QUANTIZATION OF ECE2 THEORY.

by

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ABSTRACT

Quantization schemes are developed for ECE2 theory based on the fact that it is Lorentz covariant within the context of a generally covariant unified field theory. The equations of special relativity apply, and are quantized using various schemes which result in measurable energy shifts. A new axiom of special relativity is introduced, that the laboratory frame velocity of the Lorentz transform is bounded above by c / $\sqrt{2}$. This axiom allows a particle of finite mass m to move at the speed of light, thus removng many obscurites of the usual interpretation in which v0 is allowed to approach c, and results immediately in the observed light deflection due to gravitation.

Key words: ECE2 theory, quantization schemes, new axiom of special relativity.

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1. INTRODUCTION.

In the immediately preceding papers of this series {1 - 12} the Lorentz covariance of the ECE2 theory has been developed in various ways, and used notably to produce perihelion precession and light deflection due to gravitation from special relativity. In this paper the theory is quantized in various ways using quantization schemes based again on special relativity, producing a variety of new results given in the notes accompanying this paper on www.aias.us. A new axiom of special relativity is introduced, that the laboratory frame velocity used to define the Lorentz factor is bounded above by c $/\sqrt{2}$. This axiom immediately gives the observed light deflection due to gravitation and also allows a particle with mass to propagate at c, thus removing many obscurities of the standard model of physics.

As usual this paper should be read with its accompanying background notes, which are intrinsic parts of the paper and contain a great deal of detail summarized in the paper itself. Note 326(1) defines and develops the relativistic velocity in preparation for the new axiom. Note 326(2) outlines the basics of the quantization scheme and uses the Dirac approximation to produce new energy levels. This note illustrates the general method. In Note 326(3) the lagrangian of special relativity is introduced and the Lorentz gamma factor expressed in terms of angular momentum, leading to new orbital equations of quantum mechanics. Note 326 (4) develops quantized relativistic rotational motion and the relativistic particle on the ring problem and defines the relativistic Schroedinger equation. Note 326(5) develops the general theory of free particle relativistic quantization. Note 326(6) is a comprehensive description of the basics of special relativity from first principles of the Lorentz transform culminating in the relativistic relation between wavenumber and the laboratory frame velocity (v0) of the Lorentz transform. Note 326(7) introduces the new axiom of special relativity from first principles of the Lorentz transform. Note 326(8) is a comprehensive description of three quantization schemes using the relation between the hamiltonian and lagrangian of special relativity and culminates in the description of shifted energy levels in terms of v0 and in various expressions for shifted energy levels.. Finally Note 326(9) develops a novel quantization scheme to give an experimental method of measuring v0 in order to test the new axiom experimentally.

Section 2 is a description of the main results of the quantization schemes and of the new axiom of special relativity introduced already. It also gives a suggested experimental method for testing the new axiom. Section 3 gives additional calculations and graphical results on this suggested experimental method.

2. NEW AXIOM AND DESCRIPTION OF MAIN RESULTS

The fundamental equations {1 - 12} for the quantization schemes are the de Broglie Einstein equations defining the relativistic total energy:

$$E = \gamma m c^2 = \hbar \omega \qquad -(1)$$

and the relativistic momentum:

$$\underline{p} = \gamma m \underline{v}_0 = \hbar \underline{\kappa} \qquad -(2)$$

where the Lorentz factor is derived in Note 326(6) and defined as:

$$\gamma = \left(1 - v_0^2 / c^2\right)^{-1/2} \qquad -(3)$$

Here m is the particle mass, $\underline{v}_0$ the particle velocity in the observer frame, and c the speed of light, regarded in special relativity as a fundamental constant as is well known. The hamiltonian of special relativity is:

$$H = \gamma mc^2 + U \quad -(4)$$

where U is the potential energy, and the lagrangian is:

$$\mathcal{L} = -\frac{mc^2}{\gamma} - U \quad -(5)$$

so:

$$E = H + \mathcal{L} + \frac{mc^2}{\gamma}. \quad -(6)$$

The relativistic total energy E is therefore defined as:

$$E = H - U \quad -(7)$$

and is expressed as:

$$E^2 = p^2c^2 + m^2c^4. \quad -(8)$$

This equation can be factorized in two ways:

$$E - mc^2 = \frac{p^2c^2}{E + mc^2} \quad -(9)$$

and

$$E - pc = \frac{m^2c^4}{E + pc} \quad -(10)$$

$$-(11)$$

each of which may be quantized using the Schroedinger quantization:

$$p^\mu = \left(\frac{E}{c}, \underline{p}\right) = i\hbar\partial^\mu = i\hbar\left(\frac{1}{c}\frac{\partial}{\partial t}, -\underline{\nabla}\right)$$

of the energy momentum four vector. Note carefully that the relativistic energy E and momentum $\underline{p}$ appear in Eq. (11). The relativistic Schroedinger equation is obtained from

