Multidimensional Time

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Abstract
It is suggested that if there is no force of anti-gravitation between particles and antiparticles, then time may have two perpendicular and independent axes: the electrostatic- and the gravitational - temporal axes. This explains why Einstein and others failed in obtaining a fields theory that unifies the electromagnetic and gravitational fields applying only one temporal axis. Moreover, each of these two temporal axes can be split into two axes, one representing microscopic time and the other representing macroscopic time. Thus the microscopic and macroscopic phenomena occur in different subspaces of the entire space. This prevents contradiction between relativity and quantum theories, due to microscopic spatial discontinuities.
Keywords: electrically charged particles, direction of particles in time, unified fields theory, antimatter, sonoluminescence.

Dedication
This study is dedicated to the memory of the late Dr. Aharon Molchadzki, whose empirical findings in his M. Sc. thesis which was conducted under the supervision of Professor P. Avivi, convinced me that my theoretical ideas are not a mere fantasy, but are realizable in the empirical world.

1. Introduction

Feynman's (1985) suggested that some electrically charged antiparticles are, in fact, particles that move backwards in time. We shall see that this suggestion implies that there is more than one temporal dimension. Moreover, we will see that this suggestion of Feynman can be tested experimentally, thus the existence of multiple times can be tested too.

Unlike other studies that apply mathematical techniques and CPT transformations, this study applies only elementary logic in order to prove the existence of multiple times. Nevertheless, while the other studies provide information about the number of the temporal dimensions, this study provides information about the physical meaning of the additional temporal dimensions.

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This suggested existence of multiple times may shed new light, from a new angle, on the reasons of the failure to construct a unified field theory in the physics of "point particles." Thus it may be that string theory is not the only possible solution to the unified field problem.

The electrostatic force between two electrons causes them to be repelled from each other. On the other hand, the electrostatic force between an electron and a positron causes them to be attracted to each other, with an equal, but oppositely directed force. If the motion of a positron had been photographed on a movie film from the point of view of an electron, and this film has been shown to us moving backward, it would have been looked identical to a film presenting another electron from the point of view of the first electron. That is, the motion of the positron is identical to the motion of an electron, moving in an inverse order of events. This observation explains why Feynman (1985) considered a positron to be an electron moving backwards in time. This conclusion of Feynman applies also to other particles of antimatter, like anti-protons, which are equivalent to protons traveling backwards in time.

Moreover, an electron and a positron may begin their existence with the disintegration of a photon into an electron and a positron, and their existence may terminate when they are annihilated due to their collision, and the appearance of one or two photons. Thus the appearance and disappearance of this pair of particles may be considered as the same phenomenon, but in an inverse order of events.

Let us assume that Feynman is right, and particles of antimatter are indeed particles of matter traveling backwards in time. An apparent immediate outcome is that the gravitational force between particles of matter and particles of antimatter must also be inverted, and a force of anti-gravitation operates between them. However, there is no empirical evidence that there is a force of anti-gravitation between particles of antimatter and particles of matter or a material body (there is a red shift due to the fall of material particles on heavy stars, but no blue shift due to the fall of particles of antimatter). Moreover, since gravitation is determined by the mass of the two involved bodies, and an antiparticle has positive mass, there are theoretical reasons that no force of anti-gravitation exists between mater and anti-matter.

Let us assume that Feynman's hypothesis that particles of antimatter move backwards in tine is correct, and nevertheless, there is no force of anti-gravitation between particles and antiparticles, and see what is implied by these two assumptions.

2. Forces and Their Unification

Force is defined by Newton's law as the multiplication of the mass of a body by its acceleration. Namely, a force is characterized by dynamical changes in a body while time changes. This change in time must cause dynamic changes related also to other time-dependent forces. For example, a change in the electrical field implies a change in the magnetic field, which enables the construction of electromagnets. On the other hand, a change in the magnetic field implies a change in the electrical field, which enables the construction of electrical generators. This mutually dependent varying of the two forces, while time changes, enabled their unification into the electromagnetic force.

