A New Description of Nature - The Way to Unification

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Abstract

A model of the structure of space and time is proposed. It consists of a discrete four-spatial-dimensional space where the fourth dimension is closed on itself, and a discrete time dimension. A single gravitational-interaction-"charge" is obtained, and a unification of all the interactions of nature, by the **electrodiscrete** interaction, is demonstrated.

Introduction

According to the current standard model of elementary particle physics, the fundamental ontology of the world is a set of interacting fields. There are two types of fields: matter fields and interaction fields, distinguished by their general properties, including spin statistics. The quanta of matter fields, the fermions, have half-integral spins and are exclusive - only a single fermion occupies a particular state. The quanta of interaction fields, the bosons, have integral spins and are gregarious - many bosons can occupy one state.

There are twelve matter fields, and each has its anti-field. The twelve matter fields are divided into three generations. The higher generations are replicas of the first except their quanta have larger masses. Measurements done in the LEP collider in Geneva suggest there are only three light neutrinos, thus there may not be a fourth generation of matter fields.

There are four fundamental interactions. Gravity is responsible for the large-scale properties of the universe. Neither a quantum theory nor a fully interactive theory is available for gravity. Electromagnetism is responsible for all physical and chemical properties of solids, liquids, and gases. The strong interaction binds quarks into nucleons and nucleons into atomic nuclei. The weak interaction is responsible for the decay of certain nuclei.

The Standard Model forms the current view of the world; however, it is a collection of theories, each describing a different part of physics. As Gerard 't Hooft comments:
"… The Standard Model will be nothing but a mathematical approximation that we have been able to create such that all presently observed phenomena are in agreement with it, …" [1].

In the Standard Model, all known forces are due to local "gauge" symmetries. The electromagnetic interaction derives from the symmetry group U(1) in the electroweak product group SU(2)⊗U(1); the weak interaction derives from the symmetry group SU(2)

in the electroweak product group; and the strong interaction derives from the symmetry group SU(3). In addition, the local Lorentz group describes the theory of gravity.

In particular, the requirement of a local symmetry with respect to a phase change of the de Broglie wave of a charged particle defines the electromagnetic field as the requisite compensating field. The existence of the symmetry in nature logically requires the existence of the forces. This symmetry with respect to phase rotation is labeled U(1). In general, the process is of invoking a symmetry group to derive the properties of a boson field coupled to a fermion multiplet (a singlet in the case of the electromagnetic field).

Every symmetry leaves something unchanged, and for each *continuous* symmetry there is a corresponding conservation law (Noether's theorem). The classical conservation laws - the conservation of momentum, angular momentum and energy - are related to invariances in the space and time description of nature. The *continuity* of space and time plays a great role in our picture of the universe.

The Greek method of dealing with continuous magnitude was wholly geometrical, for there was at that time no knowledge of an arithmetical continuum. It was of necessity based on notions of the continuity of space - intuitions which denied any ultimate indivisible portion of space, or any limit to the divisibility in thought of any line segment [2].

These intuitive notions of the continuity of space and time seem to be a great deterrent to the development of our understanding of nature. The beauty of the calculus misled physics for hundreds of years. Space and time are the framework of our view of the world, yet we regard them as "composed" of infinite numbers of zero-size intervals or points. Thus, the intuitive notions of the continuity of space and time, the framework of the picture of the world, led to the development of our mathematical tools, those we use to "draw" this picture.

In Richard P. Feynman's words: "I believe that the theory that space is continuous is wrong, because we get these infinities and other difficulties, and we are left with questions on what determines the size of all particles. I rather suspect that the simple ideas of geometry, extended down into infinitely small space, are wrong." [3]. "Another way of describing this difficulty is to say that perhaps the idea that two points can be infinitely close together is wrong - the assumption that we can use geometry down to the last notch is false." [4].

Nothing in the universe is "really" continuous. Except for our mathematical tools and descriptions of nature, which are based on intuitive notions of the continuity of space and time, nature reveals itself as a discrete structure whenever we look at it deeply enough.

A new description of nature is presented here - a description which denies our intuitive notions of continuity of space and time. The new structure consists of a discrete four-spatial-dimensional (DFSD) space where the fourth dimension is closed on itself, and a discrete time dimension. We conclude the following:

1. The closed-fourth-spatial dimension appears to be related to our internal clocks and, as such, gives rise to the space-time description of the Theory of Relativity. (Will be discussed).

2. The discrete picture, where space and time are no longer continuous but have discrete structure, modifies our space and time symmetries and hence requires modifications of the laws of conservation of momentum, angular momentum and energy.

Complementarity and Heisenberg-Uncertainty (which are principles that express in qualitative terms the physical content of quantum mechanics), are a consequence of the corrections to the conservation laws of the continuous description of space and time. (Will be discussed).

Hence, the breakdown of our continuous space and time symmetries due to the discreteness, as described by the DFSD space model, gives rise to the behavior of nature in the Heisenberg-Uncertainty way.

3. In addition, the new description of nature presented here suggests a different symmetry for the phase of the de Broglie wave (will be discussed) - it is no longer a continuous symmetry but a discrete one (the symmetry is broken or reduced).

Thus, the breakdown of the continuous symmetry of the phase of the de Broglie wave due to the discreteness, as described by the DFSD space model, modifies the law of conservation of electrical charge.

Gravity is a consequence of the correction to the conservation law (of electrical charge) of the continuous description of the phase of the de Broglie wave.

In other words, the requirement of a local symmetry with respect to a phase change of the de Broglie wave of a charged particle, as described in the discrete space and time proposed here, defines a new field, the **electrodiscrete** field, as the requisite compensating field.

Hence, there exists a correcting field to the electromagnetic field, compensating for the inaccuracies brought about by our continuous description of nature. Gravity, as will be discussed, is a consequence of this correcting field.

The **electrodiscrete** field is the correct description of nature and has to be regarded as the unifying field for electromagnetism and gravity, and for the weak and the strong nuclear forces as well, as will be discussed.

Hence, the breakdown of our continuous space and time symmetries due to the discreteness, as described by the DFSD space model, gives rise to the multi-force appearance of our continuous-manifold nature.

Now, it remains to lay out the structure of the DFSD space model, and then to argue that this model fits the picture that has just been drawn. However, a complete mathematical description of the electrodiscrete interaction is not formulated yet, and hence some arguments used through the article are not completely proven. This is what needs to be done next.

The Basic Structure - A New Framework

Let us consider a four dimensional space which is composed of the three regular spatial dimensions and one more spatial dimension (which we do not perceive directly) which is curved (in a fifth dimension) and closed on itself like a ring (for every “point” of our regular 3D space). The radius of the ring at any “point” of the regular 3D space is determined by the energy at that “point”. The radius is inversely proportional to the

energy. The periodic nature of movement in the closed-fourth-spatial dimension is responsible for its clock-like nature, which manifests as our perception of time.

Now, let us further consider a discrete, non-continuous, space and a discrete, non-continuous, time. Space and time which are composed of space-segments and time-periods which constitute the basic elements of space and time respectively. This basic time element should not be confused with the time dimension that we perceive which is more directly related to the closed-fourth-spatial dimension (as we shall see). The basic time element requires the assumption of a basic "clock", the Basic-Generator, "at" the basic structure of the universe, like an oscillator with cycle T_B. (This basic time element is required for the definition of motion in the proposed discrete four-spatial-dimensional space). Everything in the universe is synchronized with the Basic-Generator, which can be understood as a common correlation which has been carried over since the beginning of time (the Big Bang). The speed of light, c, is the basic and only speed in nature (as seen from the wider point of view of the proposed discrete four-spatial-dimensional space). It defines a relationship between space and the Basic-Generator.

Movement in the discrete four-spatial-dimensional (DFSD) space is not continuous but quantized due to the discrete space structure and due to the nature of the Basic-Generator. The basic-energy, E_B, which is a characteristic value of the basic structure, appears at a space-segment of size D_B for a duration T_B, then disappears and reappears at the consequent space-segment. The speed of the movement which is the speed of light, c, is a characteristic value of the basic structure of nature. It is defined as:

$$c = D_B/T_B, \tag{1}$$

where D_B is the basic unit of displacement and T_B is the basic unit of time (the Basic-Generator cycle).

Planck's constant, h, is another characteristic value of the basic structure of nature. It is defined as:

$$h/2 = E_B T_B, \tag{2}$$

where h/2 is the smallest and the basic unit of action.

