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On the Electrodynamics of Motionless Events

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Abstract

The problem of electrodynamics among charged particles is analyzed by a physical interpretation of the consequences of the Dirac relativistic equation for the electron. By replacing the mathematical opposites of positive and negative energies with the physical opposites of actual and potential energies and serially coupling them in an oscillation the electron becomes fully discrete in both space and time. When the oscillations of individual charged particles and photons are suitably geometrically related their classical aspects reduce to motionless events whose genesis and interactions form a seamless union of quantum mechanics and special relativity. The model is simply particulate, fields and waves play no role. The logical development of the extension of the model among electrons and protons leads naturally to the electromagnetic interaction of the components of the helium atom.

Key words: discrete electrodynamics, physical model, quantum mechanics and special relativity, nonlocality, mass, electron pairing, Pauli exclusion.

1. Introduction

Quantum theory, as it is generally understood, contains an implicit assumption of continuity of motion, space and time which does not appear to be inherent in the results of quantum measurements. The electron is assumed to change its position in space and time continuously, but switch orbits without passing between the two and its energy levels change discontinuously. Quantum theory seems to imply that both the concepts of continuity and discreteness are necessary for a description of Nature. The principle of Occam's Razor would be served if quantum theory were discrete or continuous, rather than a blend of the two. However, any interpretation of the theory employing continuity of all observables would be contrary to quantum principles and inconsistent with observation.

Efforts to understand the atom within the framework of quantum theory have proceeded in the absence of underlying principles which lead naturally to the kinematics of quantum systems. Einstein's opinion of the limitation of the theory as a means of understanding the microscopic world is well known and he ruled out classical physics as the source of those principles, as expressed for example in [1].

> 'It is to be expected that behind quantum mechanics there lies a lawfulness and a description that refer to the individual system. That it is not attainable within the bounds or concepts taken from classical mechanics is clear.'

An adequate understanding of what quantum mechanics really is, according to 't Hooft, has so far not been realized [2], and it may be that the quantum analogues of the mathematical categories of classical physics have so far not been found [3]. Although quantum mechanics works faultlessly without underlying principles from which it arises, it is often assumed that they will eventually be discernible within quantum theory itself, rather than originating in a separate, more fundamental scheme from which quantum behaviour arises.

The mathematics of quantum physics, like that employed throughout physics generally, is derived from set theory and attributes set theoretic assumptions to the system under investigation. At the centre of set theory is the classical continuum, whose physical relevance to the quantum domain is by no means certain. The present paper leaves the quantum formalism aside and deals instead with a physical interpretation of two consequences that Dirac found remarkable about his equation for the electron[1]. They are positive and negative energy states and the oscillation of the

1Dirac drew attention to the problem of mathematics and underlying reality, when he said “It is found that an electron which seems to us to be moving slowly, must actually have a very high frequency oscillatory motion of electron. In addition to the concept of negative energy, the motion of the electron, or more precisely its change of position, at the speed of light and an equal role for time and space in its description are natural elements of the theory. In the discrete scheme, quantum nonlocality and the rules of special relativity, as they apply to the concept of mass and the speed of light, naturally form an harmonious whole.

It is postulated that the oscillation and the energy states of the Dirac electron are complementary aspects of the physical electron which consequently consists of an oscillation between states of positive energy and their physical opposite. The model depends upon the decay of positive energy states into zero energy states. The oscillation is not derivative of the linear harmonic oscillator as it is usually employed. Continuous time, space and motion and other classical concepts such as spacetime points are not part of the theory. The scheme is developed in a particle framework, and is extended from the electron equally to the proton and the photon. The properties of importance are mass and electric charge, which are possessed by individual electrons and protons and absent from photons. Consequently, the descriptions of the three particles take a similar form without the need for either fields[2] or waves.