However, even the most drastic change in the time related to the electrostatic force of, say, an electron, the inversion of its temporal direction, does not change the gravitational force related to the same particle, though it should have inverted the temporal order of the events when gravitational force operates between two particles. We suggest that this necessarily implies that the temporal direction of the gravitational force is independent of the temporal direction of the electrostatic force. That is, time, like space, has more than one dimension, and the temporal direction of the gravitational force is perpendicular to, and therefore independent of, the electrostatic force.

If this suggestion is correct, no united fields theory that includes both the electromagnetic and the gravitational forces is possible, and these forces are entirely independent temporally. This consideration may explain why the efforts of Einstein and of others to find a general united fields theory failed. Such a theory is impossible, at least when a one-dimensional time is assumed. Such a theory requires a "temporal plane," rather then linear time. There is a possibility that there are more perpendicular dimensions of time, related to more independent forces. It maybe that the supposed success of string theory to construct a united field theory by adding spatial dimensions is due to the introduction of at least one temporal dimension disguised as a spatial dimension.

We may consider our conscious one-dimensional time as the resultant of the two, or more, temporal directions. The projections of this conscious one-dimensional time on the electrostatic and gravitational axes of time are not necessarily equal. The projection on the electrostatic temporal axis may be considerably larger than the projection on the gravitational axis. This presents mathematically the empirical situation that the electrostatic force between two particles is considerably larger than the gravitational force between these two particles. Perhaps a particle can move backwards in time along the temporal axis of the gravitational force. If such a temporal motion exists, then it does not invert the order of events caused by electrostatic force operating on the same particle.

3. Unifying General Relativity and Quantum Mechanics

According to Heisenberg's uncertainty principle:

$$\Delta E \cdot \Delta t \geq \hbar$$

where ΔE is the range in which the energy of a particle can change, Δt is the range in which its existence-time can change and $\hbar$ is Planck's constant. Heisenberg's principle implies the existence of tunneling effect and of other effects that distort the fabric of space, thus preventing combining quantum mechanics with general relativity.

However, we may ask: What type of time is t that appears in Heisenberg's principle? This principle is derived from the fact that the light by which we derive the location and velocity of a particle has a certain wavelength. Light is an electromagnetic phenomenon; therefore its time must be the electrostatic time. Therefore the time of quantum mechanics too must be the electromagnetic time. On the other hand, general relativity explains gravitation, and therefore its time must be the gravitational time. These two temporal axes are perpendicular to each other and independent. Therefore we may assume that changes in one of them do not necessarily imply changes in the other one. Thus the frenzy effects that occur along the electrostatic temporal axis due to Heisenberg's principle do not necessarily cause the destruction of the spatial texture, which according to general relativity causes the phenomenon of gravitational force.

Therefore, all that is needed in order to unify general relativity with quantum mechanics is to relate the phenomena described by the first to the gravitational time axis alone, and to relate the phenomena described by the second – to the electrostatic temporal axis alone. The entirety of physics can now be described within a framework of three spatial dimensions and two temporal dimensions.

4. Possible Quantization of Gravitation

If we assume that gravitons and waves of the gravitational field do exist, and Heisenbeg's principle does apply to this field, it implies that there is a contradiction between the general relativistic- and quantum theoretical- aspects of the gravitational force. This contradiction can be removed if we assume that the gravitational time is not linear but it is planar. That is, there are two independent and perpendicular axes of gravitational time. One axis represents the macroscopic changes, and the second axis represents the microscopic quantum changes. Thus the subspace that includes the "macroscopic" axis and is perpendicular to the "microscopic" axis represent general relativity, while the subspace that includes the "microscopic" axis and is perpendicular to the macroscopic axis represents the quantum phenomena. Changes in one of these subspaces do not influence the events in the other one. Events involving both these temporal axes (e.g., at the temporal vicinity of the big bang or the spatial vicinity of a black hole) are represented in the entire space- times, without contradicting general relativity or quantum relativity in their respective subspaces. Thus our assumption provides three temporal dimensions in addition to the three spatial dimensions.

In the following sections we shall limit our discussion to particles moving along the electrostatic temporal axis, and neglect the relatively smaller effects related to the gravitational component of time.