Quantization of the Gravitational-Interaction-"Charge"

The 4D (5D including the Basic-Generator) model of discrete space and time that has been presented here can be developed to describe an elementary particle of any permissible mass moving at any permissible velocity, by a single type of entity (the basic-entity) that is moving at the speed of light in the DFSD space. In this model, the basic-entity is described by the basic-energy, E_B, which is a characteristic value of the basic structure of nature.

The basic-entity propagates in a wave-like manner (sequentially appears and disappears at each consequent space-segment, of size D_B, with cycle-time T_B) at the speed of light. In this description of nature we obtain (as we shall see) a quantization of the gravitational-interaction-"charge", the mass, just like all the other interactions of nature. ("Quantization" here means that the various masses can be expressed in terms of a discrete quantity). Moreover, we obtain a deeper understanding of the nature of the speed of light.

Any elementary particle, as seen in our regular 3D space, can be described (energy-wise) as a partial appearance of the basic-energy E_B. Let us define another quantity called the objectivity factor W, where $0 \le W \le 1$. W is a dimensionless value that describes the appearance ratio of the basic-energy. Then, any energy (with E_B as an upper limit) can be described as:

$$E = E_B W. \quad (3)$$

The objectivity factor, W, can be seen as the ratio of the "switching-on" (appearance in our regular 3D space) time of E_B to the cycle-time around the closed-fourth-spatial dimension ($W=T_B/T$), in a similar way to a step-down voltage switching regulator. Thus, the energy E can be seen as the "objective" (belonging to our regular 3D space) part of the basic-energy E_B, again, in a similar way to a stepped-down voltage output of a switching regulator.

Description of a Matter Particle

The description of a matter particle in the DFSD space model is illustrated in figures 1 and 2, showing:

$$\mathbf{(cT_0)} = \mathbf{(cT)} + \mathbf{r_0}, \quad (4)$$

$$(cT_0)^2 = (cT)^2 + r_0^2, \quad (5)$$

where a boldface letter denotes a vector and a boldface parenthesis also denotes a single vector as shown in figures 1 and 2.

The energy of a matter particle is:

$$E = E_B W = E_B T_B/T = (h/2)/T, \quad (6)$$

where T is the length of the circumference of the closed-fourth-spatial dimension at the particle's location, divided by the speed of light. (T is the circumference cycle-time of the closed-fourth-spatial dimension at the location of the particle). The particle's objectivity factor, $W=E/E_B=T_B/T$, means that in every one turn that the basic-energy completes relative to the closed-fourth-spatial dimension, there is a total appearance of the basic-energy for a single period of T_B in our regular 3D space.

The velocity of a matter particle, as seen in our regular 3D space, is described as follows. The relative-speed:

$$v_R = r_0/T_0, \ (0 \le v_R < c), \quad (7)$$

is measured in relation to the observer's time, as we do normally ($v_R = v$). The self-speed:

$$v_S = r_0/T, \ (0 \le v_S < \infty), \quad (8)$$

is measured in relation to the moving-particle's time.

To summarize, the DFSD space may be seen as a "collection" of 4D building blocks the size of D_B, that can be each "turned on" (excited) to E_B for the duration of T_B. This excitation of the building blocks takes place in a sequential manner, propagating around the closed-fourth-spatial dimension (circling or spiraling) at the speed of light $c=D_B/T_B$, and in a manner such that the curvature is constant ($R_0=cT_0/2\pi=ND_B/2\pi$, is constant for a given particle) - It always completes one turn relative to the closed-forth-spatial dimension in N "steps", where N is the number of segments in the particle's "ring".

The structure of the DFSD space may be described by the following conditions:

1. The spiral-ness condition: $(r/Q)^2 + R^2 = R_0^2$ (see figure 3 and equation 52), where the Q and the R coordinates are defined, in our "3D view", in terms of r, v and m_0.

2. The discreteness condition: $Q = n(2\pi)/N = nD_B/R_0$, where n = 0,1,2,….

Exploring the DFSD Space Model - Relativity

The closed-fourth-spatial dimension appears to be related to our internal clocks and, as such, to give rise to the space-time description of the Theory of Relativity.

1. Using the relative-speed v_R, in the DFSD space equation described above (equation 5), we can derive the expression for the energy derived by the Special Theory of Relativity. It goes as follows:

$$(cT_0)^2 - r_0^2 = (cT)^2. \quad (9)$$

Dividing by $(cT_0)^2$ and substituting for $r_0/T_0 = v_R = v$:

$$1 - (v/c)^2 = (T/T_0)^2 = (E_0/E)^2, \quad (10)$$

where we used equation 6 for T and for T_0. We get:

$$E = E_0/(1-(v/c)^2)^{1/2}, \quad (11)$$

where E_0 is the rest-energy of the particle. Assuming a proportional relation between energy and mass, we arrive at the expression for the mass as obtained in the Special Theory of Relativity (which introduces the relativistic correction factor to the Newtonian mass):

$$m = m_0/(1-(v/c)^2)^{1/2}. \quad (12)$$

An equivalence of energy and mass actually follows from the above expression for the relativistic energy (equation 11), when expanding in power series for small velocities and looking for the classical expression for the kinetic energy.

2. The following formula of the Special Theory of Relativity:

$$dt = dt_0/(1-(v/c)^2)^{1/2}, \quad (13)$$

describes the determination of the same interval of time in two different systems of reference. In the system where the clock is moving, the time interval dt is measured to be longer than when it is measured in the clock's rest-system, dt_0. This is so, because the moving clock appears to be advancing more slowly than it does in its rest-system. This understanding is similar to the one implied by the DFSD space picture, where the closed-fourth-spatial dimension is manifested as our perceived time sensation. The projection of the moving basic-entity (E_B) on the closed-fourth-spatial dimension can be regarded as a clock (with cycle-time T), which appears to be advancing more slowly as v is increased:

$$v(4^{th}D) = cT/T_0 = c(1-(v/c)^2)^{1/2}. \quad (14)$$

The formula for the DFSD space that has been derived above (see equation 10):

$$T = T_0(1-(v/c)^2)^{1/2}, \quad (15)$$

describes the relation between the DFSD space "clocks", and otherwise is similar to the result derived in the Special Theory of Relativity:

$$dt = dt_0/(1-(v/c)^2)^{1/2}, \quad (16)$$

which describes the relation between elapsed-time ("life-time") intervals.

The meaning of this is that as v is increased, T is decreased and thus, there are more of the T units in the elapsed-time interval dt_0 of the moving particle. Then, as we determine the moving particle's elapsed-time using our own rest system of reference "clock", T_0, we

find a longer elapsed-time for the moving particle (the moving particle's elapsed-time dt_0 appears to us as a longer one):

$$dt = (dt_0/T)T_0. \quad (17)$$

Then:

$$dt = dt_0(T_0/T) = dt_0/(1-(v/c)^2)^{1/2}. \quad (18)$$

3. When the clock is moving and appears to be slower, the clock appears to travel a longer distance (dl) during its own time interval (dt). This is the same as if the moving body's own measuring rod appears shorter to the observer (while the distance stays the same):

$$dl = vdt = (T_0/T)vdt_0 = (T_0/T)dl_0, \quad (19)$$

$$dl/L_0 = dl_0/L, \quad (20)$$

$$L = (dl_0/dl)L_0 = (T/T_0)L_0 = L_0(1-(v/c)^2)^{1/2}, \quad (21)$$

where L and L_0 are the moving and at-rest measuring rods respectively.

4. The transformation between the DFSD space "clocks" and our sensed time intervals may be described as follows:

$$dt_0 = n_t T_0, \quad (22)$$

where $n_t = 0,1,2,\ldots$. Then,

$$dt = n_t(cT_0)/v(4^{th}D) = dt_0/(1-(v/c)^2)^{1/2}. \quad (23)$$

Once the relation between time intervals is established, we can derive the relation between lengths or measuring-rods, and then the full Lorentz transformation can be derived [5].

Exploring the DFSD Space Model - Complementarity

It is not surprising that quantum behavior is naturally inherent within the structure of the periodic and quantized space and time that are presented here (and the wave-like movement of E_B through the DFSD space and through our regular 3D space as a limited view). However, the theoretical development in this direction is not complete, though some basic understanding of the Uncertainty Principle, Quantum probabilities and probability amplitudes is obtained from within the proposed structure.

