# Theory of an electro-cordic field in quantum systems. I. (Revised)

R. Wayte.

29 Audley Way, Ascot, Berkshire, SL5 8EE, England, UK

E-mail: rwayte@googlemail.com

**Submitted to vixra.org    5 November 2019**

**Abstract:** A theory of electro-cordic guidewaves is developed to supplement the standard acausal statistical laws of quantum mechanics and account for the growth of accurate information from apparently random quantum events. Every effort is made to reveal the physical reality of the guidewaves which organise photons or electrons into predictable states. Einstein's equations of general relativity have also been applied to hydrogen to yield energy levels identical to those of Dirac's theory. A companion paper covers applications of electro-cordic guidewaves to interference, entanglement and superconductivity.

Keywords: quantum mechanics

**PACS Codes:** 03.65.-w, 03.65.Ta

## 1. Introduction

Generally, the theory of quantum mechanics is interpreted statistically but is able to get very accurate classically meaningful results. This technique, attributed to Bohr, Heisenberg and Born has at times been extended to imply that there exists no classically real world of particles or fields supporting quantum theory. Dirac (1962, p 15) concluded that sufficient justification for the whole scheme of quantum mechanics rests on agreement of the final results with experiment. It appears that concepts of reality, particles and orbits are being eroded because of the lack of an inclusive physical theory. However, physicists abhor slavish calculating in ignorance and require understanding as well as numerical results. Einstein believed that a causal theory of micro-physics is essential for compatibility with macro-physics, and also from a heuristic point of view. Bell (1987) regarded quantum theory as being an incomplete theory of observation. De Broglie (1956), Bohm (1984), Vigier (1987), Bohm & Hiley (1995), have produced theories of physical potentials or pilot-waves which guide particles in their trajectories. Therefore, received wisdom of a mysterious quantum theory need not exclude the advantages of a real guiding-field with a statistical-particle interpretation *based on evidence.* After all, gravitational and electric field quanta have never been observed directly but we appreciate their existence.

In this paper, an *electro-cordic* field will be proposed which determines the statistical aspects of quantum theory. This rests upon observations which show that the stars in spiral galaxies travel in discrete orbits, obeying quantisation rules analogous to those of Bohr orbits, (see Wayte, 2019). Likewise, the dimensions of stars, star clusters, and binary systems show signs of quantisation, (Wayte, 2011). Earlier, planetary rings were found to be quantised in angular momentum (Wayte 2010), as was the Solar System of planets (Wayte, 1982). It was considered improbable that all this quantisation on a grand scale could have resulted from statistically random events, so a real *gravito-cordic* field was proposed to exist there acting azimuthally to control angular momentum. Thus, normal gravity acting radially and a gravito-cordic field acting azimuthally may imply existence of a *gravitational* Schrödinger equation.

## 2. The proposed theory of electro-cordic guidewaves

The electro-cordic guidewave theory presented here differs from other theories but it is equally aimed at producing a real causal physical interpretation of quantum theory to eliminate some incongruity between theory and experimental physics.

### 2.1 Problems with standard quantum theory

*Standard* quantum theory is a theory of observation with problems that clearly expose its incompleteness; for example:

a) Schrodinger's mathematical equation represents a probability of getting some result without any real physical mechanism. The notion of negative probability amplitude is unreal. The probability density involves only the spatial eigenfunction while the high frequency temporal aspect of the probability amplitude phase factor is ignored.

b) In a double-slit experiment the fringe pattern of photons or particles is built from apparently random events at a few counts per second, yet it may become extremely smooth after many days as it approaches its *predicted* profile. Information content in the pattern increases inexorably. If the number of slits is increased, the fringe pattern becomes more detailed and precise. The fringe pattern is calculated by assuming trajectories which are not supposed to exist.

c) Absorption and emission-line spectra may be very sharp and predictable, contrasting with the broad probability wavefunctions. There is no mechanism to make the lines narrow. *Individual* atoms emit precisely the same spectra yet the wavefunction represents an *average* result for an ensemble of atoms.

d) In atoms the proposed fuzzy electron clouds do not conserve energy in detail and there is no inherent stability to maintain atomic structure. Separated atoms and particles of a species are identical and long-lived, as if some precise laws determine their *detailed internal* structure.

e) Tracks in cloud-chambers imply that particles are real and continuous in motion rather than being a series of observational events. The Crookes tube and cathode ray tube design assume trajectories. When an electron is accelerated in an electron gun, it conserves energy by existing continuously right up to the target and throughout any observable scattering process.

f) Quantum theory is incapable of dealing with details of particle creation and structure. This leads to infinities in the mathematics which have to be cunningly renormalised. High energy experiments may require the inclusion of sub-quantum structure.

g) The very existence of Heisenberg's uncertainty principle cannot be explained by quantum theory because it originates at a lower level of particle structure.

h) Alpha particle emission appears random and not determined by any mechanism; yet we can distinguish between radioactive elements by their *characteristic* mean lifetimes.