Eq. (9) and (11):

$$\frac{p^2}{2m}\phi = \frac{mc^2}{2}\left(\gamma^2 - 1\right)\phi \quad -(12)$$

and can be used for various types of quantization as described in the notes accompanying this paper. Eq. (12) can be developed as:

$$-\frac{\hbar^2}{2m}\nabla^2\phi = \frac{mc^2}{2}\left(\gamma^2 - 1\right)\phi \quad -(13)$$

which in the limit:

$$v_0 \ll c \quad -(14)$$

gives the self consistent result:

$$\frac{p^2}{2m} = mc^2\left(\left(1 - \frac{v_0^2}{c^2}\right)^{-1} - 1\right) \xrightarrow[v_0 \ll c]{} \frac{1}{2}mv_0^2 . \quad -(14)$$

Eq. (12) may also be expressed as:

$$\left(\frac{p^2}{(1+\gamma)m} + U\right)\phi = \left(H - mc^2\right)\phi \quad -(15)$$

as explained in detail in Note 326(8). The relativistic Schroedinger equation is therefore defined by the replacement:

$$\frac{p^2}{2m} \rightarrow \frac{p^2}{(1+\gamma)m} \quad -(16)$$

in the non relativistic Schroedinger equation:

$$\left(\frac{p^2}{2m} + U\right)\phi = \left(H - mc^2\right)\phi := E_{tot}\,\phi . \quad -(17)$$

The relativistic Schroedinger equation (15) may be developed as:

$$\left(\frac{p^2}{2m} + U\right)\phi = E_{tot}\phi + \frac{1}{2}(\gamma - 1)(E_{tot} - U)\phi \quad -(18)$$

where in the conventional notation:

$$E_{tot} := H - mc^2. \quad -(19)$$

In the H atom:

$$U = -\frac{e^2}{4\pi\epsilon_0 r} \quad -(20)$$

and the energy levels of th eH atom are shifted by:

$$E_{tot} \rightarrow E_{tot} + \frac{m^2 v_0^2}{4}\left(\left(1 - \frac{v_0^2}{c^2}\right)^{-1/2} - 1\right). \quad -(21)$$

This scheme allows v0 to be observed from the spectrum of the H atom. Knowing v0 the relativistic velocity for each orbital may be calculated:

$$\underline{v} = \gamma \underline{v}_0 . \quad -(22)$$

The Dirac type quantization scheme is developed from:

$$H - U - mc^2 = \frac{p^2 c^2}{H - U + mc^2} \quad -(23)$$

in the rough approximation:

$$H = \gamma mc^2 + U \rightarrow mc^2 \quad -(24)$$

when:

$$\gamma \rightarrow 1, \quad U << E. \quad -(25)$$

So:

$$\left(-\frac{\hbar^2 \nabla^2}{2m} + U\right)\phi = E_{tot}\phi + \frac{\hbar^2}{4m^2c^2}\nabla^2(U\phi) \quad -(26)$$

and

$$\nabla^2(U\phi) = U\nabla^2\phi + 2\underline{\nabla}U\cdot\underline{\nabla}\phi + \phi\nabla^2 U \quad -(27)$$

The energy levels of the H atom are shifted by the expectation values:

$$\langle \Delta E_{tot} \rangle = -\frac{\hbar^2}{4m^2c^2}\left(\int \phi^* U \nabla^2 \phi \, d\tau + \int \phi^* (\nabla^2 U)\phi \, d\tau + 2\int \phi^* \underline{\nabla} U \cdot \underline{\nabla}\phi \, d\tau\right) \quad -(28)$$

which can be evaluated using hydrogenic wavefunctions in the first approximation,

The factorization (10) leads to:

$$E = pc + \frac{m^2c^4}{E + pc} \quad -(29)$$

so from the de Broglie / Einstein equations:

$$\omega = \kappa c + \frac{1}{\hbar}\frac{mc^3}{\gamma(c + v_0)} \quad -(30)$$

This gives another method of measuring v0 and v by measuring ω and κ experimentally. By using Eq. (30) with the de Broglie / Einstein equation:

$$\underline{p} = \gamma m \underline{v_0} = \hbar \underline{\kappa} \quad -(31)$$

the mass m and velocity v0 may be determined experimentally.