1. The discreteness of space and time, which requires modifications of our conservation laws, appears to give rise to the Heisenberg-Uncertainty behavior of nature, as corrections to the conservation laws of the continuous description of space and time.

In the DFSD space model, an energy E is described by the appearance of the basic-energy, E_B, for the duration of T_B, in our regular 3D space, once in every T. And, as defined, $E_BT_B=h/2$.

Thus, it follows that in the limited 3D point of view, the "stepped-down" energy, E, is associated with the time period T, just as E_B is associated with T_B in the DFSD space picture (see equation 6):

$$ET = E_BT_B = h/2. \quad (24)$$

Hence, it follows from the basic structure of the proposed DFSD space, that any energy is associated with a time period as described above, and thus dEdt cannot be smaller than h/2. Hence, for energy and time, we have:

$$dEdt \geq h/2, \quad (25)$$

which is similar to the Heisenberg-Uncertainty relation for energy and time.

2. Let us derive the expression for the momentum of a matter particle. It goes as follows.

In the DFSD space, we have:

$$(cT_0)^2 = (cT)^2 + r_0^2. \quad (26)$$

Setting: $v_R = v$, and taking:

$$P = (E/c^2)v, \quad (27)$$

then from (26) and (27) we get:

$$E_0^2 = E^2 - (Pc)^2. \quad (28)$$

In the DFSD space, length-segment, time-period and energy are associated with each other. The energy (Pc) is associated with a time-period T_{Pc}:

$$Pc = E_B T_B / T_{Pc} = (h/2)/T_{Pc}. \quad (29)$$

Calculating T_{Pc}:

$$(Pc)^2 = E^2 - E_0^2, \quad (30)$$

$$1/T_{Pc}^2 = 1/T^2 - 1/T_0^2, \quad (31)$$

$$T_{Pc} = T(c/v). \quad (32)$$

The expression for the momentum is:

$$Pc = (h/2)/T_{Pc}, \quad (33)$$

$$P = (h/2)/(cT_{Pc}) = (h/2)/L_{Pc}, \quad (34)$$

where $L_{Pc} = cT_{Pc}$. From (32):

$$L_{Pc} = (cT)(c/v). \quad (35)$$

3. We have arrived at the following results for a matter particle:

$$E = (h/2)/T, \quad (36)$$

$$P = (h/2)/L_{Pc}. \quad (37)$$

In comparison with the known relationships between the energy and frequency: $E=h\omega/2\pi=h/T_E$, and between the momentum and de Broglie wavelength: $P=hk/2\pi=h/\lambda$, we get:

$$T = T_E/2, \quad (38)$$

$$L_{Pc} = \lambda/2. \quad (39)$$

However, the frequency ω describes the probability amplitude fluctuations: $\exp(i\omega t)$, and the wave-number k describes the probability amplitude fluctuations: $\exp(i\mathbf{k}\bullet\mathbf{r})$. Thus, the probabilities themselves contain components that fluctuate with the frequency 2ω and with the wave-number 2k respectively. Then, for the probabilities themselves, we get:

$$T_E(\text{probability}) = T_E/2 = T, \quad (40)$$

$$\lambda(\text{probability}) = \lambda/2 = L_{Pc}, \quad (41)$$

in agreement with the DFSD space model.

The length:

$$L_{Pc} = (cT)(c/v) = (cT)(cT_0)/r_0, \quad (42)$$

may be interpreted in the DFSD space model as follows. There are two different units of time ("clocks"), that of the particle (T) and that of the observer (T_0). Because only an integral number of turns (of E_B) relative to the closed-fourth-spatial dimension is meaningful to us, a meaningful measurement will always occur "at" $(cT)(cT_0)$. In units of

the basic-unit of length in our regular 3D space (r_0), we get for the meaningful-measurement-length:

$$L_{mm} = (cT)(cT_0)/r_0 = L_{Pc}. \quad (43)$$

4. The DFSD space model seems to unveil the "hidden variables" of quantum mechanics. It will be shown that the phase factor in the particle's de Broglie wave is related to the DFSD space particle's "ring" (or spiraled "string").

The quantum mechanical probability of finding a free particle has a circle-like form. The time component can be understood as the closed-fourth-spatial dimension "ring" of the DFSD space model. The probability amplitude in this case, $\exp(i\omega t)$, is described in terms of the two non-curved dimensions that define the plane of the "ring" (instead of the one closed-fourth dimension that defines the "ring"). Then, the components of the "ring" are:

$$x_1(\text{ring}) = (cT/2\pi)\cos(\omega t), \quad (44)$$

$$x_2(\text{ring}) = (cT/2\pi)\sin(\omega t). \quad (45)$$

Then, we can write for the probability amplitude:

$$x_1(\text{ring}) + ix_2(\text{ring}) = (cT/2\pi)\exp(i\omega t). \quad (46)$$

The position component of the probability of finding a free particle also describes a "ring", related to the momentum of the particle. L_{Pc} can be regarded as the length of the circumference of a virtual "ring" representing the energy Pc. The relation between L_{Pc} and the wavelength of the particle is described above.

Exploring the DFSD Space Model - Spin

The spin of a matter particle is assumed to be related to the excitation mechanism of the basic-entities which is correlated by the Basic-Generator. As described in the DFSD space model, the spin can be determined as follows.

The angular momentum of E_B (in the DFSD space) is:

$$J_{4D} = (E_B/c)(cT_0/2\pi). \quad (47)$$

Then, the "3D" spin is:

$$S = J_{4D}(T_B/T_0) = E_B T_B/2\pi = (h/2)/2\pi. \quad (48)$$

When $v>0$, the rest-energy "ring" becomes a "spiral" whose characteristics are a function of v (see figures 1 and 2). The length (cT_0) of the rest-energy "ring" does not change in magnitude as it becomes such a "spiral". The "curvature" of the rest-energy "ring" does not change either as it becomes such a "spiral" (see the derivation below). Segments of the particle's "spiral" always have the same "curvature", independent of v. Only the direction of the segments (or "ring" arcs) changes in the DFSD space as a function of v and is rotating around the "3D" path of movement (**r**) of the particle.

The equation of the "spiral" is (see figure 3):

$$r = (Q/2\pi)r_0, \quad (49)$$

$$r_0^2 = (cT_0)^2 - (cT)^2, \quad (50)$$

then:

$$r = Q(R_0^2 - R^2)^{1/2}, \quad (51)$$

or:

$$(r/Q)^2 + R^2 = R_0^2. \quad (52)$$

Equation 52 describes the moving-particle's "spiral" in the DFSD space, where R and Q (in radians) represent the closed-fourth-spatial dimension in polar coordinates, and r represents the path of movement (or a segment of it) in our regular 3D space. R_0 represents the "curvature" of the spiral which is constant (for the same kind of particle). R_0 is the radius of the rest-energy "ring" of the particle, as described in figure 3(a).

The direction of the spin is perpendicular to the closed-fourth-spatial dimension "ring" (when v=0) and thus can be in any direction in our regular 3D space, unless the particle is moving in our regular 3D space, in which case the direction of the spin (forth or back) is increasingly well-defined as $v \rightarrow c$.

The spin direction of a matter particle at rest is not defined in our regular 3D space. As described in the DFSD space, the spin direction is perpendicular to the particle's "ring" and hence can be in any direction in our regular 3D space. As the particle gains speed, the particle's "ring" becomes a spiraled "string", and as the speed approaches the speed of light, the spin can be in any direction in the plane perpendicular to the direction of motion (in our regular 3D space). Thus, in the limit of the speed of light, the spin has no component in the **r** direction in contrast to any other direction in the regular 3D space. Hence, in the limit of the speed of light, a spin direction can be defined only as forward or backward relative to the direction of motion.

Exploring the DFSD Space Model - Helicity

In the DFSD space, the sign of the electromagnetic-interaction-charge is determined by the handedness of the particle's "spiral" around the closed-fourth-spatial dimension. (Note that particles with zero kinetic energy may not have a definite electrical charge). A right-hand spiral (right-hand thread) denotes a positive charge while a left-hand spiral (left-hand thread) denotes a negative charge. This description makes it clear that positrons and electrons have opposite helicities. The positron is right-handed, hence, in the limit of the speed of light, its spin direction is aligned with its direction of motion. The electron, on the other hand, is left-handed and hence, in the limit of the speed of light, its spin direction is opposite to its direction of motion. Thus, the positron has a positive helicity while the electron has a negative helicity.

