On Reconciling Quantum Theory and Relativity

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Abstract

One of the most important open questions in physics is the possibility of reconciliation, and perhaps unification, between quantum theory and relativity theory. Here I show that a relativity theory without the Lorentz Invariance Principle, termed Complete Relativity, reconciles with quantum mechanics at significant meeting points: It explains the quantum criticality at the Golden Ratio. More importantly, it confirms with Planck's energy**.** These results are quite astounding, given the fact that Complete Relativity, like Special Relativity, is a deterministic model of the dynamics of moving bodies. An application of the theory to cosmology, discussed in a recent paper, revealed that it yields definitions of dark matter and dark energy, and predicts the contents of the universe with impressive accuracy. Taken together, these results raise the exciting possibility that physics at the quantum scale, and at the cosmological scale, are the two faces of one coin: The coin of *relativity*.

Introduction

One of the important open questions on the foundations of quantum physics, summarized in [1], pertains to the possibility of reconciliation between General Relativity and Quantum Theory. The authors of the report in [1] argued that "while we have developed successful quantum theories of the other fundamental forces of Nature (electromagnetic, weak and strong), we have no analogously successful quantum theory of gravity". The authors ascribe the difficulty in reconciling quantum theory with relativity to contrasting conceptual structures of quantum theories and to controversies about interpreting them, resulting in conflicting basic approaches to quantum gravity. They go further to argue that "Whereas relativity theory is grounded on principles which are reasonable from a physical point of view, such as the principles of relativity and of equivalence, it remains an open question whether quantum theory could be based on comparable principles".

Quantum measurement problems and conflicting theorizations, as the ones discussed in [1], are without doubt obstacles to be surmounted. Nonetheless, it is argued here that the overconfidence in the validity of relativity theory should be also reconsidered. The zeitgeist in physics is that Einstein's relativity is not only correct, but that it is the only alternative to the classical, Newtonian physics.

Complete Relativity and Planck's Energy

Recently, I have proposed a new theory of relativity for inertial systems, termed Complete Relativity [2-6]. The theory is based on the following propositions: 1.The laws of physics are the same in all inertial frames of reference. 2. The magnitudes of *all* physical entities, as measured by an observer, depend on the relative motion of the observer with respect to the rest frame of the measured entities. 3. The transformations of all physical entities, from one frame of reference to another, may depend on the methods used for their measurement. 4. All translations of information from one frame of reference to another are carried by light or electromagnetic waves of equal velocity. What is worth stressing here is that Complete Relativity abandons the Lorentz Invariance (and the corresponding constancy of the velocity of light).

A comprehensive presentation of Complete Relativity, including its time, distance, mass and energy transformations, is detailed in [2]. The resulting transformations are summarized in Table 1. The triplet (t, x, ρ) in the table denotes the time, distance, and mass-density as measured in an observer's internal frame, while the triplet (t', x', ρ') denotes the corresponding variables, as measured at the internal frame of an object with mass-density ρ', which moves with constant velocity $\beta = \frac{v}{c}$ relative to the observer's frame.

Table 1

Complete Relativity Transformations

Time (One-Way) $\frac{t}{t'}$	**Time** (Round Trip) $\frac{t}{t'}$	**Distance** $\frac{x}{x'}$	**Mass-Density** $\frac{\rho}{\rho'}$	**Kinetic Energy** $\frac{E}{m_0\, c^2}$
$\frac{1}{1-\beta}$	$\frac{2}{1-\beta^2}$	$\frac{1+\beta}{1-\beta}$	$\frac{1-\beta}{1+\beta}$	$\frac{1}{2}\,\beta^2\,\frac{1-\beta}{1+\beta}$

Note that for β →0 (v << c), all the expressions in the table reduce to the corresponding Newtonian expression.

In this short note, I focus on the Kinetic Energy expression. I show that a relativity theory without the Lorentz Invariance Principle reconciles with quantum mechanics at three significant meeting points: 1. quantum criticality, 2. Entanglement, and 3. Planck's energy.