## 2.2 Advantages of electro-cordic guidewave theory

*Truly random* events such as dice-throws show no predictable results so quantum theory needs more than that. It is necessary to propose real causes behind the results and reveal some characteristics of the field which guides particles into a fringe pattern or orbits:

a) The energetic electro-cordic guidewaves are generated continuously by sub-atomic particles or photons. They are freshly created during particle creation and continue until the destruction of the particle. A wavefunction describes these guidewaves and wavefunction collapse may occur when a particle or photon is absorbed; but it may also be rearranged or followed immediately by new generation to suit a new situation. Guidewaves appear to propagate at the velocity of light or faster and may exert an inductive force on other particles as in stimulated emission or on themselves by reflection. Interference produces the characteristic de Broglie wavelength which is a major feature of the guiding phenomenon. In stable atomic orbits, spontaneous radiation is *inhibited* by controlling guidewaves which guarantee long term stability.

b) When confined to a potential-well, guidewaves build into a standing wave described by the wavefunction. *As far as interactions with other systems are concerned*, the amplitude may be regarded as probability amplitude, although the source particle remains intact and localised in its motion. The wavefunction of one atom will interfere with that of another atom and cause electrons to change orbit, resulting in scattering or a chemical reaction.

c) When calculating the energy eigenvalues of an atom, it is not essential to interpret the wavefunction as probability amplitude because the equations of Schrodinger and Dirac give the observed results without dictating the interpretation.

d) The relativistic wave equation implies propagation of a wavefunction at the velocity of light but the non-relativistic Schrödinger wave equation is approximate, assuming instantaneous action at a distance incorrectly.

e) The mechanism of quantum jumping of an atomic electron from one orbit to another involves the extended guidewave occupying both orbits during the jump.

f) The sometime equivalence of guidewave amplitude and probability amplitude is analogous to the way that antenna radiation field patterns are calculated as wave phenomena but have a quantum nature also. Average guidewave intensity is naturally proportional to probability density of quanta or particles.

g) The Heisenberg uncertainty principle is a consequence of particle properties for structured particles, (Wayte 2010). Electrons have a continuous history of position, momentum and energy from their creation onwards, with no random zig-zagging or jumping in and out of existence.

h) Energy levels calculated for hydrogen using Dirac’s relativistic theory may also be derived from Einstein’s equations of general relativity, if electron spin is neglected. This is a step towards the unification of gravity and electromagnetism because the fields are analogous and similar processes must be operating in the macro and micro-worlds.

i) In biology, apparent coherence between cells relies upon the reality of wavefunctions; see Ball (2011).

j) In quantum theory, the postulated reality of the wavefunction helps to avoid some anomalies; see Pusey, Barrett & Rudolph (2012).

These characteristics will be applied in a manner which dispels any mystery regarding the wavefunction.

## 2.3 Derivation of the electro-cordic field

Mathematical derivation of the guidewave properties is based herein on previous work applied to astronomical systems, as follows. It is postulated that particles at rest of mass $m_o$ and energy $E_o$ emit real energetic electro-cordic guidewave quanta of Compton wavelength $\lambda_{Co}$ , where:

$$\lambda_{Co} = h/(m_o c) = hc/E_o \quad . \tag{2.1}$$

The wave amplitude at the particle, as seen by a local observer may be expressed as:

$$y = y_o \exp[\pm i2\pi\nu_0 t_0] \ , \tag{2.2}$$

for a *circularly polarised* wave, where frequency is ($\nu_0 = c_q/\lambda_{Co}$); and the propagation velocity $c_q$ may be taken as the velocity of light $c$ in general. [Later in Part II, on entanglement, $c_q$ may be specified greater than $c$ for that phenomenon]. If now the particle has a velocity v in the $x$ direction relative to a coordinate observer, the wave amplitude at the particle as seen by the coordinate observer is by application of the Lorentz transformation:

$$y' = y'_o \exp \pm i2\pi\nu_0 (t - vx/c^2)/(1 - v^2/c^2)^{1/2} \quad . \tag{2.3a}$$

This may be written as:

$$y' = y'_o \exp \pm i2\pi(\nu' t - \tilde{\nu} x) \ , \tag{2.3b}$$

where $\nu' = \nu_0 (1 - v^2/c^2)^{-1/2}$ and $\tilde{\nu} = \nu' v/c^2$ .