This picture agrees with the experimental findings, that in the limit where they are emitted at the speed of light, the leptons' intrinsic angular momentum or spin is directed opposite to their direction of motion, whereas the spin of the anti-leptons is directed along their direction of motion.

Exploring the DFSD Space Model - Photons

The description of a photon in the DFSD space model is possibly as illustrated in figure 4, showing:

$$\mathbf{(cT_0) = (cT) + (r_0)}, \tag{53}$$

for the first half cycle, and:

$$\mathbf{(cT_0) = -(cT) + (r_0)}, \tag{54}$$

for the second half cycle. The average values are:

$$\mathbf{(cT_0) = r_0, (cT) = 0.} \tag{55}$$

Also:

$$(cT_0)^2 = (cT)^2 + r_0^2. \quad (56)$$

The energy of a photon is (see equation 6 and figure 4):

$$E_p = E_B W = E_B T_B/T = (h/2)/(T_p/2) = h/T_p, \quad (57)$$

where T_p is the time-period of the wave. The appearance (in our regular 3D space) of the basic-energy, in the case of a photon, occurs every half cycle because of the vibratory nature of the photon. The objectivity factor $W = T_B/T$, is "responsible" for the particle-like nature of the photon. The energy of the photon is a consequence of the "switching-on" (appearance in our regular 3D space) of the basic-energy. Its zero-charge is a consequence of the alternating, every half cycle, types of the spiral (right-handed and left-handed) as the direction of motion of the basic-energy relative to the closed-fourth-spatial dimension alternates.

The spin of the photon, as described in the DFSD space model, is zero in the **r** direction because, as described before, at the speed of light, the spin has no component in the **r** direction in contrast to any other direction in the regular 3D space. Hence, a spin direction can be defined only as forward or backward relative to the direction of motion and hence, for the alternating spirals of the photon it adds up to zero. However, the spins of the two components (right-handed and left-handed spirals) of the photon are in the plane perpendicular to **r** (in the regular 3D space) and the spin of the photon is interpreted as spin 1 - as the superposition of the spins of the two components of the photon.

The speed of the photon, as seen in our regular 3D space, is derived as follows (see figure 4):

$$\mathbf{v_p} = \mathbf{r_0}/T_0 = \mathbf{(cT_0)}/T_0 = \mathbf{c}. \quad (58)$$

The non-relative nature of the speed of light may be understood through the derivation of equation 58.

However, once a complete formalism is available, the description of photons in the DFSD space may be derived from within the particle's description (as interacting electromagnetically).

Exploring the DFSD Space Model - Maximum Velocity

A further treatment of the particle's equations, in accordance with the DFSD space structure, leads to unique behavior as the speed of light is approached. The energy of a particle is described by:

$$E = E_B T_B/T. \quad (59)$$

But:

$$E_{max} = E_B, \quad (60)$$

thus:

$$T_{min} = T_B. \quad (61)$$

Therefore, there is a maximum velocity (observed in our regular 3D space) for a particle, which is a function of the particle's rest-energy. The derivation goes as follows:

$$(cT_0)^2 = (cT)^2 + r_0^2. \quad (62)$$

At $T = T_{min} = T_B$:

$$(cT_0)^2 = (cT_B)^2 + (r_0)^2_{max}. \quad (63)$$

Then:

$$(r_0)_{max} = c(T_0^2 - T_B^2)^{1/2} = cT_0(1-(T_B/T_0)^2)^{1/2}, \quad (64)$$

and:

$$v_{max} = (r_0)_{max}/T_0 = c(1-(T_B/T_0)^2)^{1/2}. \quad (65)$$

For our known elementary particles:

$$T_0 >> T_B, \quad (66)$$

thus:

$$(r_0)_{max} \rightarrow (cT_0), \quad (67)$$

and:

$$v_{max} \rightarrow c. \quad (68)$$

Unifying Gravity and Electromagnetism

In the DFSD space model, we have the relationship $E=E_BW$ between the "3D" energy, E, and the basic-energy, E_B. Now, let us make the assumption that the electromagnetic interaction is a function of E_B, just as the gravitational interaction is a function of E. The sign of the electromagnetic-interaction-charge is determined by the handedness of the particle's "spiral" around the closed-fourth-spatial dimension, as described before.

The DFSD space can be envision as our familiar 3D space where every space-segment in it is replaced by a ring of a closed-fourth-spatial dimension, and every line of movement is replaced by a pipe (a tube, which is increasingly well-defined as $v\rightarrow c$). In this description, the electromagnetic interaction acts through the pipes (throughout the total circumference), which makes it a function of E_B for any T. Thus, the electromagnetic (electrostatic) interaction behaves like a "3D" one. The gravitational interaction, on the other hand, behaves like acting in our regular 3D space, as a function of the "objectivity" (the appearance in our regular 3D space) of E_B.

Then, the basic-energy, E_B, can be estimated from the relative strengths of the electromagnetic and the gravitational interactions (assuming simple relationships):

$$E_B/E = E_B/(mc^2) = ((ke^2)/(Gm^2))^{1/2}, \quad (69)$$

$$E_B = e(k/G)^{1/2}c^2 = 1.67\ (10^8 \text{ joule}). \quad (70)$$

Once E_B is known, T_B and D_B can be calculated:

$$T_B = (h/2)/E_B = 1.98\ (10^{-42} \text{ second}), \quad (71)$$

$$D_B = cT_B = 5.95\ (10^{-34} \text{ meter}). \quad (72)$$

The above suggested relationship between gravity and electromagnetism, within the DFSD space structure, is a first step in the development of a unified theory for these interactions. The Kaluza and Klein theories [6], although different from this one, argue in favor of this conclusion, inasmuch as they show that an Einstein-type theory of gravity in a five dimensional space-time results in an ordinary Einstein gravity plus Maxwell electromagnetism upon imposing a cylindrical constraint.

Now, let us proceed to unify the electromagnetic and the gravitational interactions within the framework of the DFSD space. As described before, the existence of a $T_{min}=T_B$ requires the existence of a maximum velocity $v_{max}<c$ for any elementary particle (see equation 65):

$$v_{max} = c(1-(T_B/T_0)^2)^{1/2}. \quad (73)$$

Therefore, the known relationship (in MKS units):

$$(ke^2)(1/c) = (h/(2\pi))/137, \quad (74)$$

is more accurately:

$$(ke^2)(1/v_{max}) = (h/(2\pi))/137. \quad (75)$$

Hence, let us calculate the correction to the continuous picture where $v_{max}=c$, for (ke^2), required by the DFSD space picture. It goes as follows:

$$(ke^2)_{NEW} = ((h/(2\pi))/137)v_{max}. \quad (76)$$

Substituting for v_{max} from equation 73, we get:

$$(ke^2)_{NEW} = ((h/(2\pi))/137)c(1-(T_B/T_0)^2)^{1/2}, \quad (77)$$

hence:

$$(ke^2)_{NEW} = (ke^2)(1-(T_B/T_0)^2)^{1/2}. \quad (78)$$

Using the approximation (binomial expansion valid for $(T_B/T_0)^2<<1$):

$$(1-(T_B/T_0)^2)^{1/2} \cong 1 - (1/2)(T_B/T_0)^2, \quad (79)$$

we get:

$$(ke^2)_{NEW} \cong (ke^2)(1 - (1/2)(T_B/T_0)^2). \quad (80)$$

The correction to the familiar electromagnetic interaction, required by the DFSD space model, is twice the above calculated correction (see equation 80). This is so because the description of the interaction between two particles, in the DFSD space, involves two "spirals" (see the section *Description of a Matter Particle*). Therefore, the correction needed because of $v_{max}<c$ has to be considered twice, once for each "spiral" involved in the interaction process. Therefore, the correction to the electromagnetic force is:

$$(ke^2)(T_B/T_0)^2 = (GE_B^2/c^4)(T_B/T_0)^2, \quad (81)$$

where we used equation 70. Using equation 6 for T_0, we get:

$$(ke^2)(T_B/T_0)^2 = (GE_0^2/c^4) = (Gm_0^2). \quad (82)$$

Thus, the correction to the electromagnetic force, that satisfies the discreteness of nature, is exactly gravity. (Newton's gravity, as approximated by the binomial expansion above).

This conclusion, in turn, implies a new charge which represents electromagnetism and gravity together. It can be described as follows:

$$q^+ = e + ib, \quad (83)$$

$$q^- = -e + ib = -(e - ib) = -(q^+)^*, \quad (84)$$

where the symbol * denotes a complex conjugate. The imaginary parts of the charge represent the part of the field that is associated with the closed-fourth-spatial dimension. This part of the field is perpendicular to the other part of the field which is associated with our regular 3D space and which is represented by the real parts of the charge.