As shown by the table, the kinetic energy for a body of mass m_0 is given by:

$$E = \frac{1}{2}\, m_0\, c^2\ \frac{(1-\beta)}{(1+\beta)}\,\beta^2 = \frac{1}{2}\, E_0\ \frac{(1-\beta)}{(1+\beta)}\,\beta^2 \qquad \text{….. (1)}$$

where $\beta = \frac{v}{c}$ and $E_0 = m_0\ c^2$

Figure 1 depicts $\frac{E}{E_0}$ as a function of the velocity β. Quite strikingly, for departing bodies (positive β values), the kinetic energy displays a non-monotonic behavior. It increases with β up to a maximum at velocity β = β_{cr} , and then decreases to zero at β = 1.

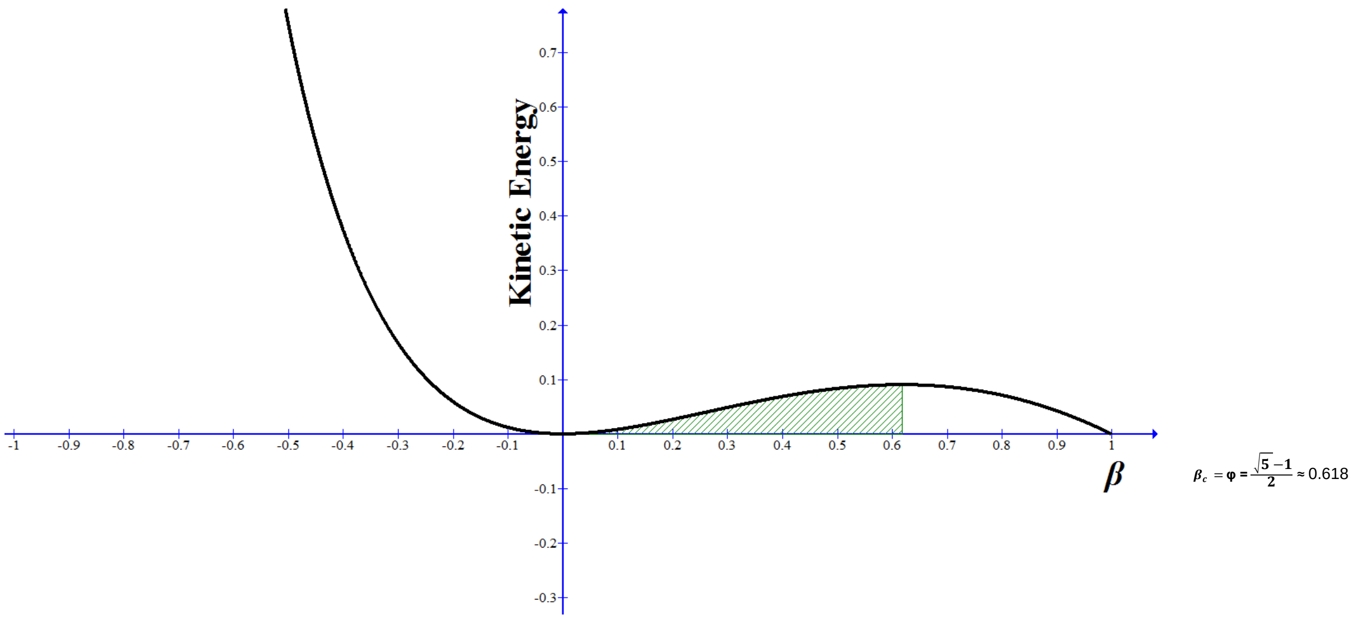

Figure 3. Kinetic energy as a function of velocity

To calculate β_{cr} I derive $\frac{E}{E_0}$ with respect to β and equate the result to zero:

$$\frac{d}{d\beta}\left(\beta^2 \frac{(1-\beta)}{(1+\beta)}\right) = 2\,\beta\,\frac{(1-\beta)}{(1+\beta)} + \beta^2\frac{[(1+\beta)(-1)-(1-\beta)(1)]}{(1+\beta)^2} = 2\,\beta\frac{(1-\beta^2-\beta)}{(1+\beta)^2} = 0. \qquad \text{.... (2)}$$

for $\beta \neq 0$ and we get:

$$\beta^2 + \beta - 1 = 0 \qquad \text{....(3)}$$

Which solve for positive β at:

$\beta_{cr} = \frac{\sqrt{5}-1}{2} = \Phi \approx 0.618$ ….(4)

Where Φ is the Golden Ratio [7-8]. Substituting $\boldsymbol{\beta_{cr}}$ in the energy expression (Eq. 1) yields :

E_{max}= ½ E_0 $\Phi^2 \frac{1-\Phi}{1+\Phi}$ .... (5)

From Eq. 3 we can write: $\Phi^2 + \Phi - 1 = 0$, which implies $1 - \Phi = \Phi^2$ and $1+ \Phi = \frac{1}{\Phi}$.