5. Entanglement of the Temporal Directions

Penrose (1989, p. 356-359) presented a proof that a particle can move backwards in time only before the collapse of the wave function (in which this particle is entangled) but not afterwards. This means that in order that an electron will travel backwards in time, it must be entangled with some other particle, and comprise together a wave function. Indeed, according to Feynman's suggestion a positron is indistinguishable from an electron that travels backwards in time. Similarly, an electron is indistinguishable from a positron traveling backwards in time. That is, we cannot know what is the temporal direction of an electrically charged particle. We can, at most, estimate the probability (amplitude) that an electron moves in the positive direction of the electrostatic temporal axis, and suggest an empirical method to measure this probability.

That is, we must consider each electrically charged particle to be a superposition of a particle that moves forwards in time and a particle that moves backwards in time. Equivalently, since the temporal direction influences the sign of the electrical charge, we may consider each electrically charged particle to be a superposition of a positively charged particle with a negatively charged particle. Therefore, before the wave function that constitutes this superposition collapses, the particle can move backwards in time. This situation is in line with Feynman's (1985, p. 98) statement: "Every particle in nature has an amplitude to move backwards in time."

We must imply another conclusion. As soon as a particle is materialized due to the collapse of the above-described wave function, it becomes entangled again with its antiparticle (provided that it is not annihilated). This is due to the observation that we cannot be certain what is the absolute temporal direction (and the electrical charge) of this particle.

This conclusion applies only to microscopic particles that do not interact with a macroscopic body. A macroscopic solid body behaves (at least approximately) according to classical physics, and therefore it is considered, or defined, as traveling forwards in time. Indeed, the solidity of a macroscopic body means that some forces, like the forces in a lattice or covalent forces, attract its atoms to each other and therefore they move together in space. This applies also to their moving together in the same temporal direction (since difference in the temporal directions of atoms that move together spatially, implies their spatial separation, which acts against the forces that hold them together). The probability, or amplitude, that a macroscopic solid body moves backwards in time is the multiplication of the amplitude that one atom moves backwards in time, which is very small, with the number of atoms in this body. This multiplication is very small indeed, and it is practically zero.

Therefore we may determine the temporal direction of a microscopic particle relatively to a macroscopic body in its vicinity that interacts (e.g., collides) with it. These notions will be clarified by examples in the sequel.

It should be stated that at least in this stage we do not assume any mathematical model for our theory, in particular not the quantum-field theory. Therefore we do not assume the mathematical superselection rules, according to which entanglement of electrically charged particles is not possible (indeed, the EPR paradox implies that such an entanglement exists). A future mathematical model should suit the unchangeable empirical facts and the logical analysis, and not the opposite. Thus we do not let any existing (and changeable) mathematical model to bias our conclusions.

6. The Amplitudes of the Temporal Directions

Each atom in our surrounding comprises electronic shells and nuclear protons. It has amplitude to move forwards in time and complementary amplitude to move backwards in time. If it moves backwards in time it is an atom of antimatter, and if it collides with an atom of matter, both atoms annihilate each other and photons of γ rays are emitted. Therefore, the amplitude of an atom to move backwards in time is the probability that when it collides with another atom it is annihilated and it emits γ photons. Such radiation, that is otherwise unexplained, is expected according to Feynman's theory, and its discovery is in line with it.

In the next sections we will analyze in which conditions such radiation may be detected, so that experimental physicists may try to detect it. The amplitude of an atom of matter to be an atom of antimatter is very small, which may count for the fact that such radiation has been hardly reported. It might have been considered to be part of the background radiation, together with cosmic rays and natural radioactivity.

7. The Temporal Direction of Macroscopic Bodies

A macroscopic body behaves according to classical physics; therefore we may expect that it move forwards in time. The initial temporal direction of the macroscopic universe might have been determined by the initial conditions in the beginning of its atoms' constituents, probably following the big bang. This direction, which, apparently, is shared by all the macroscopic bodies, is defined, in fact, as "forwards in time."