Therefore, the force is described as follows:

$$q^+q^+ = e^2 - b^2 + i2eb, \quad (85)$$

$$q^-q^- = e^2 - b^2 - i2eb, \quad (86)$$

$$q^+q^- = q^-q^+ = -e^2 - b^2, \quad (87)$$

where $b^2=Gm_0^2/k$. Thus, ignoring the imaginary parts in q^+q^+ and q^-q^-, the new charge represents both electrostatics and gravity. However, a deeper look indicates that these imaginary parts in the force description represent magnetic forces. Furthermore, in the case of $v>0$, the correction in equation 12 applies to b and b^2 in the equations above, indicating the existence of forces that are function of the velocity (will be discussed).

Hence, according to this description of the new charge, it represents both electromagnetism and gravity as one unified interaction.

The new charge, described in polar coordinates:

$$q^+ = q_0(\exp(i\theta)), \quad (88)$$

$$q^- = -q_0(\exp(-i\theta)), \quad (89)$$

where $q_0=(e^2+b^2)^{1/2}$ is the absolute value and θ is the argument:

$$\tan(\theta) = b/e = E_0/E_B = T_B/T_0, \quad (90)$$

where we used equations 69 and 6. But $T_B/T_0<<1$, thus:

$$\theta \sim 2\pi(T_B/T_0) = 2\pi/N, \quad (91)$$

where N is the number of segments in the particle's "ring" or "string". Hence, θ is the smallest angle (the basic-angle), describes the discreteness of the closed-fourth-spatial dimension.

The sign in front of q_0 is the sign of the real part of q^+ or q^-. It denotes the helicity of the particle or the handedness of the particle's "spiral" (a plus for a right-handed spiral and a minus for a left-handed spiral). The sign of the argument, θ, denotes the direction of movement around the closed-fourth-spatial dimension, where a plus sign means a counterclockwise rotation when viewed from the direction the spiral is advancing to and a minus sign means a clockwise rotation when viewed from the direction the spiral is advancing to.

The new charge description, therefore, is compatible with the DFSD space spirals picture (see the section *Exploring the DFSD Space Model - Helicity*). Moreover, these results confirm the assumed relationship between electromagnetism and gravity and confirm the estimated values of E_B, T_B and D_B. Furthermore, these results show consistency in the DFSD space model picture of nature.

Now, let us rewrite the force equations and discuss the role of the imaginary parts. From equation 82 we have:

$$ke^2/N^2 = Gm_0^2, \quad (92)$$

hence:

$$b^2 = e^2/N^2. \quad (93)$$

Substituting equation 93 in equations 83 and 84, we get:

$$q^+ = e(1 + i/N), \quad (94)$$

$$q^- = -e(1 - i/N). \quad (95)$$

Equations 85, 86 and 87 become:

$$q^+q^+ = e^2(1 - 1/N^2) + i2e^2/N, \quad (96)$$

$$q^-q^- = e^2(1 - 1/N^2) - i2e^2/N, \quad (97)$$

$$q^+q^- = q^-q^+ = -e^2(1 + 1/N^2), \quad (98)$$

and in polar coordinates:

$$q^+q^+ \cong e^2(1 + 1/N^2)(\exp(i4\pi/N)), \quad (99)$$

$$q^-q^- \cong e^2(1 + 1/N^2)(\exp(-i4\pi/N)), \quad (100)$$

$$q^+q^- = q^-q^+ = -e^2(1 + 1/N^2), \quad (101)$$

where we used equation 91.

As $v\rightarrow v_{max}$, we get:

$$b_{max}^2 = (G/k)m_0^2/(1-v_{max}^2/c^2) = b^2N^2 = e^2, \quad (102)$$

using equations 12, 73 and 93. Therefore, at $v=v_{max}$ (but with no relative velocity between the particles), equations 94-98 become:

$$q^{+} = e(1 + i), \tag{103}$$

$$q^{-} = -e(1 - i). \tag{104}$$

$$q^{+}q^{+} = i2e^{2}, \tag{105}$$

$$q^{-}q^{-} = -i2e^{2}, \tag{106}$$

$$q^{+}q^{-} = q^{-}q^{+} = -2e^{2}. \tag{107}$$

The imaginary parts in the moving particles force equations represent forces which are mostly perpendicular to the lines of movement (velocity) of the two particles. At $v>>0$, these imaginary parts become more important and as v approaches v_{max} they become dominant (see equations 105 and 106). The sign of the imaginary part in the force equations 105 and 106 denotes the direction of the magnetic field around the lines of movement of the particles, and not push or pull. At v=0, the imaginary parts in the force equations describe the interaction associated with the "magnetic moments" of the particles:

$$\mu = (ec)(cT_0/2\pi) = e(h/2\pi)/(2m_0), \tag{108}$$

where we used equation 6.

Next, let us discuss the consequences of the proposed new view of space and time (the DFSD space and the Basic-Generator) regarding quantum field theories in general and quantum electrodynamics in particular.

The DFSD space model seems to unveil the "hidden variables" of quantum mechanics. It was shown earlier that the phase factor in the particle's de Broglie wave is related to the DFSD space particle's "ring" (or spiraled "string"). The main point is that the DFSD space model tells us by interpretation that the phase of the de Broglie wave is not "continuously" symmetric but that the symmetry is broken (reduced) by the discreteness condition. This leads to a modified electromagnetic field as the compensating field for the new symmetry as a local phase ("gauge") symmetry. The corrections to the "pure" (unreal) electromagnetic field are reflected as an additional field of force, which compensates for the non-continuous reality. This compensating force gives rise to our gravitational force. The higher the particle's rest-energy, the bigger the "damage" to the continuous symmetry and the stronger the compensating force and hence, the stronger the gravitational force. This picture indicates that for particles with $N\rightarrow\infty$ (where N is the number of segments in the particle's "ring"), the symmetry is perfect and there is no need for a compensating force and there is no gravity. On the other hand, for particles with N=1, the symmetry is completely broken and there is no net interaction.

Surely, in the DFSD space model, there is no rest-mass and there is no gravity in the continuous limit where $(cT_0)\rightarrow\infty$ (or where N, the number of segments in the particle's "ring", is infinitely big). Particles with infinitely big "rings" are massless. On the other hand, one-segment-"ring" particles (N=1 particles) cannot receive any kinetic energy (see equation 65). We conclude that these (N=1) particles are undetectable and that for them there is no net interaction. The vacuum may be full of such N=1 particles that form a "ground state". In this case, movement of the basic-entity can be described as sequential

excitations of the "ground state" entities. (Note that the N=1 particles have zero spin and that they may be identified as the Higgs particles of the Standard Model).

To conclude, QED has taught us that the requirement of a local symmetry with respect to a phase change of the de Broglie wave of a charged particle defines the electromagnetic field as the requisite compensating field. The existence of the symmetry in nature logically requires the existence of the forces. However, the new description of space and time presented here suggests a different symmetry for the phase of the de Broglie wave - it is no longer a continuous symmetry but a discrete one (defined by the number of segments in the particle's "ring", which also defines the rest-mass of the particle). Hence, the requirement of a local symmetry with respect to a phase change of the de Broglie wave of a charged particle as described in the DFSD space proposed here, defines a new field, the **electrodiscrete** field, as the requisite compensating field. Hence, there exists a correcting field to the electromagnetic field, compensating for the inaccuracies brought about by our continuous description of nature. Gravity, then, is a consequence of the correcting field to the unrealistic "pure" electromagnetic field of our continuous description of nature. The electrodiscrete field is the correct description of nature and can be regarded as the unifying field for electromagnetism and gravity, and for the weak and the strong nuclear forces as well, as will be discussed in the next sections.

Further Unification - The Weak Interaction

The weak interaction is related to a fundamental symmetry which exists between certain pairs of particles, like the electron and electron-neutrino or the u and d quarks. The source for such a symmetry can be found in the DFSD space structure itself. The fourth dimension can be closed on itself in two different directions relative to a fifth dimension into which it is curved. Such a change of the "sides" of the closed-fourth-spatial dimension from the "inside out" and vise versa, has the effect of "switching" the type of the particle's "spiral" around the closed-fourth-spatial dimension from right-handed to left-handed or vice versa.

