

# Electron Wave Function

## *Electromagnetic Waves Emitted by Ring Electrons*

David L. Bergman

Common Sense Science

PO Box 767306

Roswell, GA 30076-7306 USA

*Email: dave@commonsensescience.org*

**Abstract.** A mathematical model (the Schrödinger Equation) and a physical model (Spinning Charged Ring Model) of the electron are compared for their ability to predict waves emitted by electrons.

Although it is a fundamental postulate of Quantum Mechanics, the Schrödinger Equation does not allow for an interpretation of wave-functions as *physical* waves, cannot be a complete theoretical description of a micro physical system, neglects intrinsic characteristics of particle motion, and fails in several other ways to correspond to physical reality.

The Ring Model of Electrons makes accurate and complete predictions of fields and waves by using the locations and internal motions of charge elements that make up the electron in order to determine the external fields of the electron. The physical Ring Model, compliant with the *law of cause and effect*, explains the meaning of Planck's Constant and accurately predicts the Photoelectric Effect, wavelengths of hydrogen line spectra, blackbody radiation, and the Compton Wavelength.

An unbiased assessment of these facts implies that electrons are small physical particles that closely resemble the Spinning Charged Ring Model, and these electrons are a source of electromagnetic waves.

**Wave Mechanics.** Repetitive motion of physical objects is called a 'wave.' Water waves can be seen in a lake or ocean. Waves of electromagnetic energy often are invisible but routinely generated by microwave ovens and radio transmitters. In these examples, waves are produced by material objects such as water molecules or charged particles. In 1924, de Broglie suggested alternative premises that 'matter waves' were intimately connected to the motion of "very small corpuscles":

I shall take it that there is reason to suppose the existence, in a wave, of points where energy is concentrated, of very small corpuscles whose motion is so intimately connected with the displacement of the wave that a knowledge of the laws regulating one of these motions is equivalent to a knowledge of the laws governing another.

*Conversely*, I shall suppose that there is reason to associate wave propagation with the motion of all the kinds of corpuscles whose existence has been revealed to us by experiment. I shall take the laws of wave propagation as fundamental, and seek to deduce from them, as consequences which are valid in certain cases only, the laws of dynamics of a particle [1, paragraph division and emphasis added].

This statement by de Broglie suggests that *waves* and a *motion of particles* are related. He did not say that either one produces the other. His statement permits the electron, for instance, to be a *particle* that emits waves or be a *wave* that creates moving charge elements, *e. g.* a 'cloud' of electron motions and locations. Thereafter, the electron was con-

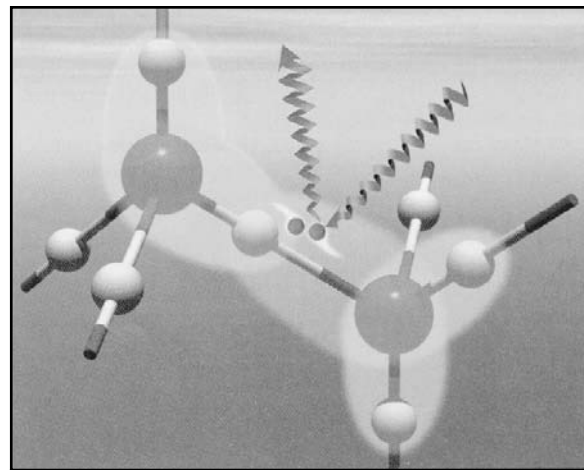
sidered to be both a particle and a wave. The electron was given a *dual nature* that literally changed “before our eyes”; *i.e.* by observation a wave-electron collapsed to become a particle-electron. The founders of quantum mechanics (QM) applied the Schrödinger Equation (SE) as an electron’s ‘wave function’— as if a wave *functioned* to produce an electron. Since the SE predicted waves, it was just one more step to proclaim that the SE *generates* waves, in the sense of being the source of waves. The founders of the new paradigm soon claimed that experimental evidence confirmed their view of reality.

Matter Waves from Electrons. Many experiments demonstrate that electrons are the source of electromagnetic radiation of various wavelengths:

- ♦ Diffraction of electrons observed by Davisson and Germer (reflection from a crystal face) [2].
- ♦ Diffraction of electrons observed by G. P. Thomson (transmission through thin foils) [2].
- ♦ Emissions of hydrogen (called ‘line spectra’) from the electrons in hydrogen with wavelengths known as the Balmer series, Lyman series, and Paschen series [2].
- ♦ Emissions of hydrogen and helium with wavelengths in the extreme ultraviolet spectrum observed by Labov and Bowyer [3].
- ♦ Emission at the Compton wavelength from scattering of an X-ray beam [2].