Given that the relativistic energy and momentum of a particle are ($E = h\nu' = mc^2$) and ($p = mv$), then equation Eq.(2.3b) is equivalent to the relativistic quantum mechanical wavefunction of a free particle:

$$\psi = \psi_0 \exp \pm i(px - Et)/\hbar \quad . \tag{2.4a}$$

In this work, the wavefunction may specifically represent a real energetic high frequency guidewave, which leads to the results described by quantum theory. The guidewave is tied to its particle and its energy is not available for exchange interactions. The free particle wavefunction describes guidewave amplitude and shows no sign of a probabilistic interpretation. Only when specifically appropriate, the wavefunction may be interpreted as probability amplitude. This gives it the wave/particle duality expected for quantum processes. The probability amplitude is proportional to guidewave amplitude as expected, since a particle is the source of the guidewave. Double peaks seen in some calculated wavefunction amplitudes are not indicative of a particle being in two places at once.

The sign (±) in the exponential of Eq.(2.3b) is arbitrary and describes right or left-handed helicity of the circularly polarised guidewave. It is thought that for leptons, left-handed helicity represents matter while right-handed helicity represents antimatter. Factor $i$ is just the orthogonal unit vector of electromagnetic theory. The given substitution of ($E = h\nu' = \mathrm{mc}^2$) and ($p = \mathrm{mv}$) into the relativistic expression Eq.(2.3b) to get Eq.(2.4a) shows that concepts of negative energy or mass are not required in this realistic physical theory. Similarly, factors $px$ and $Et$ are quantities of *positive* action only.

Differentiation of travelling wave equation (2.4a) with respect to $x$ and $t$ yields the standard operator equations:

$$\frac{\partial\psi}{\partial x} = \frac{i}{\hbar}p\psi, \quad \text{and} \quad \frac{\partial\psi}{\partial t} = \frac{-i}{\hbar}E\psi \quad . \tag{2.4b}$$

Substitution for $E$ and $p$ gives a kind of guidewave phase velocity:

$$\frac{\partial\psi}{\partial t} = -\left(\frac{E}{p}\right)\frac{\partial\psi}{\partial x} = -\left(\frac{c^2}{v}\right)\frac{\partial\psi}{\partial x} \quad . \tag{2.4c}$$

As briefly mentioned above, when investigating entanglement $c_q$ may be proposed greater than $c$. Then $\hbar$ in Eq.(2.4a) will become $\hbar_q$ in order to fix ($\hbar c = \hbar_q c_q$) within the fine structure constant; while $E$ and $p$ are unchanged particle properties. During wavefunction collapse in a bound system, the extended guidewave loses contact control *in an instant* and it may fly back to its source at superluminal velocity, as suggested by experiments on non-locality phenomena. This apparently instantaneous flyback only means that the equations do not apply to flyback. For elastic collisions, wavefunction collapse does not occur, but inelastic collisions produce either complete collapse or re-arrangement of an existing guidewave field to suit a new situation; all this happens without any mystery.

For an ensemble of particles tunnelling through a barrier, the wavefunction is interpretable as probability amplitude. This represents the direct particle application of the wavefunction and gives it the appearance of a force field. Similarly the wavefunction as guidewave amplitude may be considered a force field for interactions with other particles, which induces motion without energy exchange. Interactions are most probable where the amplitude is greatest so it is reasonable to *equate the probability of interaction with guidewave intensity*. Electron trajectories in atoms and interference patterns are controlled by this real electro-cordic field and are characterised by the de Broglie wavelength, but the high frequency component of the wavefunction is latent.

## 2.4 Reality of the de Broglie wavelength

The de Broglie wavelength may be generated physically as follows. A Compton guidewave emitted by a particle with velocity v in the direction of motion in a circular orbit would be detected by a stationary coordinate observer as having a Doppler frequency $\nu'(1 + v/c)$. Alternatively, a quantum emitted backwards would have a coordinate Doppler frequency $\nu'(1 - v/c)$. If it is postulated that these two quanta travel around the circular orbit as a continuous wave at velocity c and may interfere, the net amplitude at a fixed observation point distance *x* from an arbitrary origin on the orbit could be given as:

$$\begin{aligned} y &= y_0 \exp[-i2\pi\{(\nu' t - x/\lambda')(1+v/c)\}] + y_0 \exp[-i2\pi\{(\nu' t + x/\lambda')(1-v/c)\}] \\ &= 2y_0 \cos[2\pi\{\nu'(v/c)t - x/\lambda'\}]\exp[-i2\pi\{\nu' t - \tilde{\nu}x\}] \end{aligned} \quad , \qquad (2.5)$$

where ($\lambda' = c/\nu'$), and *t* starts from zero as the particle crosses the origin.