In section 2 the physical meaning of positive and negative energy states is developed. The mathematical opposites of positive and negative as applied to the measure of the capacity of a system to perform work, i.e. energy are transformed into physical opposites of actual and potential. In section 3 the concept of the motionless event and the phases of the oscillation of the electron are developed. Motionless events are postulated to consist of energetic phases of actualization separated by phases of immaterial potential at zero energy. Section 4 deals with photon creation and annihilation and the distinction between real and virtual photons within a fully discrete framework. The rules of special relativity as they apply to the concept of mass, the mass energy equivalence relation and the speed of light are shown to be of central importance. Section 5 deals with the discrete analog of classical charge repulsion and attraction. The photon-mediated interaction among electrons is developed. The electromagnetic bond between an electron pair is shown to require the participation of a third charged particle (an electron or proton). In section 6 the electron interaction is shown to extend naturally to an electron–proton interaction which constitutes the discrete analog of the inert helium atom.

2. The physical meaning of negative energy states

small amplitude superposed on the regular motion which appears to us." and "These quantum equations are such that, when interpreted according to the general scheme of quantum dynamics, they allow as the possible results of a measurement of kinetic energy either something greater than mc^2 or something less than $-mc^2$." [4]

2 Wheeler and Feynman drew attention to the problem of the modern notion of 'field', when they wrote: "This idea (field) developed in the study of classical electromagnetism at a time when it was considered appropriate to treat electric charge as a continuous substance. It is not obvious that general acceptance in the early 1800's of the principle of the atomicity of the electric charge would have led to the field concept in its present form." [5].

Energy for the present theory is defined, as in classical physics, as: The quantity that is the measure of the capacity of a system for doing work. And energy is always the energy of something; it is never free of an object or system. Dirac introduced the concept of positive and negative energy states with his relativistic equations for the electron, which allow the possible results of a measurement of kinetic energy to be positive or negative. The mathematical representation of the allowed energy states gives them the relation of opposites, which is denoted in the usual way by positive (+) and negative (-) symbols. For the present scheme, being physical, the mathematical relation of opposites is transformed into its physical analogue[3].

Positive energies are those usually associated with real and tangible objects such as the classical electron—physical states have positive energy. The central postulate of the theory is expressed as: the opposite of the energy of the real electron is identical with the energy of the opposite of the real electron. The opposite of the real (physical) electron is the potential electron. The physical consequence of coupling the energy states with the oscillation is to transform the Dirac electron into serial phases of physical actuality and immaterial potential. This analysis adopts the Aristotelian distinction between 'real' and 'potential' when applied to physical objects [6]. The opposite of the real electron is the potential electron, and vice versa. The potential phase of the oscillation is analogous to a virtual electron; its energy is imaginary.

In the potential phase of the electron oscillation, the values of all physical quantities, including energy, are zero. An energy of a magnitude of less than zero does not belong to the actual phase, it is a potential to achieve actual (positive) energy of that magnitude in a subsequent actual phase. Thus, the physical meaning of the mathematical representation of positive and negative energy states is the mutual opposites of the energy states of an actual and a potential electron. The physical opposite of (positive) energy is no energy, which conforms with the opposite of the photon being no photon because the opposite of light is dark.

3. The discrete electron oscillation

The potential and actual phases of the electron are coupled in an oscillation by the emergence of the actual phase out of the potential phase; the latter is the impetus for the former. The genesis of the energetic actual phase is its coupled zero-energy potential phase. The oscillation is internally driven and is independent of external influence.

The electron potential begins to actualize without any physical features or properties. The actualization is energetic and it takes time. It culminates as an actual, or classical, electron with the usual properties of electric charge, mass and internal and external geometric relations. The total energy of the ideal electron exclusively performs the work of its actualization.

3 The present analysis turns on the question of the physical interpretation of the mathematical expression of opposite *values* of the quantum variables. The physical meaning, as it is interpreted here, refers to the variable not its value.

Consequently, at the completion of actualization that phase terminates instantaneously and its energy decays to zero. The electron is then once more in the potential, or nonlocal, phase of its oscillation, from which it again begins to actualize.

The electron, in the zero-energy phase of its oscillation, is bereft of all space-time relations, both internal and external, because without energy in any form it can have neither mass nor any other objective property, including position in space or time. Distance, duration, locus, mass, energy and electric charge are all absent from the electron during its phase of pure potential; they each develop prior to the completion of actualization. As a consequence of the oscillation between actual and potential states every property of the real electron and its geometrical relations are rendered discrete in space and time. Any two actual phases of a single electron, whether successive or otherwise, are separated not in or by space and time, but by the absence of space and time[4].