Substitution in Eq. 5 gives:

E_{max} = ½ Φ^5 E_0 $\approx \frac{0.09016994}{2}$ $E_0 \approx 0.04508497\, E_0$ .... (6)

The result showing that the maximal kinetic energy is obtained at $\beta_{cr} = \Phi$ agrees with a recent experimental finding (9), which demonstrated that applying a magnetic field at right angles to an aligned chain of cobalt niobate atoms, makes the cobalt enter a quantum critical state, in which the ratio between the frequencies of the first two notes of the resonance equals the Golden Ratio; the highest-order *E8* symmetry group discovered in mathematics (10). In the framework of Complete Relativity, this is the velocity at which, in energy terms, the relativistic decrease in mass equals the positive energy ($\frac{1}{2}$ v^2 , contributed by the body's velocity. Interestingly, the ratio $\frac{E_{max}}{E_0} = \frac{E_{max}}{m_0\, c^2} \approx 0.04508497$, precisely half of L. Hardy's probability of entanglement (0.09016994) (11-12).

To demonstrate that the results of Complete Relativity concurs with Planck's constant, consider a particle of rest mass m_0 and velocity *v*. The minimal observable energy in quantum mechanics is given by:

$E = \frac{h\, c}{\lambda}$ .... (7)

Where *h* is the Planck's constant (*h* = 6.26069 x 10^{-34} J.s), *c* = 299729458 $\frac{m}{s}$ and λ is the particles wave length.

The corresponding particle's velocity, according to Complete Relativity, is obtained by solving the equation:

$$\frac{h\,c}{\lambda} \;==\frac{1}{2}\;m_0\,c^2\;\frac{(1-\beta)}{(1+\beta)}\,\beta^2 \qquad \text{.... (8)}$$

Which gives:

$$\beta^3 \;-\beta^2 + \frac{2\,h}{\lambda\,m_0\,c}\,\beta + \frac{2\,h}{\lambda\,m_0\,c} = 0 \qquad \text{.... (9)}$$

For a photon with mass m_0 = 1.67x10^{-27} kg and λ = 1.2398 x 10^{-6} m. (energy = 1 eV) we have:

$$\frac{2\,h}{\lambda\,m_0\,c} \approx 2.017691 \text{ x } 10^{-9} \qquad \text{.... (10)}$$

And,

$$\beta^3 \;-\beta^2 + 2.017691 \text{ x } 10^{-9}\,\beta + 2.017691 \text{ x } 10^{-9} = 0 \qquad \text{.... (11)}$$

A numerical solution of Eq. 11 yields:

$$\beta \approx 0.999999999\text{, or v} \approx 0.999999999 \text{ c} \approx \text{c} \qquad \text{…. (12)}$$

Concluding remarks

For a photon with energy of 1 eV I have shown that the energy predicted by Complete Relativity is equal to photon's Planck energy. This is a striking result, given the fact that Complete Relativity, like Special Relativity, is a deterministic model of the mechanics of inertial systems. This agreement between two very distinct models of reality could be easily tested for a wider range in the photon sector, as well as for other particles, like neutrinos. Moreover, consideration of gravitational and other forces should be undertaken.

The possibility of reconciling the dynamics of moving bodies with quantum mechanics is further supported by the above discussed connectedness of Complete Relativity to quantum criticality and Hardy's entanglement probability.

In [1] I have applied CR to cosmology and showed that it predicts with impressive accuracy the contents of the universe. At a cosmic scale, the decrease in kinetic energy for velocities β > **Φ** (Φ = Golden Ratio), is explained as resulting from the dominance of dark matter and dark energy over baryonic matter and kinetic energy. This raises the exciting possibility that physics at the quantum scale and at the cosmological scale are the two faces of one coin: The coin of *relativity*.

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