force emerged before the emergence of kinetic energy, while electromagnetism and the weak force after the emergence of kinetic energy. As a result, quarks associated with the strong force have fractional charges, while the fermions associated with electromagnetism and the weak force are integral charge electron and neutral charge neutrino, respectively. The strong force binding the quarks increases with distance, unlike the electromagnetic force whose strength decreases with distance. When one attempts to separate quarks, bond energy increases up to a point where it becomes more favorable to decay to other particles. As a result, fractional charge quarks are confined by the strong force, while integral charge electron is not confined by electromagnetism to follow the integer-fraction principle of the digital electric charge. The strong force is the confinement force field to confine fractional charge quarks. No isolated fractional charge quark has been observed directly, and collective fractional charge quarks can be observed within hadron. Fractional charges can be observed only in the confinement of collective fractional charges.

According the integer-fraction transformation from integral charge to fractional charge, the formation of quarks from electrons is as follows.

$$\begin{array}{l}\text{individual e}\,\overline{\text{e}}\xrightarrow{\text{2 electric flux quanta}}\text{individual}\,F_c\ \overline{F_c}\\ \xrightarrow{\text{3electric flux quanta}}\text{transitional collective}\,B_c\ \overline{B_c}\ \xrightarrow{\text{QCD}}\\ \text{collective 2}\ Q_c\ \overline{Q_c}\ \text{of}\ \pm\dfrac{1}{3}\ \text{and}\ \pm\dfrac{2}{3}\ \text{charge with 3 gluons}+\text{individual e}\,\overline{\text{e}}\end{array} \tag{10}$$

where F_c, B_c, and Q_c are the composite fermion the composite boson, and the composite quark, respectively. The first step of the integer-fraction transformation from electron to quark is the attachment of 2 flux quanta to individual integral charge electrons to form individual composite fermions (F_c's). The flux quanta (70.0252 MeV) are the electric flux quanta as proposed by Peter Cameron to calculate accurately the masses of pion, muon, and proton [17]. The quantum of 70.0252 MeV is also the bosonic mass quantum proposed by Malcolm H. MacGregor for a basic building block to calculate accurately the masses of hadrons [18]. According the oscillating M-theory postulate, the electric flux quantum is B_6 the boson which one mass dimension higher than F_5 that is electron as fermion as follows [10] [11].

$$M_{B6} = M_{F5}/\alpha = M_e/\alpha = 70.0252\ \text{MeV} \tag{11}$$

where α is the fine structure constant for electromagnetism. The F_c (the composite fermion) consists of two B_6 as electric flux quanta.

$$M_{Fc} = 2M_{B6} = 140.0505\ \text{MeV} \tag{12}$$

The mass of pion (boson) is the mass of the composite fermion (F_c) minus the mass of electron (fermion) [17].

$$M_\pi = M_{Fc} - M_e = 139.5395\ \text{MeV} \tag{13}$$

which is in excellent agreement with the observed 139.5702 MeV.

The second step is the attachment of 3 flux quanta (B_6's) to the individual integral charge composite fermions (F_c's) to form the transitional collective integral charge composite bosons (B_c's). The transitional composite bosons are derived from the combination of the three composite fermions (3 F_c's) with the three flux quanta (3 B_6's) which are connected and located at the same position in the same 3-F_c energy level. One 3-F_c energy level consists of the three connected F_c sites with the connected three flux quanta (3 B_6's). The mass of the transitional composite bosons B_c is as follows.

$$M_{Bc} = 3M_{Fc} + 3M_{B6} = 630.227\ \text{MeV} \tag{14}$$

In the third step, 3 electric flux quanta (B_6's) are converted to 3-color gluons (red, green, and blue) in QCD to confine the collective fractional charge composite quarks (Q_c's) conversed from the transitional composite bosons (B_c's). The integer-fraction transformation explains the origin of the three colors in gluons. Each of the three F_c sites in the energy level has ±1/3 charge. The fractional charges of quarks are the integer multiples of ±1/3e. One composite boson (B_c) is converted into two composite quarks (fermions) in the same way as the conversion of one photon (boson) into two fermions (electron-positron). As a result, the composite quark (Q_c) has 1/2 mass of the composite boson (B_c) in addition to the mass of 0, 1, 2, or 3 electrons for the three F_c sites for different electric charges.