In conformity with the matter–force distinction, as implied by the terms 'fermion' and 'boson', the former being a matter particle and the latter a force or binding particle, the phases of the postulated oscillation are fermionic and bosonic. The fermionic phase is energetic and terminates as the actual fermionic electron. The bosonic phase is purely potential. Successive pairs of fermionic phases are separated by the intermediate bosonic phase.

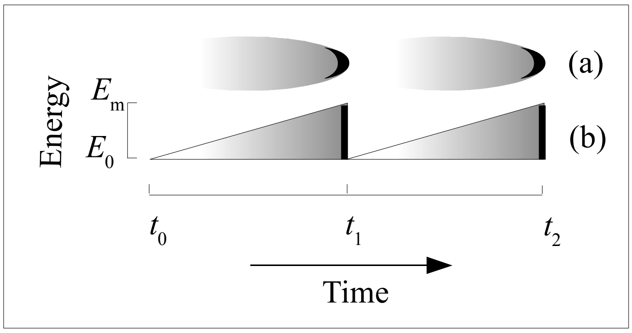

Fig 1: Energy and actualization of two serial oscillations of the discrete electron. Dark bands depict the fermionic classical aspect of the actual electron (a) and energy maxima (b), at t_1 and t_2 . Grey parts depict nonlocal actualization.

The transition between successive fermionic phases, including their relative positions in space and time, is indistinguishable from a quantum jump. The concept of the quantum jump is usually employed to explain transitions between states of different values of a variable. Here the jump occurs between separate space-time loci and discrete stationary states of the same or different values of other variables. The fundamental and indivisible ideal electron of continuous physics is thereby divided into discrete motionless events, separated by nonlocal immaterial potential. The oscillation as it is applied to the electron is likewise applied to the proton and the photon.

4. Discrete photon annihilation and creation

4 The Cartesian and Leibnizian concept of space and time are those of the present theory. For the electron itself, space and time have a primitive origin in its own internal geometric relations. For the termini of two successive actualizations of a single electron, the duration between them is identical with the duration of the second actualization. The distance between them is the distance of the second actualization. The one dimensional space and one dimensional time belong not merely to the electron, but to a single motionless event.

The characteristics of the oscillation for photons are of the same form as those of the electron and proton. The chief difference is a mass effect. The absolute mass difference between a photon and a proton or electron means that the duration of actualization of a photon, irrespective of its energy, is absolutely shorter than that of an electron or proton. Electric charge, as it applies to its effects at a distance, is simply the property of a fermion that enables it to annihilate a photon. Thus, charges of opposite polarity, which characterize the proton and electron, are equally the property that enables photon annihilation.

4.1 The real photon

If the space separation and phases of the oscillations of an electron and a photon are suitably related they will actualize together; their actualizations are spatially and temporally congruent. Such a co-actualization is a consequence of electric charge. The charge-mediated annihilation of the photon is dependent upon their being propitiously separated in space and time at the termination of their immediate antecedent actualizations. The ensuing potential phase of such an excited actual fermionic electron consists in the double potential of a photon and an electron without any quantum properties, including charge. Each potential begins to actualize at the termination of the fermionic phase.

The absolute difference of the mass potentials of the photon and electron in the bosonic phase obeys the laws of special relativity as they apply to the concept of mass and the speed of light; the massive electron cannot change its position as fast as the massless photon[5]. The duration of actualization of a massive object is absolutely greater than that of a massless object; mass and duration are directly related. Consequently, the absolute difference in the duration of their next individual actualization means that the photon potential actualizes before that of the electron. Therefore, their actualizations cannot be temporally congruent.

The mass-induced consequence of the absolute difference in the rates of actualization of the photon and electron potentials is that the charge of the electron does not actualize in time to capture the actualizing photon; their phase relations are no longer propitious for their co-actualization. In the present theory, the special relativistic absolute mass difference prevents an electron from overtaking its emitted photon. In contrast to the field-theory requirement that fields enable self interaction, in the discrete scheme special relativity forbids an electron self-interaction via its emitted photon.