What is Waving? The emissions just listed are oscillations of electric and magnetic field intensities. And almost certainly, the source of these waves are subatomic particles (electrons, *i.e.* ‘corpuscles’) in motion, just as de Broglie hypothesized. What was unclear is the mechanism whereby an electron emits a wave. De Broglie mentions *motions of matter* but does not tell us if these subatomic particles are in orbit, vibrating, expanding, compressing, or in random motion. As we know, the founders of QM postulated circular and elliptical orbits of point-like particles, and even spins of *zero-size* particles. Later, chemists depicted electrons as ‘clouds’ of motions. (In quantum field theory, the clouds are photons that “pop in and out of existence.” For a modern example of this concept, see Figure 1.) Eventually, even these imaginary mechanisms were set aside in favor of a mathematical equation created by Schrödinger with fewer, if any, ties to an electron’s dynamical structure.

The question of what is waving became unimportant. Physical particles and their mechanisms for exchange of energy were pushed out of Modern Physics. Starlight



**Figure 1.**  
Bonds in Water Molecule  
Pulling Together. Covalent bonds (darker yellow clouds) in water spread their influence into intermolecular hydrogen bonds (lighter yellow clouds)  
—SCIENCE, 29 January 1999, p. 614.

could be detected by photographic plates that responded to light, now considered a photon, *i.e.* a particle instead of a wave. (Light had also been given a dual nature.) Wavelengths could be measured by interferometers that didn't ask what was waving. And in subatomic physics, electromagnetic fields were replaced by bosons such as the photon.

The founders of QM acknowledged that waves could be caused by the motion of subatomic particles. But, with little evidence if any, Heisenberg also proclaimed that if anyone had knowledge of a particle's location, then the particles must be in motion. The Heisenberg Uncertainty Principle was formulated to quantify a minimum movement that scientists must acknowledge in subatomic particles. The 'clouds' shown in Figure 1 are meant to illustrate the random motions and positions of electrons or photons. Heisenberg's concepts of chance events were quickly incorporated into QM. In the new paradigm, *determinism* in the universe was rejected and replaced by *chance-events*.

Schrödinger Wave Equation. The founders of QM adopted the SE to express their belief in the reality of an electron's so-called "wave nature." Powell and Crasemann state that the Schrödinger wave equation represents a free particle with certain features based on the ideas of Einstein (explanation of the Photoelectric Effect) and de Broglie (explanation of 'matter waves'):

[A] nonrelativistic free particle, of energy  $E = \frac{1}{2}mv^2$  and momentum  $\mathbf{p} = m\mathbf{v}$ , is associated with a wave, of frequency  $\nu = E/h$  and wavelength  $\lambda = h/p$ .... The Schrödinger Equation for the wave function of a free particle arises directly from the Einstein-de Broglie relations and is, in a sense, equivalent to them...[4, pp. 56, 59].

The SE was also applied to atoms of hydrogen. Bohr placed a restriction on the angular momentum allowed in the orbiting electrons of his model for hydrogen. Certain wavelengths are associated with the orbits allowed by the quantization of angular momentum that accommodate quantized de Broglie 'matter waves.' The length of these wavelengths, given by  $\lambda = h/p$ , connected deBroglie 'matter waves' with the waves emitted by the orbiting electron of Bohr's hydrogen atom.

When Schrödinger produced an equation to describe the new mechanics of particles proposed by de Broglie and Bohr, his colleagues liked it more than he did. Schrödinger himself desired "actual realism" and was not satisfied with his equation. But today,

The Schrödinger wave equation is commonly regarded as one of the postulates of quantum mechanics[5].

The common opinion is that the SE (in view of its modifications considered in modern QM and QED) proved its validity by conformity of its solutions with vast amounts of experimental data and the coordination with general physical notions[5].

Problems with the SE. Hofer notes that a long discussion of "the scientific and logical implications of quantum theory" [based on the SE] has diminished, "until today any fundamental question in this respect seems to be considered a lack of scientific soundness[6]. But he also sees flaws in the SE: "From the viewpoint of common sense the most profound reason of uneasiness with quantum theory, despite its indisputable success-

es, has been expressed by Richard Feynman"[6]:

You see, my physics students don't understand it either. That is, because I don't understand it. Nobody does.