This is a circularly polarised wave of fundamental frequency:

$$\nu' = [m_o(1 - v^2/c^2)^{-1/2} c^2/h] = (mc^2/h) \quad , \qquad (2.6)$$

and beat frequency $\nu'(v/c)$. The beat wavelength is then the de Broglie wavelength:

$$c/(\nu' v/c) = 1/\tilde{\nu} = h/mv = \lambda_B \quad . \qquad (2.7)$$

Hence, by superimposing or interfering two Doppler-shifted Compton guidewaves in a circular orbit, we get a standing wave pattern rotating around the orbit with the particle and a physical interpretation of the de Broglie wavelength ($\lambda_B = 1/\tilde{\nu}$). This characteristic wavelength for particles depends on the fundamental guidewave being returned to interfere with the source. There are no de Broglie quanta as such, but during interactions the interference produces the same ponderomotive effect as quanta.

The individual Compton guidewaves propagate around the orbit at the velocity of light but we can show that the beats naturally stay fixed relative to the orbiting particle source, as follows. From Eq.(2.5) the condition for a beat maximum, for a given beat number s, is:

$$2\pi[\nu'(v/c)t - x/\lambda'] = s\pi \quad . \tag{2.8a}$$

Hence by differentiation, the beat envelope velocity is:

$$dx/dt = \lambda'\nu'(v/c) = v \ . \tag{2.8b}$$

At an anti-node, a particle receives the two Compton quanta in phase with its emission so there is resonance at the particle. The amplitude equation (2.5) will be single-valued when ($c/v = \lambda_B/\lambda'$ = integer), if the orbit circumference is an integral number of de Broglie wavelengths. Then the amplitude repeats itself temporarily (*x* constant) every period ($\tau_B = \nu_B^{-1}$), and spatially (*t* constant) every distance $\lambda_B$ .

Physical interpretation of the quantum mechanical wavefunction as a guidewave amplitude, and probability amplitude when appropriate, enables a realistic explanation of phenomena without altering the mathematical analysis. If the propagation velocity of the wavefunction is under some circumstances $c_q$ rather than $c$, then the de Broglie wavelength is unchanged but the frequency increases proportionally.

## 3 The hydrogen atom.

The hydrogen spectrum will now be studied in different ways to see where real physical guidewaves complement the standard statistical interpretation of quantum theory. For example, emission lines are observed to be sharp and calculable from Schrödinger’s equation, which produces exact energy eigenvalues from *broad* wavefunctions in terms of the integral quantum numbers $n$, $\ell$, $m$. Given that the hydrogen electron is purported to describe a nebulous cloud, one would logically expect to observe broad emission lines centred on the eigenvalues.

## 3.1 Schrödinger's non-relativistic wave equation for hydrogen atom

Schrödinger's basic non-relativistic wave equation is given by Schiff (1968) p24 as:

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi + V(r,t)\Psi\,. \qquad (3.1a)$$

A particular solution of this is given by Schiff (1968) p31, p77 as:

$$\Psi(r,t) = R(r)Y(\theta,\varphi)e^{-i\,Et/\hbar}\,. \qquad (3.1b)$$

Clearly, the physically active component is the temporal part representing a circularly polarised guidewave of high frequency. The radial R(r) and angular Y(θ,φ) terms only represent the spatial distribution of this guidewave. In polar coordinates, R(r) is given by Schiff (1968) p90 as:

$$\left[\left(\frac{-\hbar^2}{2\mu}\right)\left(\frac{1}{r^2}\right)\left(\frac{d}{dr}\right)\left(r^2\frac{dR}{dr}\right) - \frac{Ze^2}{r}R + \ell(\ell+1)\frac{\hbar^2}{2\mu r^2}R\right] = ER\,. \qquad (3.2a)$$

This suffers from instantaneous action at a distance $(c\to\infty)$, plus the purported zero angular momentum condition. Alternatively, solution of (3.2a) shows it is the Coulomb energy term which accounts for the angular momentum around the proton. This is illustrated by normalising Eq.(3.2a) with respect to eigenvalue (E) x 4 as follows:

$$\frac{1}{\rho^2}\frac{d}{d\rho}\left(\rho^2\frac{dR}{d\rho}\right) + \left[\frac{(\eta+\ell+1)}{\rho} - \frac{\ell(\ell+1)}{\rho^2}\right]R = \frac{1}{4}R\,, \qquad (3.2b)$$

where, [ $\rho = r\times(8\mu|E|/\hbar^2)^{1/2}$ ]. Here, $[(\eta+\ell+1) = n]$ is the total quantum number, η is the radial quantum number, and $(\ell+1)\times(\hbar)$ is *total* angular momentum due to the central field. Clearly, the angular momentum cannot fall below $1\hbar$, in agreement with Dirac's (1962) relativistic analysis, and the Bohr atom.