Photon creation, or emission, by an electron occurs in the potential or bosonic phase; photon

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5 This consequence of special relativity is expressed classically as: the mass of an object cannot be accelerated to the speed of light. The speed of the photon is absolutely greater than that of the electron, not because they change position at a different rate but because the electron occupies a position for longer. Differences in the rate of change of position are due to differences in the duration of the actualization of the motionless events of which they consist.

annihilation, or absorption, occurs during the actual or fermionic phase. Photon creation always follows the decay of its creator. For photons and charged fermions, electric charge is the discrete property which enables photon annihilation and their absolute mass difference is the physical basis for photon creation. For a single electron, the oscillating phases of creation and annihilation relate serially to one another, therefore photon creation and annihilation cannot occur simultaneously.

4.2 The virtual photon and the electromagnetic bond

In the present scheme, real photons oscillate between actual and potential phases when alone and effectively independent of charged fermions during journeys of indefinite distance and duration, across a room or across a galaxy. The sum of the durations of the actual phases gives it the finite value of the speed of light; the potential phases make no contribution to the duration of the journey.

By contrast, a virtual photon is created in the potential phase of one energized, charged particle and is annihilated by its co-actualization with another charged particle, without achieving photonic actualization between the two; virtual photon transfer involves only one photonic, bosonic phase. Such a photonic potential, or bosonic phase, is a virtual photon tunnelling between two charged fermions, the one which created it and the one which annihilated it. Because the virtual photon tunnels during a single bosonic phase, from which space-time relations are absent, it does so instantaneously; which is the discrete Hartman effect [7]. There is no difference between individual potential phases of a real photon and the single bosonic phase of a virtual photon and neither is there a difference between their creation nor annihilation.

In continuous physics, there is no concept of a bond that maintains the enduring electron because there are no parts to be bound. By contrast, the classical aspect of the discrete electron consists of a series of motionless events. Those actual events are individual parts of the electron separated in time and space. Therefore, the discrete electron requires a bond between the contiguous events of which it is comprised in order to explain its endurance. That bond is the bosonic phase of its own oscillation, which bind the serial actualizations of the enduring electron. The same analysis applies to the photon. The principle of elementary particle endurance is that each motionless event is bound to its immediate antecedent event from which its potential derives; the potential forms the bond.

The same principle explains the electromagnetic force of the electron–electron and the electron–proton interactions. The co-actualization of the separate potentials of a virtual photon, emitted by a charged particle at the termination of its actualization, plus a second actualizing electron forms the bond between the two actualizations from which the two potentials derived.

Pairs of discrete charged particles bind by the one-way transfer of virtual photons between the motionless events of which they are composed.

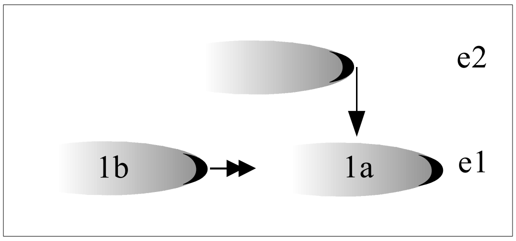


Fig.2: The discrete electromagnetic bond between two electrons. The co-actualization (1a) of the electron potential derived from event 1b (double arrow) and the photon potential derived from e2 (single arrow) forms the discrete bond between e1 and e2.

The energy of the electron, proton and real photon perform the work of their individual actualizations. The duration of co-fermionization of a photon plus an electron is always greater than that of an ideal bare electron alone. The energy of co-fermionization includes its mass. Mass is derivative of the co-fermionization of more than one potential. Because real photons do not co-fermionize, except at their annihilation, their actualizations are energetically massless and their rate of change of location (speed) is therefore absolutely faster than that of massive particles.

5. Electron interactions

A logical consequence of the distinction between the concepts of mathematical and physical opposites, as it is here applied to energy, is its application to electric charge. The physical interpretation of the concept of opposites is applied to charge in the same manner that it is applied to energy. Therefore, the opposite of the charge of the electron is the charge of the opposite of the electron, which is zero charge of the potential electron. Energy and charge are two properties of a single oscillating electron. Each actualizes and then decays to the opposite status of an immaterial potential. By contrast, the opposite of the polarity of the charge of the electron is the polarity of the charge of the proton. The concept of polarity is a property relation that involves differences between charged elementary particles. Charge is simply the property, in the present case, of individual electrons and protons that enable photon annihilation. Photons do not distinguish the polarity of the charges of the electron and proton. For a photon, the opposite of the electron charge is the absence of charge because the opposite of annihilation is endurance.