Hofer[6] and Shpenkov and Keidik[5] have documented many problems with the SE. The summaries that follow are their concise statements based on their detailed analyzes:

- ♦ Schrödinger's wave mechanics, now a fundamental part of quantum theory, does not allow for an interpretation of wave-functions as *physical* waves due to the contradiction a spreading wave-packet presents to mass conservation. On a fundamental level, the contradiction originates in the difference between phase velocity and group velocity of de Broglie waves[6].
- ♦ If the volume of a particle is finite, then wavelength and frequency become *intrinsic* variables of motion, which implies, due to energy conservation, that the wave function itself is a measure for the potential at an arbitrary point  $\mathbf{r}$ . If it is a measure for the physical conditions of the environment—*i.e.* the intensity of  $V(\mathbf{r})$ —, then it must have physical relevance. But if it has physical relevance, then the EPR dilemma will be fully confirmed, and the result will favor Einstein's interpretation of quantum theory: quantum theory cannot be complete under the condition that (1) particles do have finite dimension, and (2) the Schrödinger Equation is the correct description of the variations of particle waves in the presence of external fields. The only alternative, which leaves quantum theory intact, is the assumption of particles with zero volume: an assumption which leads, in the context of electrodynamics, to the equally awkward result of the infinite energy of particles.... [T]herefore, ...[t]he interpretation of particles as physical waves allows the conclusion, that quantum theory cannot be, in a logical sense, a complete theoretical description of micro physical system[6].
- ♦ *Because* quantum theory neglects intrinsic characteristics of particle motion, the Schrödinger Equation is generally not precise by a value described by Heisenberg uncertainty relations[6].
- ♦ Schrödinger together with Weyl, contrary to the logic and all experience of theoretical physics, artificially cut off the divergent power series of the radial function  $R(r)$  at the  $k$ -th term. This allowed them to obtain the radial solutions, which, as a result of the cut off operation, actually were ... fictitious solutions[5].
- ♦ The quantum numbers of the SE are usually compared with the quantum numbers in Bohr-Sommerfeld's generalized theory of the hydrogen atom.... [T]he superficial resemblance of its quantum numbers to those of the SE was groundlessly used by founders of QM.... Such a formal juxtaposition must mean that the wave function in the SE contains elliptical orbits in the form of 'electron clouds.' All these definitions are fruits of fantasy. In fact, the SE describes only the *circular* orbits, but not mystic clouds-orbitals that were shown...[5].
- ♦ [T]he *wave number* in Schrödinger's radial equation is a *quantity that varies continuously in the radial direction*. Is it possible to imagine a field where the wave num-

ber, and hence the frequency, change from one point to another in the space of the field? Of course, it is not possible. *Such wave objects do not exist in Nature!* [5].

- ♦ In the case where the wave number  $k$  also takes imaginary values, the field will not be a wave field, and hydrogen-like atoms will be surrounded, beyond their spheres of the radius  $r_{\max}$ , with the field of the *aperiodic* structure. However, this completely contradicts reality. Thus, a limiting sphere bounds around the Schrödinger atom. Beyond the sphere, it is impossible to speak about the structure and wave properties of the atom [5].
- ♦ [T]he radial functions  $R_{nl}$  define the shells of the most probable values of radii in accordance with the quantum mechanical interpretation of the wave function. These radii form a *discrete series, which cannot be averaged*, as it is impossible to average an inverse series of distances. Indeed, suppose we need to know the mean wavelength of the hydrogen-atom spectrum, for example, the Balmer series. Of course, we can calculate it, but it is an meaningless operation, because such an averaged wave does not exist in nature [5].

Problems of the Bohr Model and Postulates Embedded in the SE. Bohr's model of the hydrogen atom is a single electron with kinetic energy  $T = \frac{1}{2} m v^2$  moving in orbit about a proton nucleus. The electron is negatively charged and *point-like*. Its mass, spin, magnetic moment, and charge are proclaimed to be inherent properties without explanation. But, by the *laws of classical physics, these properties cannot exist in a size and volume of zero extent*, and the electron is considered to be a 'quantum object' with quantum properties. These violations of the *laws of nature* are quite sufficient in themselves to dismiss the SE as a description of nature and as science.

Conclusions about Schrödinger's Equation and Quantum Mechanics. The abstract mathematical equation that was put forward by Schrödinger, and which is inherent in QM, lacks scientific validity, partly due to mathematical errors, but fundamentally due to *an unreasonable disconnection between the physical source and the waves* that the equation predicts. "[T]he basic SE (and consequently any other equations based on the basic one) is in fact false.... QM is at best a phenomenological theory, with definite fit of it to the experiment" [5].