$$\begin{aligned} M_{Qc} &= M_{Bc}/2 + 0, 1, 2, \text{or } 3M_e \\ &= 315.1136.\ 315.6246,\ 316.1356, \text{ or } 316.6646\ \text{MeV} \end{aligned} \tag{15}$$

The fully occupied integral charge composite quark (316.6646 MeV) decays into three muons (one muon and one muon-anti-muon pair). The mass of muon is as follows.

$$M_\mu = M_{Qc}/3 = M_e + \frac{3M_{Fc}}{2} = M_e + \frac{3M_e}{2\alpha} = 105.5489\ \text{MeV} \tag{16}$$

which is in excellent agreement with the observed 105.6584 MeV. The muon mass formula in Equation (16) is identical to the Barut lepton mass formula for the masses in the periodic table of elementary particles [14] [19]. Equation (16) explains the origin of 3/2 which cannot be explained easily by Cameron, MacGregor, and Barut [17]. In Equation (15), the composite quark at 315.1136 MeV without the addition of electron is not really a true fermion, so the 1/3 of the composite quark without the addition of electron is used as the fermionic mass quantum at 105.0379 MeV for a mass building block to calculate accurately the masses of hadrons by MacGregor [18].

The composite quark is the starting quark for all quarks [14]. The composite quark at the high energy condition is a low-mass current quark surrounded by three-color gluons to confine quarks. The composite quark at the low energy condition is a high-mass constituent quark with a small amount of binding energy. The calculated mass of neutron is equal to 939.54 MeV as the combined constituent quarks minus a small amount of binding energy [20] [21] in excellent agreement with observed mass of 939.57 MeV.

4. The Fractional Quantum Hall Effect

The charges of the quasiparticles in the FQHE are fractional, because of the confinement by a two-dimensional system, the Landau levels, and an extremely low temperature and the collectivity by high energy magnetic flux quanta. The Hall effect allows the observation of fractional charges [6].

When an electric current flows through a conductor in a magnetic field, the magnetic field exerts a transverse force on the moving charge carriers which tends to push them to one side of the conductor. A buildup of charge at the sides of the conductors produces a measurable voltage (the hall voltage for the Hall effect) between the two sides of the conductor. The Hall effect has become a standard tool for the determination of the density of free electrons in electrical conductors, particularly, the electron density of semiconductors. In semiconductors, electrons can be confined in a two-dimensional system, such as in the interface between silicon and silicon oxide. Electrons can be confined further by the Landau levels derived from the vortices generated by the high energy magnetic field. Some of the electrons get trapped (localized) and isolated in the Landau levels. At an extremely low temperature, electrons can be confined even further by suppressing the disturbing scattering process originating from electron-phonon interactions. Electrons are confined by a two-dimensional system, the Landau levels, and an extremely low temperature.

The collectivity of fractional charge quasiparticles is provided by the strong magnetic flux quanta from the strong magnetic field in the Hall effect. As in Equation (3), the integer-fraction transformation from individual integral charge electron to collective fractional charge quasiparticles consists of 1) the attachment of an even number of magnetic flux quanta to individual integral charge electrons to form individual integral charge composite fermions, 2) the attachment of an odd number of magnetic flux quanta to individual integral charge composite fermions to form transitional collective integral charge composite bosons, and 3) the conversion of magnetic flux quanta to the confinement force field to confine collective fractional charge quasiparticles. The integer-fraction transformation for the FQHE is similar to the composite fermion theory for the FQHE [8] [9]. The integer-fraction transformation explains the origin of $1/(2n + 1)$ in the composite fermion theory through the transitional composite boson as described in Section 2. The transformation is possible under the strict confinement condition and the strong magnetic field to generate magnetic flux quanta to attach to electrons and composite fermions. Without the strict confinement condition and the strong magnetic field, only the ordinary Hall effect without quantum Hall effect is possible.