The physical meaning of *n*, $\ell$, *m* is understandable in terms of guidewaves and electrons in orbits, as follows. Let the electron in a *circular* polar orbit (say in the x-z plane) around the nucleus generate a guidewave around this orbit. For stability, this guidewave amplitude must be single-valued so an integral number of de Broglie guidewavelengths is necessary around the orbit, say *n*. This polar orbit has no component of velocity in the direction of azimuthal angle ϕ. If now, the orbit is tilted over a little due to an applied magnetic field, a component of electron velocity will exist in the equatorial (x-y) plane such that a guidewave may be emitted into the equatorial orbit, by the passing electron. For a particular value of this equatorial velocity component $v_e$ there will exist one de Broglie guidewavelength around the equatorial orbit, therefore ($2\pi r_e = \lambda_{B1} = h/m_e v_e$) for electron mass $m_e$, and magnetic quantum number ($m_\phi = 1$). By tilting the orbit further, there could be two complete de Broglie wavelengths around this equatorial orbit when the passing electron's component of velocity is increased to $2v_e$, and ($2\pi r_e = 2\lambda_{B2} = 2h/m_e 2v_e$), ($m_\phi = 2$). Orbit tilting may be continued until there are ($m_\phi = n-1$) de Broglie wavelengths around the equatorial orbit. Thus, for integral $m_\varphi$, the guidewave amplitude $u(\phi)$ in the equatorial orbit may be *single-valued* and periodic in $2\pi$ such that:

$$u(\phi) = U \exp(i\, m_\phi \phi) \quad , \tag{3.3}$$

which effectively represents the eigenfunction of the z-component of angular momentum.

If the original circular polar orbit of $n$ de Broglie wavelengths is now made elliptical, the component of passing electron velocity into the *original circular polar* orbit is reduced, and fewer de Broglie wavelengths exist around it, say ($n$-η). The ellipticity can increase in steps up till ($\eta = n-1$) when $(\ell = 0)$. Then when this elliptical electron orbit is again tilted out of the x-z plane, due to an applied magnetic field, the number of de Broglie guidewavelengths in the *equatorial* orbit can only increase to ($m_\phi = n-\eta-1$).

The standard interpretation of quantum theory, in which fuzzy electron clouds surround a nucleus in separate suspended lobes, is not obviously compatible with precise energy eigenvalues or conservation of energy. Negative probability amplitude is not really viable, either. In contrast, the theory of real guidewaves stabilising electron orbits at exact energy levels determined by guidewave standing wave patterns is plausible. The electron may be emitting guidewaves in all directions to produce the appearance of clouds, but its precise orbit is stabilised by an integral number of de Broglie wavelengths. Thus, within atoms the calculated wavefunctions represent guidewave amplitude or intensity, not electron probability density. The reality and single valuedness of wavefunction amplitude is a physical necessity for these guidewaves in stable orbits.

When an electron anticipates dropping from its current orbit to a lower orbit, it has the ability to send guidewaves in advance to assess the orbit and its surroundings. The electron can then move smoothly, following its guidewave into the lower orbit while generating a concurrent photon emission process. The electron's wavefunction *evolves* from the original steady state to the final steady state in a continuous controlled manner, until the photon emission is complete over one or more periods. Wavefunction collapse does not occur, nor step discontinuities in the move.

## 3.2 On Dirac's derivation of hydrogen energy-levels

Dirac's relativistic quantum theory of fine-structure in the hydrogen spectrum is precise and complete for an electron with spin, see Dirac (1962). It is Lorentz invariant and involves the velocity of light *c* for wavefunctions rather than purported instantaneous interactions.