Any number of mathematical expressions (equations) can be created to represent waves proceeding from a material object. But our knowledge of nature (science) is trivial when the terms of a wave equation have no relationship to the physical mechanism that generates the waves. Logically and scientifically, a wave function should make predictions of waves from a real physical model of the wave source. Shpenkov and Keidik agree:

[W]e live in a real world. Accordingly, our knowledge about Nature must also be concrete and truly reflect reality, ...as far as possible. In particular, the development of nano-technology, where dimensions of devices tend towards magnitudes comparable with atomic sizes, requires as early as possible knowing the real spatial structure of atoms [5].

**Ring Model's Wave Function.** Philip Gardner [7] wants “physical models of subatomic particles that have no singularities, no discontinuities.” In defining acceptance criteria for such models he assumes that any alternative model must:

- (1) have a role for the particle's wave function
- (2) define its structure (charge, mass and current densities), internal motion and external fields as functions of this wave function
- (3) describe in some detail such processes as pair creation and annihilation.

The Spinning Charged Ring Model of the electron [8, 9] meets the general scientific objective to predict and explain the waves produced by a charged particle. The Ring Model ‘wave function’ is fundamentally superior to the SE, because the physical object (a spinning charged ring representing an electron) functions to produce a wave instead of placing the function of producing a wave in an equation. This paper will show the fundamental relationships of the Ring Model and its ‘wave function.’ It will:

- ♦ Explain the origin, value, and meaning of Planck's Constant  $h$  by showing its relationship to the Ring Model,
- ♦ Show that the Ring Model produces the relation between energy and frequency discovered by Planck and used by Einstein for describing the Photoelectric Effect ,
- ♦ Examine the relationship of the Schrödinger Equation to the Ring Model, and
- ♦ Explain how the Ring Electron produces empirically observed wave phenomena (by reference to other papers).

The General Wave Function. [This and some following sections are adapted from reference 7 and used by permission.] The first wave function (the SE) was an equation used to predict various wave-like properties of hydrogen atoms. Gardner's correspondence [7] describes the wave itself as “real and physical...electromagnetic fields” with definable and measurable energy density. Modern telecommunications validate this description.

Following French [2], “a wave of amplitude  $\psi$  associated with a particle, with the equation

$$\psi = \sin 2\pi v \left( t - \frac{x}{w} \right) \quad (1)$$

is called the wave function.” This equation is obtained from the geometry and relationships of time, distance, velocity, and frequency of the wave. Equation (1) relates nothing more than the geometrical relationships in three-dimensional Euclidean space, and every wave obeys this wave function, including light-waves generated by a Ring Electron. Thus, in general, the Ring Model satisfies Gardner's first acceptance criteria. Specifically, this paper and others cited here show the relationship of the Ring Model to important waves emitted by the electron.

Mechanism for Making Waves. A physical mechanism of the Spinning Charged Ring Model accounts for such wave-like emissions as the Compton wavelength[10], line spectra [10], and blackbody radiation[11]. These processes depend upon electromagnetic induction to produce radiation from the charge fiber that makes up an electron. The physical mechanisms of the finite-size Ring Model explain (instead of assert) the processes called the ‘wave function.’

When light is regarded as ‘photons’ (important quantum particles for QM) instead of energy fields, the fundamental processes are obscured, and the wave function is nothing more than an equation without cause and effect relationships. When light is regarded as waves of electromagnetic energy, a physical relationship exists between the material object and the waves emitted by it.

Self-Energy of Ring Electron. The Ring Model, based on the electromagnetic character of matter, has a well-defined structure with a theoretical basis for the self-energy of an elementary particle. From [8] and [9], the self-energy  $E$  of a charged ring particle has been derived from the size and shape of its electric charge:

$$E = \frac{e^2}{4\pi^2 \epsilon_0 R} \ln\left(\frac{8R}{r}\right) = \frac{K_o}{R} \quad (2)$$

where  $e$  is the electron charge, the radius  $R$  of a ring electron is  $3.86607 \times 10^{-13}$  meters, the ratio of radius and half-thickness radius  $r$  is a constant [8, 9], and  $K_o$  is a constant with the value  $3.16153 \times 10^{-23}$ . Equation (2) applies to the stable, free-standing elementary particles, *e.g.* electron, proton, positron, and antiproton. From equation (28) of reference [8], the self-energy is also known to be

$$E = \frac{\hbar c}{R} \quad (3)$$

where  $h$  is Planck’s Constant, and  $c$  is the speed of light. An electron’s self-energy exists in two locations: the energy of the compressed charge within the boundary of the ring and the energy of electric and magnetic fields everywhere outside the boundary of the ring. The mutual pressure between charge and fields is equal (with opposite directions) everywhere at the boundary of the ring surface. In Classical Physics, the self-energy of an electron is identified as potential energy.