5.1. Like-charge repulsion

When the actual phases of two electrons are synchronized and spatially separated within the constraint of the tunnelling distance of a virtual photon they have like charge. Being synchronized, the development of the property of electric charge of both electrons is the same at any instant. Under those conditions neither can co-actualize with a photon emitted by the other. A simultaneous two-way exchange of photons is impossible because an electron emits a photon during its potential phase and annihilates a photon during its actual phase and virtual photons tunnel instantaneously between their creation and annihilation [8].

Simultaneous creation of virtual photons by a pair of suitably located, in-phase oscillating electrons causes the space-time relations between their next actual phases to be scattered—they repel one another. For one electron to absorb a virtual photon emitted by the other, actualization of the absorber must be out of phase with that of the emitter and propitiously spatially separated. The potential phase of the emitter must coincide with the actualization of the absorber. Consequently an electron pair whose oscillations are in phase cannot exchange virtual photons for the same reason that special relativity forbids one electron from annihilating its own created virtual photon.

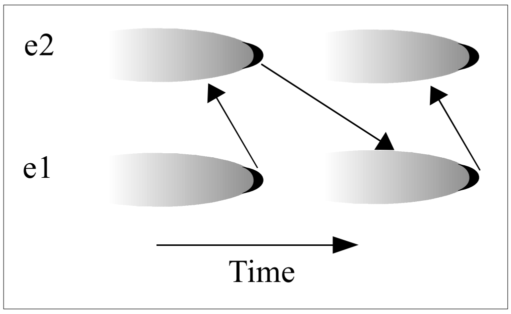


Fig. 3: Virtual photon-mediated, like-charge repulsion between the simultaneous motionless events of two oscillating electrons (e). Photon transfers (arrows) are shown going either backwards or forwards in time.

Two electrons engaged in virtual photon transfer, which consequently belong to the same quantum system, cannot simultaneously be actual or fermionic; which, in the present theory, is the physical basis for the Pauli exclusion principle. Discrete like-charge repulsion is a manifestation of the 'Pauli force'. Figure 3 shows the two oscillating electrons to be simultaneously in the fermionic state. Only the antisymmetrical class of two charged-particle ensembles is able to transfer photons. Thus, like-charge repulsion applies not only to two electrons, but to any two charged fermions capable of photon creation and annihilation, including a proton plus an electron. A one-way photon transfer between the members of a two electron system implies that the first electron annihilated a photon from outside the system prior to the transfer and the photon emitted by the second electron is subsequently lost from the system.

5.2. Electron pair formation

If the two electrons are suitably separated in space and in time[6] they will bind together by a one-way transfer of a virtual photon. The first electron will emit the photon in the potential phase of its oscillation and the second will annihilate the same photon during the actualization phase of its oscillation. Pauli exclusion is a natural feature of the interaction because only one electron can be in the fermionic state. The process of pairing can only occur among two charged particles and always forms an antisymmetrical two-particle ensemble which constitutes a discrete two-particle

6 The separation in time is a manifestation of their phase relations. Simultaneity of phase is zero time separation.

quantum system.

In order for the first electron to emit the photon it must first annihilate a photon from another source, which cannot be the second electron because of their phase relations. The kinematics of photon transfer among paired electrons only allows one-way transfers; a second photon cannot be returned. Therefore at least one further charged particle must participate. Membership of two-particle quantum systems is fully discrete and changes with each oscillation. An electron forms a two-particle ensemble first with the origin of a photon it annihilates and then with the electron to which it emits a photon. Figure 4 depicts the serial one-way transfers of virtual photons between three electrons.

Three electrons form two serial pairs that comply with Pauli exclusion. It can be seen in figure 4 that the dark fermionic termini of the three oscillating electrons are out of phase with one another and are not in the same quantum state at the same time. The transfer of photons among indefinitely large numbers of electrons, whose oscillations are out of phase, is a simple extension of the three electron case and is postulated to be the electromagnetic interaction for electron plasmas[7].