Dirac's relativistic wave equations can be understood here as representing real electro-cordic guidewave amplitude due to the orbiting electron within a hydrogen atom. For the radial wavefunction they take the form:

$$(E + e^2/r - mc^2)\Psi_a + \hbar c(\partial/\partial r + 1/r + \kappa/r)\Psi_b = 0 \quad , \qquad (3.4a)$$

$$(E + e^2/r + mc^2)\Psi_b - \hbar c(\partial/\partial r + 1/r - \kappa/r)\Psi_a = 0 \quad . \qquad (3.4b)$$

Here, $\kappa$ is an integer representing total angular momentum with electron spin, ranging from 1 to *n* the total quantum number; so electron trajectories past the nucleus are excluded. Following Section 2.3, it is also possible to replace ( $\hbar c$ ) by ($\hbar_q c_q$) for superluminal guidewave trajectories, should they exist between equilibrium states.

Discrete energy-levels of the hydrogen spectrum derived from Eq.(3.4a,b) are given by:

$$E = mc^2[1 + \alpha^2/\{\eta + (\kappa^2 - \alpha^2)^{1/2}\}^2]^{-1/2} \quad . \qquad (3.5a)$$

Here, ($\alpha = e^2/\hbar c \sim 1/137$) is the fine structure constant, and it appears that $\eta$ and [$\kappa + \eta = n$] can represent the *radial* and *total* quantum numbers of electron orbits in the original quantum theory. When [$\kappa + \eta = n$] for different values of $\kappa$ and $\eta$, a set of energy-levels lying close to one another are observed to compare with the levels calculated from Eq.(3.2a). This confirms the importance of *interpreting* quantum theory in terms of the full relativistic treatment; although Schrödinger's non-relativistic equation is valuable for calculating approximate results.

When the radial quantum number $\eta$ is zero, Eq.(3.5a) reduces to:

$$E = mc^2\,[1 - \alpha^2/n^2]^{+1/2} \quad , \qquad (3.5b)$$

which is the same as for the General Relativistic particle derivation, to follow next.

There is good evidence for the reality of well-defined electron orbits because they fit the de Broglie wavelength, as can be determined from the radial wavefunction ($\chi = r\psi_a$). The maximum value of $\chi$ for a circular Bohr orbit is derivable from Dirac (1962) p270, where:

$$\chi = e^{-r/a} \sum_s c_s r^s \quad . \tag{3.6}$$

After differentiation, the maximum value is found where:

$$2\pi r = \left(\frac{n^2 h}{\alpha\, mc}\right)\left(\frac{E}{mc^2}\right) \quad . \tag{3.7}$$

This is very informative because the first term on the right represents the non-relativistic system with *n* de Broglie wavelengths around an orbit, for stability through guidewaves of de Broglie wavelength (given that $\alpha = v_1/c$). The final term can be incorporated if the electron has relativistic mass increase due to its velocity around the orbit. In the next section, the electron's general relativistic coordinate energy is given by Eq.(3.17) as:

$$E = mc^2\,[1-(v/c)^2]^{1/2} = mc^2[1-e^2/mc^2 r]^{1/2}; \tag{3.8}$$

therefore Eq.(3.7) may be written:

$$2\pi r = \frac{n^2 h}{\alpha\,(m/[(1-(v/c)^2]^{1/2})c} \quad . \tag{3.9}$$

Thus, for stability there are exactly *n* de Broglie wavelengths around the circular orbit due to the electron's *increased local* relativistic mass, in spite of its *reduced coordinate* energy. However, the question arises as to how the general relativity analysis which produced Eq.(3.8) can satisfy the Dirac analysis built upon special relativity. It appears that Dirac's analysis is automatically set so that the wavefunctions satisfy *local* dimensions of scale and time in order to fit the *local* de Broglie wavelengths. That is, physically real guidewaves in the local frame are being fitted around orbits.

## 3.3 General relativistic theory of hydrogen energy-levels

Einstein’s equations of general relativity may be applied to the hydrogen atom if electromagnetic field energies of the proton and electron are introduced, as suggested earlier (Wayte, 1983). It was shown there that when gravitational field energy is explicitly introduced, the field of gravitons is analogous to an energetic Coulomb field. Then Einstein’s equations behave like a relativistic version of Poisson's equation representing field energy. The concept of space-time curvature has to be replaced by a description of a particle's time and length variation caused by the field environment, which is analogous to Lorentz transformation for particles in an acceleration field.

It will now be shown how this general relativistic solution can produce hydrogen energy-levels identical to the Dirac solution when spin is neglected. The electron's real electro-cordic guidewave field controls the electron in obeying Dirac's wave equation. The allowed orbits are thereby selected from a theoretical continuum of particle trajectories. Abstract hidden variables are not involved.