However, there is some amplitude that particles, or atoms, will move backwards in time. According to Feynman (1985, p. 97 Fig 63 c, p. 99 Fig 64) the changing of the temporal direction of an electron (at T_6) or a positron (at T_3) is equivalent to their annihilation due to their collision, or to the disintegration of a photon into an electron and a positron. This energy is equal at least to the to the sum of the resting masses of the electron and the positron, i.e., at least to twice the resting mass of the electron. Therefore, if a photon pushes an atom, or a gaseous molecule, backwards in time, its energy should be at least $2mC^2$, where m is the resting mass of the atom or the molecule and C is the velocity of light. This energy is very high, and the amplitude that such a photon will collide with an atom is very small. This small probability may explain the rareness of atoms of antimatter in nature (and implies that enormous energy is required for a time machine, which makes it not practical).

Let us consider the possibility that single atoms within a macroscopic solid body may move backwards in time, and are annihilated together with ordinary atoms of this body, and emit radiation of γ photons.

Let us assume that some of the atoms of a macroscopic solid body move backwards in time. Than when this body moves in space in would have been disintegrated, and the atoms that move backwards-in time would have been located elsewhere.

Moreover, suppose that such an atom comes from the future to the present, collides with a material atom of this body, and both are annihilated. The annihilation of the atom of antimatter at the present and its turning into photons, causes it to cease to exist in the future as an atom, contrary to its coming from the future as an atom. Suppose that the atom of antimatter moves from the present to the past and it is annihilated in the past. This contradicts its existence in the present as an atom. Therefore no collapse of the wave function of an atom within a macroscopic solid body, resulting in its materialization as an atom of antimatter and its annihilation, is possible. That is, all the atoms of a macroscopic solid body can materialize only in the state of being matter.

An additional argument, based on the proof of Penrose (1989), presented in the next section regarding collisions of gaseous molecules with a solid macroscopic body, is true also regarding an atom of the macroscopic solid body.

8. Collision of a Gaseous Molecule with a Macroscopic Body

Suppose that a gaseous molecule collides with a macroscopic solid body and we detect a photon of γ ray coming from the direction of the collision, with no apparent known reason. We may explain this phenomenon as indicating the collapse of the wave function of the gaseous molecule, and its mutual annihilation together with an atom of the solid body, which according to the previous section is necessarily an atom of matter. This means that the gaseous molecule travels backwards in time, and it came to the present instant of annihilation from the future. However, the annihilation of the molecule at the present contradicts its existence in the future and its coming from there.

Moreover, as soon as the macroscopic body and the physicist who detects the annihilation continue their temporal voyage towards the future the physicist knows right away (an instant <u>after</u> the detection of the photon) that the gaseous molecule exists and comprises atoms of antimatter. Therefore it is both moving backwards in time (relatively to the temporal direction of the macroscopic solid body) and not entangled, contrary to the above proof of Penrose (1989).

Therefore, no detection of photons due to the collapse of the wave function of a gaseous molecule while colliding with a macroscopic solid body is possible.

However, a positron originating, say, in a radioactive decomposition (or an artificial atom of antimatter, produced from particles originating in radioactive decompositions), which collides with a macroscopic body is annihilated together with an electron of an atom of a solid body. This means that this positron must be considered to be a positively charged particle, that moves in the same temporal direction as the macroscopic body, and not an electron moving backwards in time. Indeed, the fact that the positron has been annihilated at the present of the macroscopic body means that it does not exist in the future of this body, and it cannot come from there; it cannot travel to the past of this body and be annihilated there, since it has been already annihilated in the present. The radioactive decomposition that emitted this positron is the collapse of the wave function (of entangled subatomic particles) that according to the proof of Penrose (1989) prevents it from moving backwards in time (indeed, if this positron passes through a Wilson chamber influenced by a magnetic field, it will be biased in the mode expected from a positively charged particle, before colliding with the macroscopic body and its annihilation). No such collapse of the wave function is known regarding the constituents of the atoms of a natural gaseous molecule, which might have existed in nature during milliards of years.

An artificial atom of antimatter, like anti-hydrogen, is produced from two particles of antimatter, which are the outcome of radioactive disintegration, i.e., a collapse of a wave function, and we know that it is an atom of antimatter before its collision with a macroscopic body, and its annihilation. Therefore, it is not a superposition nor a wave-function.

9. Collision of two Gaseous Molecules

Suppose that two gaseous molecules collide, and we detect a γ-ray photon originating at the direction and the time of this collision. Then we may conclude that the wave functions of both these molecules have collapsed, one of them has been materialized as matter, and the other as antimatter, and the molecules have annihilated each other.