The weak interaction "deals" with spirals - the particles' "spirals" around the closed-fourth-spatial dimension are the main feature. On the other hand, the electromagnetic interaction is concerned with the projections of the spirals on the closed-fourth-spatial dimension - the motion of E_B relative to the closed-fourth-spatial dimension. (The sign of a charge is only important in relation to the sign of an other charge - either the same or the opposite). For this reason, the electromagnetic interaction does not distinguish between right-handed and left-handed particles (invariant under the operation of charge conjugation) while the weak interaction does. Furthermore, the spirals have "structure" in the regular 3D space, which may be the reason for the short range (as related to the "3D" size of the spirals) of the weak interactions.

The "inside out" (changing "sides") operation described above, looks like "switching" between two different kinds of electromagnetism, the one we know and another one, the "inside out" one. What we recognize as the weak interaction is some sort of intermix of the two - a neutrino that is "paired" to the electron is like an "inside out" positron. Thus,

we are better off discussing the combined electromagnetic and weak interactions, as described below.

The descriptions of matter particles and field particles (photons) presented in the previous sections (see figures 1, 2 and 4) can be unified to one understanding as follows. If R^+ represents a positive charge and R^- represents a negative charge, then, there are two consistent combinations and one alternating combination:

1. R^+/R^+ : A positively charged, spin 1/2 matter particle like a positron.
2. R^-/R^- : A negatively charged, spin 1/2 matter particle like an electron.
3. R^+/R^- (same as R^-/R^+): A spin 1 field particle - the photon.

The same treatment for the combined "charges" RG, where R represents the charge (of the regular electromagnetic interaction or of the "inside out" "electromagnetic interaction") and G represents the "side" (of the closed-fourth-spatial dimension) "charge", gives the electroweak interaction particles. There are four consistent combinations, four alternating combinations and two other combinations that can be regarded together as one alternating (in R) combination of a second order:

1. R^+G^+/R^+G^+ : Positron-like.
2. R^+G^-/R^+G^- : Antineutrino-like.
3. R^-G^+/R^-G^+ : Electron-like.
4. R^-G^-/R^-G^- : Neutrino-like.
5. R^+G^+/R^-G^- : W^+-like.
6. R^+G^+/R^-G^+ : Photon-like.
7. R^+G^-/R^-G^+ : W^--like.
8. R^+G^-/R^-G^- : Like a "photon" of the "inside out" "electromagnetism" (can decay only to particle-antiparticle pairs of G^- particles, like neutrino and antineutrino).
9. R^+G^+/R^+G^-
10. R^-G^+/R^-G^-

The last two combinations together can form an alternating (in R) combination:

$(1/4)(R^+G^+/R^+G^-/R^-G^+/R^-G^- + R^+G^+/R^+G^-/R^-G^-/R^-G^+ +$

$R^+G^-/R^+G^+/R^-G^+/R^-G^- + R^+G^-/R^+G^+/R^-G^-/R^-G^+)$,

where the first and the fourth components are both like a combination of the W^+ and W^-, and the second and the third components are both like a combination of the two photons (combinations 6 and 8) and hence like a Z^0.

Note that the above clearly describes the photons and the Z^0 as phase-changing field particles and the W^+ and W^- as identity-changing field particles. Also note that the photons "consist" of alternating directions of motion relative to the closed-fourth-spatial dimension, while the W^+ and W^- "consist" of alternating "sides" of the closed-fourth-spatial dimension.

The three generations of leptons, the electron and its neutrino, the muon and its neutrino and the tau and its neutrino, are distinguished from each other not only by the charged leptons' different masses, but also by the property called lepton-flavor. Observations of decay processes of the muon and the tau, and other interactions of leptons, suggest the assignment of a different type or flavor to each of the lepton generations. Then, in a reaction involving leptons, lepton-flavor is conserved.

In the DFSD space model, the nature of the lepton-flavor property may be understood as a consequence of the DFSD space invariant distance cT_0, which is a constant for a given particle. The DFSD space invariant distance cT_0 (or the time T_0), is a function of the rest-mass of the particle. Thus, the invariance of the DFSD space distance cT_0 requires the conservation of the property we call lepton-flavor. The differences in the rest-masses of the charged leptons of the different generations of leptons, are responsible for such a property. This explanation relies upon the supposition that the neutrinos are the same as their charged leptons partners, except for their "inside out" "electromagnetic interaction".

The combined electromagnetic and weak interaction picture presented above is compatible with the description of the new (electrodiscrete) charge presented earlier (see equations 83 and 84). As described below, the new (electrodiscrete) charge represents electromagnetism, gravity and the weak forces in one unified system.

The description of the new (electrodiscrete) charge in equations 83 and 84 is not complete. The pair q^+=e-ib and q^-=-e-ib represents another system, one with opposite sign for the imaginary parts. Assuming that all the four charges (four combinations of plus and minus signs of the real and the imaginary parts) represent something of nature, and keeping in mind the description of the combined electromagnetic and weak interaction presented above, we can describe the "parallel" pair q^+=e-ib and q^-=-e-ib as representing the "inside out" "electromagnetism" described above. Therefore, the combined "charges" RG can be described by the new (electrodiscrete) charge, as shown in the diagram in figure 5 (where the real coordinate represents R and the imaginary coordinate represents G).

The new (electrodiscrete) charge describes the combined (unified) electromagnetism, gravity and weak forces as a consequence of the discreteness and the spiral-ness of the DFSD space. The various charges are the "generators" of the matter and the field particles of the combined (unified) interaction.

The sign in front of q_0 is the sign of the real part of q^+ or q^-. It denotes the helicity of the particle or the handedness of the particle's spiral (a plus for a right-handed spiral and a minus for a left-handed spiral). The sign of the argument, θ, denotes the direction of movement around the closed-fourth-spatial dimension, where a plus sign means a counterclockwise rotation when viewed from the direction the spiral is advancing to and a minus sign means a clockwise rotation when viewed from the direction the spiral is advancing to. Hence, the upper pair in the diagram of figure 5 describes the regular electromagnetism and gravity (regular right-handed and left-handed spirals), but the lower pair in the diagram describes some other kind of fields.

Note that the "inside out" concept that we used is just a description of a two-alternatives symmetry. This symmetry is contained in the generalized (electrodiscrete) charge presented here.

Further Unification - The Strong Interaction

Let us construct the DFSD space step by step from a four-spatial-dimensional space, while observing the symmetry patterns involved.

1. The fourth spatial dimension is closed. The two-alternatives symmetry around the closed-fourth-spatial dimension - the two alternatives of the direction of movement of E_B relative to the closed-fourth-spatial dimension (which give rise to the two types of spirals, right-handed and left-handed, around the closed-fourth-spatial dimension) - gives rise to the massless electromagnetic field.

2. The fourth spatial dimension can be closed in two different ways (like having two sides). The two-alternatives symmetry gives rise to the weak interaction forces responsible for the "pairing" of leptons and of quarks.

3. The closed-fourth-spatial dimension is discrete. The modified symmetry calls for a correcting field (to the electromagnetic field) which gives rise to gravity (masses).

4. The regular 3D space is discrete. Space displacement and rotation have a discrete nature. Knowing that the hadrons have structure in the regular 3D space (they are not point-like in the regular 3D space), additional corrections to the electromagnetic interaction are in order. These additional corrections give rise to the strong nuclear forces. Each single dimension of the regular 3D space is responsible for one color charge.

The differences between leptons and hadrons are simply due to the fact that the leptons are point-like in our regular 3D space. The hadrons, on the other hand, are not point-like but have structure in the regular 3D space. Then, further correcting forces are required for the hadrons at the relevant (to their structure in the regular 3D space) distances.

Quarks can be described as "trapped" leptons, where a "trapped" particle is a moving-particle "string" (see figure 1(b)) which is closed on itself in the regular 3D space, or one which is confined in a region of space comparable to its size. According to this description, the quarks are structures of the closed-fourth-spatial dimension and of at least one dimension of the regular 3D space, possibly in a form of a ring in the regular 3D space. It is a moving-particle "string" which closes on itself to form a ring in the regular 3D space, or one which is confined in a region of space comparable to its size. Hence, quarks have structure in the regular 3D space. The three different color charges of quarks are related to the three different planes in the regular 3D space where the ring can be contained. Thus, there are three different color charges just because our regular space is three dimensional.