Briefly, an electron of *local* rest mass $m_o$ at radius *r* would have a coordinate rest mass $[m_r = (m_o - e^2/c_o^2 r) = \gamma\, m_o]$ due to loss of potential energy, which is really mass energy. If the electron is actually orbiting at *local* velocity $v_{local}$, its relativistic local mass is increased to $\{m_l = m_o /[1 - (v_{local}/c_o)^2]^{1/2}\}$. Then the *coordinate* total electron energy should be $(E = \gamma\, m_l\, c_o^2)$, which will be confirmed from the geodesic equations as follows.

The geodesic equations for the electron trajectory in the proton's Coulomb field will be taken as, (Tolman, 1934, p207):

$$\gamma^2 (dt/ds)^2 - \gamma^{-2} (dr/ds)^2 - r^2 (d\phi/ds)^2 = A \quad , \tag{3.12}$$

$$\gamma^2 (dt/ds) = B \ , \tag{3.13}$$

$$r^2 (d\phi/ds) = D \ , \tag{3.14}$$

where ds is an element of local time or space, $[\gamma^2 = (1 - e^2/m_o c_o^2\, r)^2]$ is to be the metric tensor component, (A = 1) for particles, (A = 0) for quanta, B represents total electron energy, D is an angular momentum constant.

From Eq.(3.12) and Eq.(3.13) for a *circular* electron orbit we have:

$$\gamma^2 - r^2 (d\phi / dt)^2 = \gamma^4 / B^2 \quad , \tag{3.15}$$

where $[r(d\phi/dt) = v_{coord}]$ is the electron velocity according to the coordinate observer. And from Eq.(3.12), putting (A = 0, ds = 0), we get for the coordinate velocity of light in the orbit, $(c_{coord} = \gamma\, c_o)$. Therefore, all velocities in the orbit are reduced by factor $\gamma$, according to the coordinate observer. Equation (3.15) may then be written:

$$\gamma^2 / B^2 = 1 - (v_{coord} / \gamma c_o)^2 = 1 - (v_{coord} / c_{coord})^2 = 1 - (v_{local} / c_o)^2 . \tag{3.16}$$

We need to simplify this by relating $\gamma$ to (v/c) through two conditions: (a) For large radius orbit we expect $[e^2/2r \approx (1/2)m_o v^2]$. (b) For minimum radius at the electron classical radius ($r = r_o$), we have ($v_{local} = c_o$), where ($\gamma = 0$) and ($e^2/r_o = m_o\ c_o^2$). In general therefore, ($e^2/r = m_o v^2_{local}$ ), and then $\{\gamma = [1 - (v_{local}/c_o)^2]\}$. Thus, from Eq.(3.16) the electron total energy constant may take different forms:

$$B = \gamma / [1 - (v/c)^2]^{1/2} = [1 - e^2/m_o c_o^2\ r]^{1/2} = [1 - (v/c)^2]^{1/2} = \gamma^{1/2}. \qquad (3.17)$$

So the orbiting electron has coordinate energy $E = Bm_o c_o^2 = \gamma\ m_l\, c_o^2$ as derived earlier. Equation (3.13) shows that the orbiting electron's local time element ds is decreased relative to coordinate time dt by $\gamma[1-(v/c)^2]^{1/2}$, due to local field plus its own velocity.

When ($r = n^2 a_o$) for hydrogen, this gives coordinate electron energy:

$$B = (E / m_o c_o^2) = (1 - \alpha^2 / n^2)^{1/2}\ , \qquad (3.18)$$

which is identical to Dirac's particular solution Eq.(3.5b) wherein the radial quantum number is zero. This result is very important because it demonstrates successful application of Einstein's general relativity field theory of particles to quantum theory of electro-cordic guidewaves. That is, the Coulomb field and gravitational field are similar, conserved tensor fields obeying Einstein's equations. Einstein's interpretation of his *geometric* theory is completely different from electromagnetic theory, and cannot lead to Eq.(3.18).

To conclude this section, it is appropriate to briefly describe the normal Coulomb electromagnetic field which conveys the electric force. Analogous to the gravitational field (Wayte, 1983), the electric field of a particle consist of tied quanta which propagate out and back at the velocity of light. These quanta interact with the *quanta* from other bodies and are deflected either towards or away from those bodies, according to whether they are of the opposite or same helicity. The change in quanta momentum is conveyed back to the charges and, for an elastic collision, it is this process which constitutes the attraction or repulsion of opposite or like charges, respectively. The quanta do not sink into the other particles, or neutralise their charges in the sense sometimes graphically depicted. All charges remain intact and total field energy density at any point is the sum of individual field intensities from all nearby charges, whatever their signs. This total field energy has erroneously been identified as vacuum energy by some investigators.