This case is different from the case described at the previous section by the fact that if a gaseous molecule would have been annihilated as a result of its collision with a macroscopic solid body, we know that the macroscopic body comprises only atoms of matter, and therefore the gaseous molecule must have been materialized as antimatter. In the present case we do not know which of the two gaseous molecules is the molecule of antimatter, and which of them traveled backwards in time before the collision. Therefore, when the physicist who detects the annihilation continues his (or her) temporal travel in the direction of the future, he (or she) must consider each of the two molecules to be a wave function, which is an entanglement of matter and antimatter. Thus the detecting of the annihilation does not contradict the proof of Penrose (1989). When the physicist and his laboratory are in the future, the gaseous atom that had come from the past (the material atom) has been annihilated, while the one that had come from the future (the atom of antimatter) should exist. Its existence dose not contradicts its being annihilated together with the atom of matter, since it is not known which of the two atoms is the atom of matter, and each of them has probability of 0.5 to exist, and probability of 0.5 not to exist. The atom that had come from the future is a superposition of both these atoms, i.e., it is in a superposition of existence and non-existence. Therefore it fulfills both requirements: it exists in the future as an atom that came from the future (before its annihilation), and it does not exist, as an atom that has been annihilated in the past.

Moreover, the direction in time and the temporal locations of both gaseous molecules are not determined, and these directions are entangled. When the temporal direction of the system of the two gaseous molecules is supposed to be inverted, nothing changes, since we do not know which molecule is of matter and which is of antimatter. However, the event of annihilation of matter and antimatter is equivalent, then, to the disintegration of photons into particles and antiparticles, and these two events are entangled. Therefore the detection of the annihilation of the two gaseous molecules does not contradict the existence of one of them in the future; the annihilation is indistinguishable from, and may be interpreted as, such disintegration of photons. This situation is different from the situation analyzed in the previous section, where the macroscopic solid body was not entangled.

We observed that there is no of emission of photons due to the collapse of the wave function of the states of matter and antimatter of colliding atoms, when one of the colliding atoms is included in a macroscopic solid body, but such emission is possible when both colliding atoms are gaseous. This situation is due to Feynman's hypothesis that atoms of antimatter move backwards in time. If this situation will be proved empirically, this may be an empirical proof of Feynman's hypothesis.

No unexplained emission of γ- photons has been has been observed when macroscopic solid bodies are involved. We may conclude that an empirical proof of Feynman's Hypothesis may be obtained only by collisions between gaseous (or liquid) molecules. In the sequel we will analyze two particular situations in which the probability of collisions between gaseous molecules, and therefore of obtaining the hypothesized effect, are larger than usual.

10. Cooled Gases

The lower is the temperature of gas; the larger is the probability that its molecules will collide. This follows from Heisenberg's principle of uncertainty, according to which:

$$\Delta V \cdot \Delta X \geq \hbar/m = \text{constant}$$

where ΔV is the range in which the velocity of molecule may change, ΔX is the range in which the location of the molecule may change, m is the mass of the molecule and $\hbar$ is Planck's constant. The smaller is V, the smaller is ΔV. Therefore, when V is small, then ΔX is large, and the amplitude of slow (cold) molecule to collide with another molecule is larger than of a fast (hot) molecule. Therefore Probability that annihilation of matter and antimatter due to the collapse of the wave functions of colliding molecules is larger in cold gas than in warm gas.

Molchadzki (1959) described an experiment, performed by him on November and December 1958, as part of his M. Sc. thesis, conducted under the supervision of P. Avivi. This experiment is reviewed in Fidelman (2002). The experimenters cooled the gas xenon, liquefied it and froze it, in the presence of a photomultiplier. During this process they detected radiation of photons, which was significantly, but not dramatically, larger than the background radiation. This phenomenon was repeated also with other gases. This phenomenon was not understood at that time and was not published. Maybe that other experimenters encountered the same phenomenon and their findings shared the same fate. We suggest to repeat this experiment and to measure the intensity of the radiated photons in order to determine whether this intensity suits the annihilation of atoms of matter and antimatter

11. Sonoluminescence

Sonoluminescence is a phenomenon where bubbles of gas implode due to acoustic waves and emit light. The mechanism of the emission of sonoluminescence light is as yet unexplained (Barber et. al 1994). It may involve more than one factor. We suggest the following (possibly partial) explanation of the sonoluminescence light.