5. Summary

In the integer-fraction principle of the digital electric charge, individual integral charge and individual fractional charge are the digital representations of the allowance and the disallowance of irreversible kinetic energy, respectively. The disallowance of irreversible kinetic energy for individual fractional charge brings about the confinement of individual fractional charges to restrict irreversible movement resulted from irreversible kinetic energy. Collective fractional charges are confined by the short-distance confinement force field where the sum of the collective fractional charges is integer. As a result, fractional charges are confined and collective. The confinement force field includes gluons in QCD (quantum chromodynamics) for collective fractional charge quarks in hadrons and the magnetic flux quanta for collective fractional charge quasiparticles in the fractional quantum Hall effect (FQHE). The collectivity of fractional charges requires the attachment of energy as flux quanta to bind collective fractional charges. The integer-fraction transformation from integral charges to fractional charges consists of the three steps: 1) the attachment of an even number of flux quanta to individual integral charge fermions to form individual integral charge composite fermions, 2) the attachment of an odd number of flux quanta to individual integral charge composite fermions to form transitional collective integral charge composite bosons, and 3) the conversion of flux quanta into the confinement force field to confine collective fractional charge composite fermions converted from composite bosons. The charges of quarks are fractional, because QCD (the strong force) emerged in the universe that had no irreversible kinetic energy. Kinetic energy emerged in the universe after the emergence of the strong force. The charges of the quasiparticles in the FQHE are fractional because of the confinement by a two-dimensional system, the Landau levels, and an extremely low temperature and the collectivity by high energy magnetic flux quanta. From the integer-fraction transformation from integral charge electrons to fractional charge quarks, the calculated masses of pion, muon and constituent quarks are in excellent agreement with the observed values.

References

[1] Abbiendi, G., *et al.* (2003) *Physics Letters*, **B572**, 8-20. http://dx.doi.org/10.1016/S0370-2693(03)00639-7

[2] The MACRO Collaboration (2000) *Physics Review*, **D62**, 052003. http://dx.doi.org/10.1103/PhysRevD.62.052003

[3] Halyo, V., *et al.* (2000) *Physics Review Letters*, **84** 2576-2579. http://dx.doi.org/10.1103/PhysRevLett.84.2576

[4] Bian, J. and Wang, J. (2012) *Journal of Instrumentation*, **7**, 7020. http://dx.doi.org/10.1088/1748-0221/7/07/P07020

[5] Tsui, D., Stormer, H. and Gossard. A. (1982) *Physical Review Letters*, **48**, 1559. http://dx.doi.org/10.1103/PhysRevLett.48.1559

[6] Stormer, H. (1999) *Reviews of Modern Physics*, **71**, 875. http://dx.doi.org/10.1103/RevModPhys.71.875

[7] Laughlin, R. (1983) *Physical Review Letters* **50**, 1395. http://dx.doi.org/10.1103/PhysRevLett.50.1395

[8] Kamilla, R., Wu. X. and Jain, J. (1996) *Physics Review. Letters*. **76**, 1332. http://dx.doi.org/10.1103/PhysRevLett.76.1332

[9] Jain, J. (2007) Composite Fermions. Cambridge University Press, New York. http://dx.doi.org/10.1017/CBO9780511607561

[10] Chung, D. (2015) *Journal of Modern Physics*, **6**, 1820-1832. http://dx.doi.org/10.4236/jmp.2015.613186

[11] Chung, D. (to Be Published in April, 2016) *Journal of Modern Physics*, **7**, 642-655. http://dx.doi.org/10.4236/jmp.2016.77064

[12] Randall, L. (2005) Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions. Harper Collins, New York.

[13] Randall, L. and Sundrum, R. (1999) *Physics Review Letter*, **83**, 3370-3373. http://dx.doi.org/10.1103/PhysRevLett.83.3370

[14] Chung, D. (2014) *Journal of Modern Physics*, **5**, 1234-1243. http://dx.doi.org/10.4236/jmp.2014.514123

[15] Chung, D. (2015) *Journal of Modern Physics*, **6**, 1249-1260. http://dx.doi.org/10.4236/jmp.2015.69130

[16] Chung, D. and Krasnoholovets, V. (2013) *Journal of Modern Physics*, **4**, 77-84. http://dx.doi.org/10.4236/jmp.2013.47A1009

[17] Cameron, P. (2011) *Apeiron*, **18**, 29-42.

[18] MacGregor, M. (2007) The Power of Alpha: The Electron Elementary Particle Generation with Alpha-Quantized Lifetimes And Masses. World Scientific Publishing, Singapore.

[19] Barut, A. (1979) *Physical Review Letter*, **42**, 1251. http://dx.doi.org/10.1103/PhysRevLett.42.1251

[20] Chung, D. (1999) *Speculations in Science and Technology*, **21**, 277-289. http://dx.doi.org/10.1023/A:1005513404873

[21] Chung, D. (2001) The Periodic Table of Elementary Particles and the Composition of Hadrons. arXiv:hep-th/0111147v5