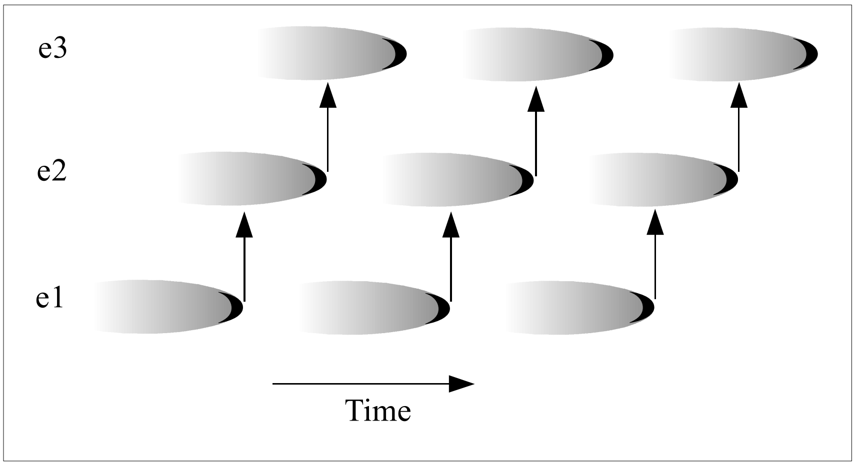


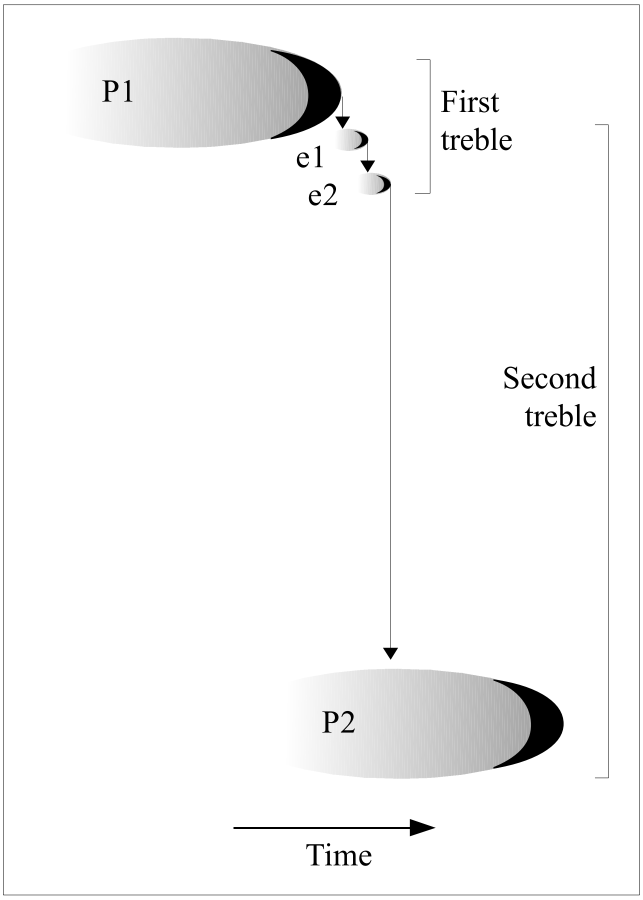
Fig. 4: The binding interaction for three oscillating electrons (e). The property of charge actualizes between the beginning and end of the ovals of co-actualization. One-way photon transfers are indicated by arrows.

The crucial feature of the binding interaction for two electrons is that it must engage an additional charged particle, because the second of the three can neither transfer a photon back to the first nor overtake and annihilate its own emitted photon. The obligatory three-particle geometry of the interaction forms two serial pairs that are bound to one another by the shared membership of one of the three. In figure 4, e1 and e2 form a discrete bound pair by the transfer of a photon between them. Then e2 pairs with e3 by the same process. At their next oscillation the three electrons form two serial bonds in the same sequence, and so on. The treble interaction is the consequence of the shared membership of one electron by two serial electron pairs.