The hadrons, which are composed of these quarks, have more complex structures in the regular 3D space. The leptons which form the quarks, became trapped with each other to form the hadrons at the Big Bang time, where enough energy was available to overcome electromagnetic forces. Note that according to the DFSD space model, a finite energy was required. The trapping mechanism that governs the construction of the hadrons from leptons is a consequence of the size (in the regular 3D space) of moving leptons. It is described below.

The proposed associations between the various leptons and "their" quarks are listed below (for the first generation):

1. "trapped" positron (p_T) $\rightarrow$ u quark,
2. "trapped" electron (e_T) $\rightarrow$ anti-u quark,
3. "trapped" anti-neutrino (anti-ν_T) $\rightarrow$ d quark,

4. "trapped" neutrino (ν_T) $\rightarrow$ anti-d quark,

where the subscript T denotes a "trapped" lepton.

A "trapped" lepton cannot exist by itself, but only in a system of leptons which are trapped by each other. The existence of these systems is a consequence of the size (in the regular 3D space) of moving leptons as described in the DFSD space model.

A simplified description of the trapping mechanism is presented next. The effective size (in the regular 3D space) of the moving leptons involved is denoted by L_{ES}. When two moving leptons ($r_0>0$) are squeezed together into a small enough region of the regular 3D space, where the distance between the particles $r<L_{ES}$, they can become trapped with each other.

It is obvious, that two rings "carrying" the same electrical charge, are trapped with one another once they are squeezed together so that $r<L_{ES}$ in the way shown in figure 6(a). In the case of two rings with opposite electrical charge, the system (see figure 6(b)) is not stable and eventually will decay ($r\rightarrow 0$).

The system of figure 6(b) is a simplified mechanism for describing mesons. The decay modes of mesons agree with this picture. For example:

$$\pi^- \rightarrow \mu^- + (\text{anti-}\nu_\mu) \rightarrow e + (\text{anti-}\nu_e) + [\nu_\mu + (\text{anti-}\nu_\mu)], \qquad (109)$$

where, by the associations list above, $e_T + \text{anti-}\nu_T \rightarrow \text{anti-u} + d \rightarrow \pi^-$.

The system of figure 6(a) is a simplified mechanism for the understanding of baryons and of the strong nuclear forces. The real picture is more complicated. It appears that in order for such a system to exist in our 3D space, a third particle has to be involved. It is like having three rings (in the regular 3D space) "trapped" with one another, where the normal vectors to the rings' planes are orthogonal to each other, forming a "colorless" system.

The positron's "RING" (to be distinguished from the closed-fourth-spatial dimension "ring") appears as a particle (quark) with positive electrical charge of +2/3 electronic charge. This is so because it is a dynamic system and, on average, each one third of the time we "observe" a different cross-section (each ring is like a "bagel" in the DFSD space). Only two of the cross-sections appear as one (positive) electronic charge each. The third cross-section appears as a zero charge (more precisely, it appears as an alternating charge that cancels itself). Thus, on average, we get +2/3 electronic charge for the positron's "RING" which is the u quark.

A "RING" can be visualized as a coiled wire (one turn) that is stretched and twisted so the ends of the coil are joined together, forming a "bagel" shaped coil. If the "RING" lays in the x-y plane, the x-z and the y-z cross-sections look each like a regular DFSD space particle (see figure 3). On the other hand, the x-y cross-section is a "bagel" viewed perpendicular to its big circumference, showing a back-and-forth movement of the basic-entity of the DFSD space (as it moves around the small circumference of the "bagel"), which cancels itself to a zero charge.

The anti-neutrino's "RING" appears as a particle (quark) with negative electrical charge of -1/3 electronic charge. This is so because it appears as 2/3 of the "inside out" charge which is recognized as 2/3-1=-1/3 electronic charge. It is recognized as such because of the missing third of the "inside out" charge. (The difference of one electronic charge

between the u quark and the d quark, is a consequence of the weak interaction, just like the difference of one electronic charge between the electron and the neutrino).

At distances of $r \sim L_{ES}$ between the particles, the regular electromagnetic force has to be corrected for the size (in the regular 3D space) of the particles. The resultant correcting forces give rise to the strong nuclear forces that hold the quarks together and also hold the nucleons together.

For $r > L_{ES}$, the correcting force gets smaller as r gets larger and it vanishes for $r >> L_{ES}$. For $r < L_{ES}$, the repulsive force between the two particles' "rings" that possess the same kind of electrical charge, can actually pull the particles together, acting as a virtually attractive force (see figure 6(c)). For $r < L_{ES}$, in accordance with figure 6(c), the force between the particles is:

$$F = \Sigma F_1 - F_2, \tag{110}$$

where F_2 is a virtually attractive force that pulls the particles together. The distance $r = r_{EQ}$ where F=0 is the equilibrium distance. Thus, the size of the system of figure 6(c) is:

$$L_{SS} = L_{ES} + r_{EQ} \sim L_{ES}. \tag{111}$$

If we take the proton's size to be L_{ES}, and if we assume that $L_{ES}=L_{mm}$, where L_{mm} is the meaningful-measurement-length (see equation 43), then, we can calculate the proton's mass as follows. Using equations 43, 37 and 28, we get:

$$L_{mm} = L_{Pc}, \tag{112}$$

$$P = (h/2)/L_{Pc} = (h/2)/L_{mm} = (h/2)/L_{ES}, \tag{113}$$

$$E^2 = E_0^2 + (Pc)^2 = E_0^2 + (h/2)^2 c^2 / L_{ES}^2, \tag{114}$$

then:

$$m_u^2 c^4 \cong m_0^2 c^4 + (h/2)^2 c^2 / L_{ES}^2, \tag{115}$$

where m_u is the u quark (the "trapped" positron) mass, m_0 is the rest-mass of the positron and L_{ES} is now the compton wavelength of the proton ($h/m_P c$). Note that we assume that the electromagnetic energy of the "trapped" lepton is included in its kinetic energy. Thus, we get:

$$m_u^2 \cong m_0^2 + (m_P/2)^2, \tag{116}$$

$$m_u \cong m_P/2, \tag{117}$$

where m_P is the known value of the proton's mass. The proton is composed of two u quarks (and a d quark), therefore, there is agreement between the above calculated mass and the known mass of the proton. The d quark is a "trapped" anti-neutrino which contributes very little to the mass of the proton.

Summary

The DFSD space model has emerged from a new philosophical approach to understanding nature. Difficulties in the theories currently describing the various parts of physics and the absence of one single theory that describes our "one" nature, have necessitated a new philosophical approach which has led to the new understanding of nature.

Everything in the universe as we perceive it, is a manifestation of the interactions between our mind and the "outside". Space and time are not the ultimate framework of our universe, but are properties of the interactions, as are manifested in our mind. It is

not "... atoms and the void." (Demokritos), but one "whole" with various properties, manifested as particle, wave, space, time, etc. We see "in" 3D because this is the way we interact with nature and perceive it (our 3D space perception is a manifestation of central inverse-square-law interactions). This does not mean that nature is 3D or that we ourselves are 3D, but that our perception is of a 3D spatial universe (and of a time dimension). Dimensionality is not an objective thing but subjective - our "own filtered" nature.

Furthermore, nothing in the universe is "really" continuous. Except for our mathematical tools and descriptions of nature, which are based on intuitive notions of the continuity of space and time, nature reveals itself as a discrete structure whenever we look at it deeply enough. These intuitive notions of the continuity of space and time seem to be a great deterrent to the development of our understanding of nature. The beauty of the calculus misled physics for hundreds of years.

The new description of space and time presented here consists of two main concepts. One concept is the separate space and time dimensions (instead of space-time), where space is four dimensional with the fourth one closed on itself. The second concept is the discreteness of space and time - they are not treated as continuous manifolds anymore. The DFSD space model proposed here describes the new structure and reveals the new understanding.

The breakdown of space and time symmetries due to the discreteness, as described by the proposed DFSD space model, gives rise to the behavior of nature in the Heisenberg-Uncertainty way, and to the multi-force appearance of our continuous-manifold nature. Furthermore, this model provides a deeper understanding of the nature of time, and appears to provide the "hidden variables" of the Quantum behavior of nature. Finally, the **electrodiscrete** interaction does seem to be the unifying force which underlies the correct description of nature.

References

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Figure Captions

Figure 1. A description of the closed-fourth-spatial dimension, for: (a) A particle at rest in our regular 3D space; (b) The same particle moving in the **r** direction in our regular 3D space, relative to the system of reference of figure 1(a); (c) The same particle approaching the speed of light.