A new axiom of special relativity may be developed using Note 326(6) by considering the relativistic momentum:

$$\underline{p} = \gamma m \underline{v_0} \quad -(32)$$

and the laboratory frame momentum:

$$\underline{p}_0 = m\underline{v}_0 \quad -(33)$$

It follows that the relativistic velocity is:

$$\underline{v} = \gamma \underline{v}_0 \quad -(34)$$

The relativistic velocity $\underline{v}$ is the observable velocity of a particle in special relativity. The Lorentz factor is defined by the observer frame velocity as given in detail in Note 326(6):

$$\gamma = \left(1 - \frac{v_0^2}{c^2}\right)^{-1/2} \quad -(35)$$

so it follows that:

$$v^2 = \frac{v_0^2}{1 - \frac{v_0^2}{c^2}} \quad -(36)$$

and

$$v_0^2 = \frac{v^2}{1 + v^2/c^2} \quad -(37)$$

In the usual interpretation of special relativity the velocity v0 is allowed to approach an upper limit of c. This is in fact an assertion or axiom of the old theory, in which v0 was very rarely if ever observed experimentally. This assumption:

$$v_0 \rightarrow c, \quad -(38)$$

results however in

$$\gamma \rightarrow \infty, \quad -(39)$$

which is obscurely referred to in the old literature as the hyper relativistic limit. It forces the mass m of a particle travelling at c to be identically zero. The relativistic momentum becomes mathematically indeterminate, zero multiplied by infinity. Such as theory ought to have been discarded as unphysical but unfortunately a photon of zero mass became a dogmatic feature of standard physics. A zero mass photon causes many severe difficulties {1 - 12} as is well known.

A new axiom of special relativity is proposed as follows:

$$v_0^2 \rightarrow \frac{c^2}{2} \quad -(40)$$

and this is the maximum allowed value of v0. Under condition (40), the relativistic velocity becomes c and the Lorentz factor goes to:

$$\gamma \rightarrow \sqrt{2} \quad -(41)$$

and stays finite. The mass of a particle moving at c remains finite. Furthermore the condition (40) immediately gives the correct light deflection due to gravitation as follows:

$$\Delta\phi = \frac{2mG}{R_0 v_0^2} \xrightarrow[v \rightarrow c]{} \frac{4mG}{R_0 c^2} \quad -(42).$$

as in immediately preceding papers. The new axiom also gives the correct O(3) little group of the Poincaré group, allows canonical quantization without problems, produces the Proca equation, and is also compatible with the longitudinally directed B(3) field {1 - 12}. It removes the need for the Gupta Bleuler procedure and allows all four states of polarization of a photon to exist. For a massless photon only the transverse modes are allowed to exist, resulting in the unphysical E(2) little group of the Poincaré group as is well known. The new axiom also introduces photon mass theory in general, and changes the entire structure of physics, refuting the Higgs boson and the Higgs mechanism, and indeed the entire structure of standard particle physics as described in over six hundred papers and books on www.aias.us since 1993. Some methods of measuring v0 are given earlier in this section so it may be possible to test the new axiom experimentally.

As described in notes such as 326(6) the relativistic Schroedinger equation may also be written as:

$$-\frac{\hbar^2}{2m}\nabla^2\phi = \frac{1}{2}(\gamma^2-1)mc^2\phi := E_{rel}\phi \quad -(43)$$

whose solution is:

$$\phi = A\exp(i\kappa Z) + B\exp(-i\kappa Z) \quad -(44)$$

where:

$$\kappa^2 = \frac{2mE_{rel}}{\hbar^2}. \quad -(45)$$

This leads to a relativistic quantum tunnelling theory {1 - 12} and also to an expression for v0 in terms of κ:

$$\left(\frac{v_0}{c}\right)^2 = 1 - \left(1 + \left(\frac{\hbar\kappa}{mc}\right)^2\right)^{-1} \quad -(46)$$

which may be used with Eq. (32) to determine v0 and m experimentally.