6. The electron–proton interaction

7 Examples of electron plasmas include small spark discharges and lightning.

The principle of the electron oscillation is applied equally to the proton. During the actualization phase of a proton it acquires the property of electric charge thus enabling its co-actualization with a suitably separated actualizing photon. During the ensuing potential phase the proton emits a photon. The principle of photon annihilation and creation is the same for the electron and proton.



The mass difference between the proton and electron gives the proton a proportionately greater duration of actualization.

Fig 5: The electromagnetic interaction for two electrons (e) and two protons (P) mediated by one-way photon transfers (arrows).

Following the generalized Pauli principle as it applies to the bound atomic nucleus, a nucleon is in a superposition of two states; a neutron state and a proton state. The nucleon actualizes as either a proton or a neutron in any oscillation. Charge conservation is assured if one nucleon switches states from a proton to a neutron and another switches from the neutron to the proton state. In that case, on average, a nucleon lacks electric charge during alternate actualizations, when it is in the neutron state.

When a proton is substituted for one member of a treble electron interaction, two electrons bind to the proton (figure 5). The sequence of virtual photon transfers is from proton P1 to electron e1 and then to electron e2. Electron e2 emits a photon that cannot transfer to P1 because at its next actualization it will be a neutron. Therefore, in a charge-neutral system the photon goes to a second proton, thus forming the second of two sequential treble interactions. Each treble consists of two coupled, sequential, charged-particle pairs bound by the common membership of the second charged particle. In the first treble e1 binds first with P1 and then with e2. In the second bound treble e2 binds first e1 and then P2. The first and second trebles are then bound to each other by the common membership of the electron pair e1 and e2.

The discrete electromagnetic interaction arises from a single principle which binds pairs of charged particles and then binds pairs into trebles and finally binds trebles into global bonds all by a one-way transfer of virtual photons. As shown in figure 5, no two fermions are simultaneously actual. Pauli exclusion, charge neutrality and charge conservation are all natural elements of the interaction.

According to the postulate that the mass of actualization is related to its duration, the two spacetime intervals separating two electrons and a proton are equal if a photon transfers from the proton to the first electron, and then to the second electron. By contrast, when the photons transfer first between the electrons and then to the proton, the spacetime interval separating the electrons is less than that separating the second electron and the proton, as shown in Figure 5.

The electromagnetic interaction as described includes the number of electrons and protons of the single He-4 atom. The interaction is complete in the sense that the number of its electrons and protons accommodates the principle of the interacting treble together with charge conservation and neutrality plus compliance with the Pauli principle with respect to both the bound nucleus and electron pairs. There is neither an electron deficit which would tend to be made up by the inclusion of an additional electron supplied by another source nor an excess of electrons which would tend to be lost or interact with an electron of an other source. Such electron sharing would form a molecular bond between the electrons of two atoms. Neither a hydrogen nor lithium atom, with one and three electrons respectively, is able to form a treble interaction on its own and remain electrically neutral. The helium atom has the status of an inert monatomic gas which is consistent with the discrete model of electrodynamics in which special relativity and quantum theory form a seamless whole.

7. Discussion

The discrete model of the electron described here is a radical approach in which the contents of the theory are neither put into mathematical form nor are symmetry principles invoked—it is also clearly defined, simple and consistent with observation. Central to the theory is the physical interpretation of the Dirac electron in terms of the Aristotelian concept of actual and potential. The coupled oscillation and energy states transform the continuous electron of classical physics into contiguous phases of nonlocal actualization separated by immaterial phases of pure potential. The theory is a departure from the continuity concepts that underlie quantum field theory and the standard model of particle physics. Electrons do not move through space or time, instead, motionless events of which they are composed arise at unique spacetime loci then vanish. A mark of the radical nature of the model is its reliance upon the reality of states of negative energy, the motion of the electron at the speed of light and an equal role for space and time in its description. All three are essential elements of the theory and they comply with the rules of special relativity, despite their unreality in the usual continuous framework of particle theory.