When the bubble collapses, many molecules of gas collide simultaneously at the center of the bubble, and there is a larger than usual amplitude that the wave function of some molecules will collapse, and annihilation of matter and antimatter will occur, causing the emission of γ-photons. These photons may cause secondary effects, like the ejection of electrons from their orbits, and then the falling of electrons into the vacant orbits, causing the emission of visible light.

It should be noted that the emission of sonoluminescenc light increases while the temperature of the liquid, and of the gas inside the bubbles, decreases (Barber et al. 1994, Taleyarkhan et al. 2002). They explained this phenomenon by the smaller evaporation and larger condensation of the vapor inside the bubble while the temperature is lower. This reduces the cushioning effect of the vapor during the implosion of the bubble. This explanation is not convincing entirely, since smaller evaporation and larger condensation decrease the volume of the bubble, so that its internal pressure remains in equilibrium with the external pressure, otherwise the bubble collapses. It is not clear why a smaller bubble emits more light than a larger bubble.

However, we observed in the former section that cold temperature by itself is sufficient to increase the amplitude of annihilation of gaseous atoms. Therefore, a possible partial explanation may be that cooling the gas slows its molecules, and according to Heisenberg's principle, this increases the amplitude of collisions at the center of the bubble.

Barber et al. (1994) suggested that the temperature caused by the implosion of the bubble may be sufficient for causing nuclear fusion reaction in which deuterium may change into tritium. Taleyarkhn et al. (2002) performed this experiment and detected nuclear radiation, namely, γ rays and/or neutrons, during the implosion of bubbles of acetone, which includes atoms of deuterium instead of atoms of hydrogen. This emission was around the time of the sonoluminescence light. However, the experimenters found also increase in the nuclear radiation, around the time of the emission of the sonoluminescence light, in the control experiment with natural acetone (comprising natural hydrogen), though to a lesser degree. This last finding cannot originate in nuclear fusion, since no deuterium was present. Therefore it may originate in the annihilation of atoms of matter and antimatter, due to the collapse of the wave function of colliding gaseous atoms. This annihilation may occur in more than one stage. First some components of the colliding atoms may touch each other, are annihilated and emit γ rays. Than the remaining partially annihilated atom may disintegrate, emit neutrons, and electrically charged particles and antiparticles, and the process of collisions and annihilations may continue.

It should be noted that the outcome of the control experiment of Taleyarkhan et al. (2002) has been predicted by Fidelman (2002), which is published in the Proceedings of CASYS'01, Fifth International Conference on Computing Anticipatory Systems, Liege, Belgium, August 13-18, 2001.
This Conference occurred prior to the publication of Taleyarkhan et al. 2002.
Thus this prediction is not post hoc.

12. Discussion

The photons emitted due to the annihilation of matter and antimatter are typical. Usually they are two back to back photons, their energy is equal to the energetic values of the masses of the annihilated particles, according to Einstein's formula:

$$E = m \cdot c^2$$

Therefore repetition of the two experiments described in the last two sections, and performing the required measurements of the photons' energies and directions, may provide a clear answer to the question whether the emitted photons originate in the annihilation of matter and antimatter.

The amplitude of an atom to be an atom of matter and the complementary amplitude to be an atom of antimatter may be computed as follows: We can compute the total number of collisions between the molecules of a certain volume of gas at a certain temperature during a unit of time, applying thermodynamics. Then we can count the number of emitted photons, from the same volume of gas, during the same time, originating in the annihilation of gaseous molecules of matter and antimatter, and estimate the number of collisions terminated in the collapse of the wave function and annihilation. The percentage of the collisions terminated in annihilation is the square of the amplitude of the entangled gaseous molecule to be a molecule of antimatter.

This means that Feynman's suggestion regarding the traveling of particles backwards in time is not merely an un-testable speculation, but a scientific hypothesis, according to Popper's definition of a scientific theory as a theory that an attempt to falsify it empirically is possible. We conclude that Feynman's hypothesis can be tested experimentally.

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