Free particle quantization occurs when

$$U = 0 \quad -(47)$$

and an example is described in Note 326(4), the relativistic particle on a ring. The interested reader is referred to this note for further details. Another approach to relativistic rotational quantization is given in Note 326(3) in which the lagrangian of special relativity is introduced to give the force equation in plane polar coordinates:

$$F(r) = -\frac{\partial U}{\partial r} = \frac{d}{dt}(\gamma m\dot{r}) - \gamma m r\dot{\theta}^2 \quad -(48)$$

As in immediately preceding papers thsi force equation is equivalent to the Lorentz force equation of ECE2 theory. The lagrangian and hamiltonian of ECE2 are related with Eq. (6) giving scope for great development because the relativistic lagrangian can be introduced to quantization schemes based on the relativistic hamiltonian. Note 326(3) for example develops the potential energy U in the Dirac approximation in terms of

$$U \sim mc^2 \left(1 - \left(\frac{L}{L_0} \right)^2 \right) \quad -(49)$$

where L is the relativistic angular momentum and L0 the non relativistic angular momentum. For a hydrogenic potential:

$$U = -\frac{e^2}{4\pi\epsilon_0 r} \quad -(50)$$

this procedure leads to the orbit type equation:

$$\frac{d\theta}{dr} = \frac{d\theta}{dt} \left(\frac{e^2}{4\pi\epsilon_0 m r} - r^2 \left(\frac{d\theta}{dt} \right)^2 \right)^{-1/2} \quad -(51)$$

$$\frac{d\theta}{dt} = \frac{L}{mr^2} \left(1 - \frac{e^2}{8\pi\epsilon_0 m c^2 r} \right) \quad -(52)$$

Finally in this Section the Dirac approximations (24) and (25) are used to produce the relativistic Schroedinger equation:

$$\left(-\frac{\hbar^2 \nabla^2}{2m} \left(1 + \frac{U}{2mc^2} \right) + U \right) \phi = \left(H - mc^2 \right) \phi \quad -(53)$$

and the shift in total energy levels of the H atom:

$$\langle E_{tot} \rangle \rightarrow \langle E_{tot} \rangle + \left\langle \frac{\hbar^2 U \nabla^2}{4m^2c^2} \right\rangle \quad -(54)$$

where

$$\left\langle \frac{\hbar^2 U \nabla^2}{4m^2c^2} \right\rangle = -\int \phi^* \frac{\hbar^2 e^2}{16\pi\epsilon_0 m^2 r} \nabla^2 \phi \, d\tau \quad -(55)$$

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3 Graphics and analysis

The relativistic Schroedinger equation for a free particle is according to note 326(4):

$$H_1 = H - m\,c^2 = \frac{p^2}{m(1+\gamma)} \tag{56}$$

with relativistic momentum

$$p = \gamma\,p_0 = \gamma\,m\,v_0 \tag{57}$$

and γ factor

$$\gamma = \frac{1}{\sqrt{1 - \frac{p_0^2}{m^2c^2}}}. \tag{58}$$

Inserting p and γ into (56) gives a relation between H_1, p_0 and v_0, i.e. the relativistic energy can be set in relation with the non-relativistic momentum and the frame velocity. From (56) follows

$$\frac{{p_0}^2}{m\left(1 - \frac{{p_0}^2}{m^2\,c^2}\right)} = \left(\frac{1}{\sqrt{1 - \frac{{p_0}^2}{m^2\,c^2}}} + 1\right) H_1. \tag{59}$$

This equation can be resolved for p_0 by computer algebra, giving intermediately an equation of eighth order for p_0 with three solutions for p_0^2:

$$p_0^2 = 0, \tag{60}$$

$$p_0^2 = \frac{m^2c^2\,H_1\,\left(H_1 - 2\,m\,c^2\right)}{\left(H_1 - m\,c^2\right)^2}, \tag{61}$$

$$p_0^2 = \frac{m^2c^2\,H_1\,\left(H_1 + 2\,m\,c^2\right)}{\left(H_1 + m\,c^2\right)^2}. \tag{62}$$

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It can be seen that in the approximation $H_1 \ll m\,c^2$ the third solution approaches the non-relativistic case

$$\frac{p_0^2}{2m} = H_1. \tag{63}$$

Alternatively, the two non-trivial equations (61, 62) can be resolved for H_1, resulting in two solutions

$$H_1 = \frac{-m\,c^2\,p_0^2 \pm m^2c^3\,\sqrt{m^2c^2 - p_0^2} + m^3c^4}{p_0^2 - m^2c^2}. \tag{64}$$

This is the relativistic free particle energy, written in terms of p_0.