Formidable difficulties confront the unification of special relativity and quantum theory in the classical, continuous spacetime framework. There, the emphasis falls on Lorentz symmetry and the uniformity of the observed laws of Nature. By contrast, the discrete theory is dependent upon a division of special relativity into two parts. The first part concerns the concepts of mass[8] and the speed of light. Energy is actively converted into mass during each oscillation of the electron. The mass–energy identity relation expressed in the equation $E = mc^2$ is a dynamic fact of the discrete electron and is central to its creation of its own geometric relations, both internal to itself and external with all the elementary particles of the universe.

The actualization of an indivisible potential is massless. By contrast, like the standard model in which all particle masses are due to interactions, the mass of a fermion arises from the mergence of the energy of the co-actualization of more than one potential, which is the discrete analog of the collision between and the annihilation of a photon by an electron. The consequence of the absolute difference between the zero mass of the photon and the masses of the electron and proton is the absolute difference in the rate at which they change their spacetime loci. That difference enables the creation of photons whose fate determines whether they are real or virtual. Light emission by decoupling the double potential of a charged particle and photon is a mass effect. The role of mass in the discrete scheme is fully consistent with special relativity.

The second part of special relativity is the space-time framework which arises from the oscillation. When the action of actualization is complete its geometric relations with the rest of the world arise. Only then is it observable, via photons emitted by the ensuing potential phase. Prior to the termination of actualization the concept of a definite distance or duration separating the event from its antecedents is meaningless. The nonlocal energetic actualization is in principle unobservable, only its zero energy classical residue is measurable by observers. Being at zero energy, Lorentz symmetry of special relativity then obtains among its fixed, flat spacetime relations with its contemporaries and antecedents.

Special relativity and quantum mechanics seamlessly merge in the discrete framework of the oscillating electron. The relativistic concepts of mass and the speed of light are elements of the quantum behaviour of the electron. The zero energy residue of the behaviour forms the observable classical world in which the symmetries of flat spacetime obtain. There is no inconsistency between matter-induced spacetime tension of the fermionic phase and flat Minkowski spacetime—one simply follows the other.

The Heisenberg time–energy uncertainty relation can be seen in the impossibility of predicting the energy of the electron at some instant. By contrast, the exact energy of the electron for a suitable duration is meaningful, if the duration is sufficient to include at least one complete oscillation.

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8 Einstein considered mass the most important result of special relativity [9].

The non-classicality of angular momentum generalizes naturally to include the linear case. The distinction between quantum angular momentum and classical motion about an axis or point is extended in the theory to the separation of linear momentum from the classical concept of continuous motion through fixed space. Neither tunnelling photons nor fermions move through space between their successive actual phases. Serial actualizations simply occur as motionless events at different spacetime loci, within the limits of initial conditions.

It is difficult to see why the outcome of actualization should not comply with quantum statistics. It is in principle impossible to specify the particular spacetime locus a fermion will occupy in the future because its appearance generates the locus. The motionless event arises and its space and time relations with its contemporaries and antecedents follow; there is no vacant locus lying in wait about which definite predictions can be made.

Quantum electrodynamics deals with the virtual photon-mediated attractive and repulsive forces between charged particles by a very complex procedure that employs classical and quantum concepts. By contrast, the discrete analysis uncovers a principle which derives from the non-interacting bare electron. The theory of the virtual photon mediated binding force between two charged particles is a simple extension of the bond between the motionless events that constitute a single enduring electron. The theory is simple and it embraces electrons and protons alike, together with real and virtual photons. The single interaction provides a realistic bond among pure electrons, in the form of lightning and other electron plasmas, and atomic electrons and protons.

The chief virtue of the theory is the clear quantum theoretic and special relativistic features of its provision of a physical scheme out of which several well known features of the helium atom arise naturally and in which all particle descriptions, including the photon, take the same form. It is especially satisfying that the discrete theory derives from the Dirac relativistic equation for the electron which has its origin and usual interpretation in a framework of continuous space, time and motion.

The geometry of electron pairing, which is a special relativistic imperative of the oscillation, gives rise naturally to the Pauli exclusion principle. Paired atomic electrons obey Pauli exclusion, not because of their relative spin orientations or relative energy differences, but because one is energized and the other is not; the energy difference is absolute rather than relative. Nothing is put in by hand.

Acknowledgements

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