## 3.4 Schrödinger's relativistic equation for hydrogen energy-levels

The aim is to demonstrate the duality of the relativistic particle equation

$$p^2 = E^2/c^2 - m^2 c^2 \tag{3.19a}$$

as a wave equation confirming the reality of electro-cordic guidewaves described by wavefunctions.

The corresponding relativistic Schrödinger radial wave equation for the Coulomb potential is given by Schiff (1968) p470 as:

$$\left[\frac{-\hbar^2}{r^2}\frac{d}{dr}\left(r^2\frac{d}{dr}\right)+\frac{\ell(\ell+1)\hbar^2}{r^2}\right]R = \left[\frac{(E+e^2/r)^2 - m^2c^4}{c^2}\right]R\,. \tag{3.19b}$$

Velocity of light *c* is available for guidewaves but ($\hbar c$) could be replaced by ($\hbar_q c_q$) if necessary for superluminal guidewave trajectories *between* equilibrium states. This removes the instantaneous action at a distance seen in (3.2a). Again, spin has been neglected and the high frequency component of the *total* wavefunction has been separated but it *must still exist* as the guidewave fundamental frequency.

The total quantum number is now:

$$n = \eta + 1/2 + \left[(\ell + 1/2)^2 - \alpha^2\right]^{1/2}, \tag{3.20}$$

where $\eta$ is the *radial* quantum number, and $(\alpha = e^2/\hbar c)$ is the fine structure constant. This *n* is no longer an integer because of relativistic time dilation and orbit length contraction. Energy levels are given by:

$$E = mc^2\left\{1 + \frac{\alpha^2}{\left\{\eta + 1/2 + \left[(\ell+1/2)^2 - \alpha^2\right]^{1/2}\right\}^2}\right\}^{-1/2}\ , \tag{3.21}$$

which does not fit experiment as well as Dirac's result. Nevertheless, the relativistic guidewave equation Eq.(3.19b) coexists with the particle equation (3.19a) satisfactorily.

## 4 Conclusion

Electro-cordic guidewave theory has been developed in order to supplement statistical quantum theory and account for the way predictable precision in position and energy appears within so-called statistically determined systems. Energy levels of hydrogen calculated from Dirac's theory have now been confirmed using Einstein's equations of general relativity. This effectively brings a microscopic quantum system into agreement with the macroscopic world of astronomy and means that quantum theory is no longer mysterious. We have seen that real guidewaves are described by wavefunctions and should not be dismissed because they are not observable, anymore than virtual-photons of the Coulomb field should be denied.

A companion paper (Wayte, 2012) covers other applications of guidewave theory to demonstrate more causal processes plus non-local phenomena and account for high temperature superconductivity.

## Acknowledgement

I would like to thank Imperial College Libraries and A. Rutledge for typing.

## References

Ball P., (2011) Nature 474, 272

Bell J S., (1987) Speakable and Unspeakable in Quantum Mechanics, CUP, Cambridge

Bohm D & Hiley B J., (1995) The Undivided Universe, Routledge, London

Bohm D., (1984) Causality and chance in Modern Physics, Routledge and Kegan Paul

de Broglie L., (1960) Une interpretation causale et non linéare de la mécanique ondulatoire: la théorie de la double solution. Gauthiers-Villiars, Paris (1956). English translation: Elsevier

Dirac P A M., (1962) The Principles of Quantum Mechanics, Clarendon Press, Oxford

Pusey M F., Barrett J & Rudolph T, (2012) arXiv:1111.3328v2

Schiff L I., (1968) Quantum Mechanics 3rd edition, McGraw-Hill, NY

Tolman R C., (2011) Relativity, Thermodynamics and Cosmology, reprint Dover, NY

Vigier J P, et al., (1987) Quantum Implications, ed. Hiley B J and Peat F D. Routledge & Kegan Paul, London

Wayte R., (1982) The Moon and the Planets 26, 11

Wayte R., (1983) Astrophys. Space Science 91, 345

Wayte R., (2010) Evidence for quantisation in planetary ring systems http://viXra.org/abs/1002.0017

Wayte R., (2010) A model of the electron http://viXra.org/abs/1007.0055

Wayte R., (2011) Quantisation of the auxiliary gravitational field in astronomical systems http://viXra.org/abs/1101.0040

Wayte R., (2012) Theory of an electro-cordic field operating in quantum systems II http://viXra.org/abs/1208.0210

Wayte R., (2019) An auxiliary gravitational field operating in galaxies (Revised) http://viXra.org/abs/1910.0486