Figure 2. A vector description of one unfolded turn of the closed-fourth-spatial dimension of figure 1(b), describing a moving particle.

Figure 3. A description of the closed-fourth-spatial dimension, for: (a) A particle at rest in our regular 3D space; (b) The same particle moving in the **r** direction in our regular 3D space, relative to the system of reference of figure 3(a).

Figure 4. A vector description of one unfolded turn of the closed-fourth-spatial dimension, describing a photon.

Figure 5. A description of the combined "charges" RG by the new (electrodiscrete) charge, where the real coordinate in the diagram represents R and the imaginary coordinate in the diagram represents G.

Figure 6. A simplified description of the trapping mechanism that causes leptons to become quarks. A ring represents a lepton's "string" which is closed on itself in the regular 3D space. The distance between the rings' centers is r and the force between the rings is F. (a) Two rings with the same electrical charge. (b) Two rings with opposite electrical charge. (c) A simplified description of the force of figure 6(a), treated like it has four components. The F_1 components are repulsive forces but the F_2 component acts as a virtually attractive force.

Figure 1

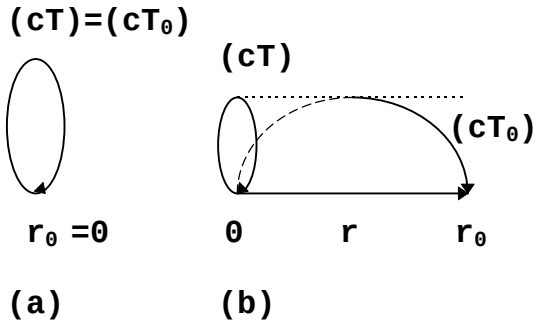


Figure 2

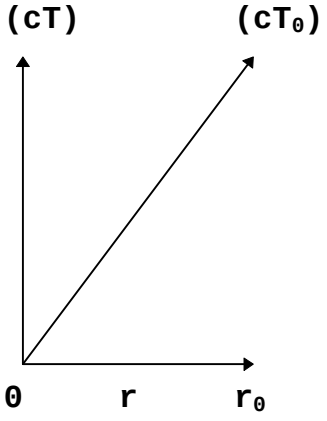


Figure 3

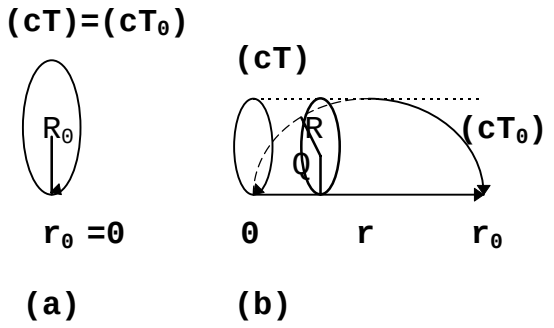


Figure 4

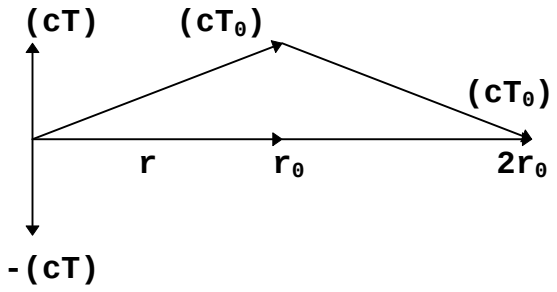


Figure 5

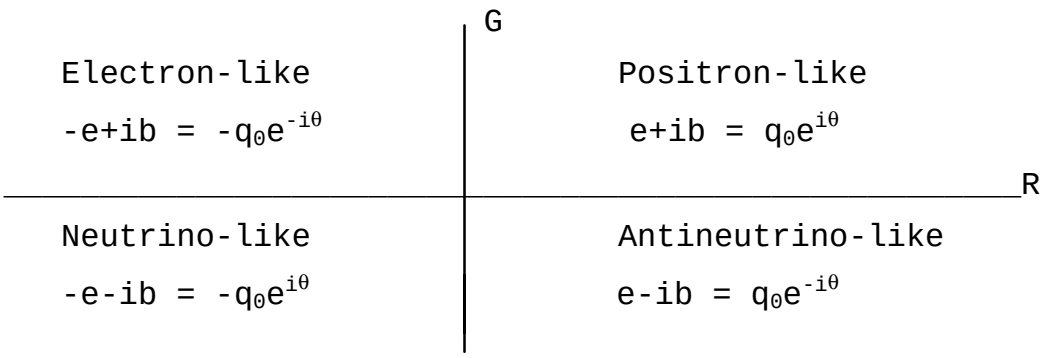
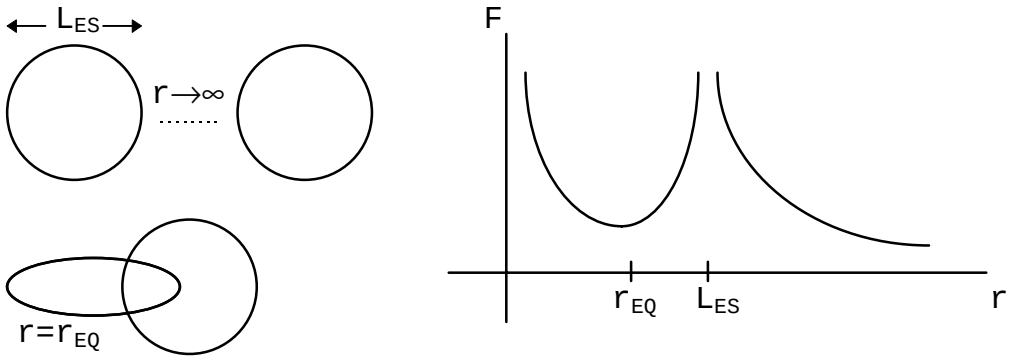
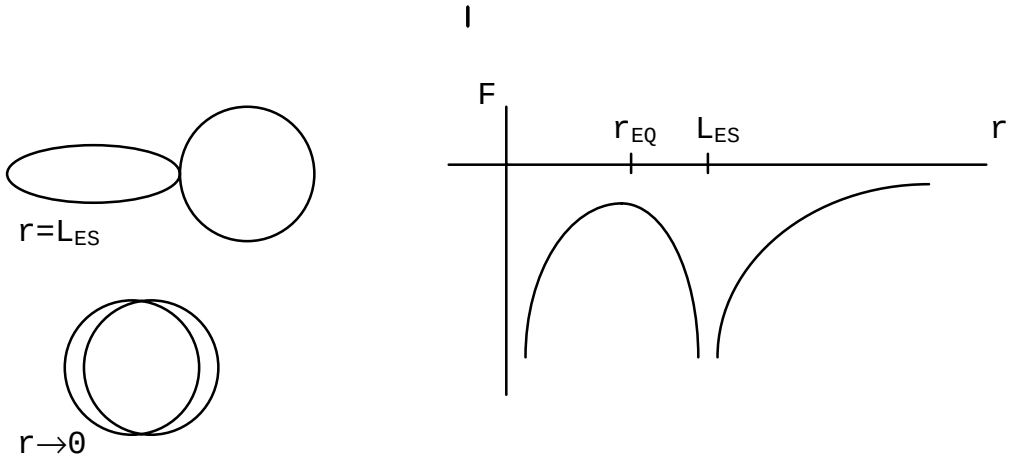


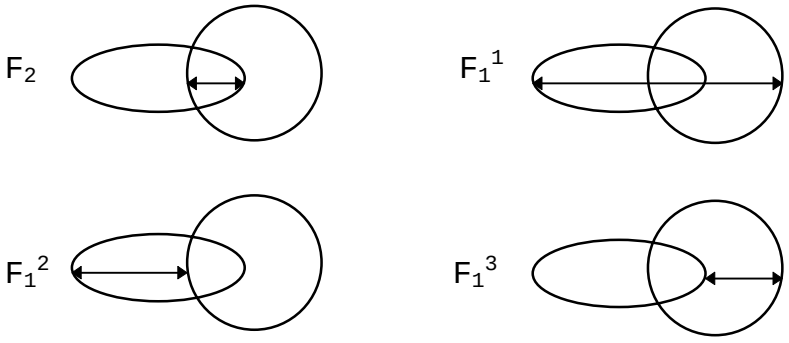
Figure 6



(a)



(b)



(c)