The relativistic de Broglie wave number was derived in note 326(6):

$$\kappa^2 = \left(\frac{m\,c}{\hbar}\right)^2 \left(\frac{1}{1-\left(\frac{p_0}{m\,c}\right)^2} - 1\right). \tag{65}$$

With $p_0 = m\,v_0$ the dependence of κ on v_0 can be graphed and compared with the non-relativistic

$$\kappa^2 = \left(\frac{m\,v_0}{\hbar}\right)^2. \tag{66}$$

In Fig. 1 both curves are graphed with all constants set to unity. It can well be seen that the relativistic κ approaches the non-relativistic, linear curve for low velocities but diverges for $v_0 \to c$.

The de Broglie frequency for free particles was given by Eq.(30):

$$\omega = \kappa c + \frac{1}{\hbar}\frac{m\,c^3}{\gamma(c+v_0)}. \tag{67}$$

Inverting this equation for v_0 gives the result:

$$v_0 = \frac{c\,\left(\hbar\omega - m\,c^2 - \hbar\,c\,\kappa\right)\,\left(\hbar\,\omega + m\,c^2 - \hbar\,c\,\kappa\right)}{\hbar^2\,\left(\omega^2 - 2\,c\,\kappa\,\omega + c^2\,\kappa^2\right) + m^2\,c^4}. \tag{68}$$

Its dependence on κ and ω has been graphed in a 3D plot (Fig. 2). There is a range of negative velocities at the borders which is unphysical. The range is further confined by Eq.(65).

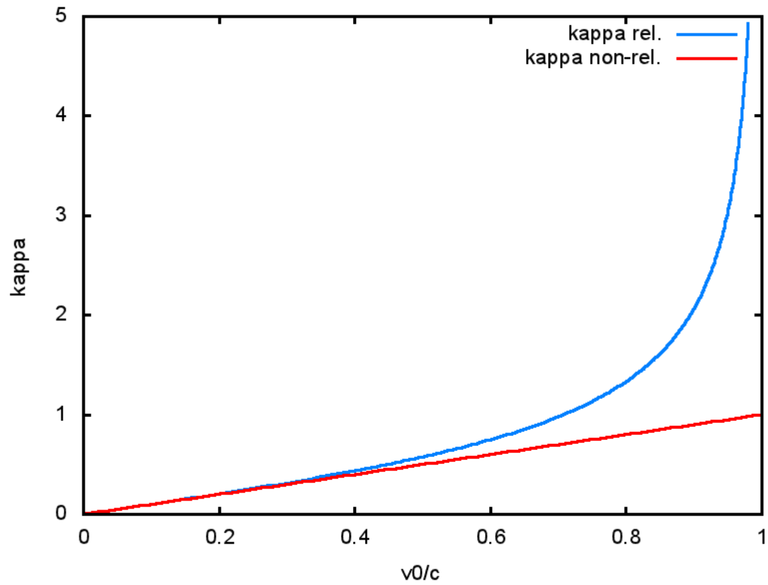

Figure 1: Free particle de Broglie wave number κ in dependence of v_0/c.

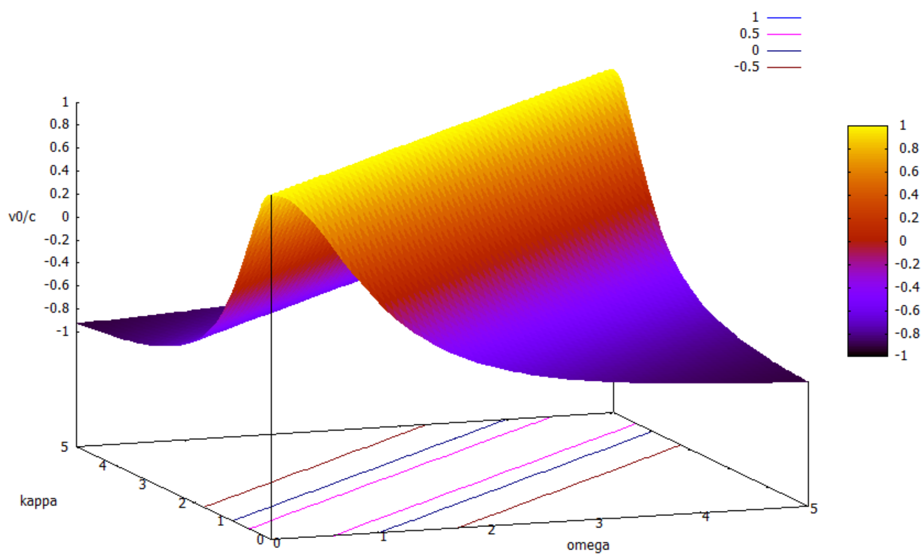

Figure 2: Free particle velocity v_0 in dependence of κ and ω.

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