The boundary of the compressed charge gives the electron its *local* properties as a particle. The fields established by the charge extend outward with an energy density that is complicated but precisely known [12]. These fields give electrons (and other stable particles) their *extended* wave-like properties (and some static properties not discussed here).

Compton Wavelength. Compton’s Wavelength is only one of many wavelengths emitted by an electron. This particular wavelength corresponds to electrons that are not excited to higher energy states, *i.e.* the *natural energy state* where the charge around the circumference of the electron is evenly distributed, and the standing wave has only one node (as illustrated for the case  $n = 1$  shown in Figure 2.)

From equation (2), the Compton Wavelength  $\lambda_C$  is simply the circumference  $C$  of the Ring Electron.

$$\lambda_C = C = 2\pi R = 2.42631 \times 10^{-12} \text{ meters} \quad (4)$$

Equation (4) relates the physical length of the electron circumference to the physical length of the electron's standing-wave. Compton observed radiation emitted by the electron with the same wavelength[2].

Origin of Planck's Constant. A Ring Electron with single electric charge  $e$  and magnetic charge  $\phi$  (flux) will maintain these two quantum charges by adjustments of its size and charge circulation that conserve the magnitude of both charges. In the Ring Model, the product of the electric charge  $e$  and magnetic charge  $\phi$  in a system of rotating charge equals Planck's Constant:  $h = e\phi$  [9].

This result was anticipated more than 100 years ago[13]:

It is a fairly straightforward task to calculate the amount of angular momentum in an electromagnetic field. Indeed, ...J. J. Thomson, in a textbook on electricity and magnetism, suggested this exercise for students: Determine the angular momentum of an electromagnetically bound system consisting of a single electric charge and a single magnetic charge. The solution reveals that the angular momentum of the system depends on the product of the electric charge and the magnetic charge but is independent of the distance between them. In other words, the electric charge and the magnetic charge may be separated by the radius of an atom or by the radius of the universe; in both cases, the angular momentum of the electromagnetic field is the same.

Intrinsic angular momentum. From these relationships, there is an apparent relationship between *Planck's Constant* and the *angular momentum* in a system of rotating charge. Bohr incorporated these relationships in his model of a hydrogen atom. The Ring Model—another system of rotating charge—is also constrained by the restrictions of angular momentum.

Carrigan and Trower explain how this constraint affects radiation known as line spectra:

An atom that has been excited to an elevated energy state tends to revert abruptly to a lower energy state, simultaneously emitting its excess energy in the form of a photon, or quantum of electromagnetic radiation. The photon [or quantum of electromagnetic radiation] not only removes some energy from the atom but also carries away some of the atom's intrinsic angular momentum [13].

Line Spectra From Ring Electron. By the influence of nearby charged particles or radiant energy, an electron may be "excited" to a higher energy state [see Figure 2 where  $n = 3$  and 7]. The charge fiber will have multiple loops, and both (electric and magnetic) fields will have a corresponding number of nodes. Thus, the standing-wave of an excited electron depends upon its circumference and the number of nodes in the standing-wave [equation (37) of reference 11]:

$$C = 2\pi R = n\lambda \quad (5)$$

where  $n = \dots 1/3, 1/2, 1, 2, 3, \dots$  for the multiples of possible wavelengths. Therefore, radiation emitted by an excited electron depends upon the number of nodes in its pre-radiation standing-wave and the number of nodes in its post-radiation standing-wave. Labov and Bowyer observed sub-harmonic wavelengths (where  $n = \dots 1/3, 1/2$ ) in the extreme ultraviolet spectrum[3] that are predicted *only* by the Ring Model [see reference 10 for a complete explanation].

Energy-Frequency Relationship. The Ring Model shows how the frequency  $\nu$  of electron radiation is related to its self-energy  $E$ .

From equations (7) and (28) of reference [8], the mass and self-energy of an electron are given by:

$$m = \frac{\hbar}{cR} = \frac{E}{c^2} \quad (6)$$

On the basis of this physical mechanism for radiation wavelength, and the wave equation  $c = \lambda\nu$ , where  $c$  is the speed of light and  $\nu$  is the frequency of oscillations, the preceding equations are combined to obtain important relationships:

$$K_0 = ER = mc^2R = ch/2\pi = 3.16153 \times 10^{-26} \quad (7a)$$

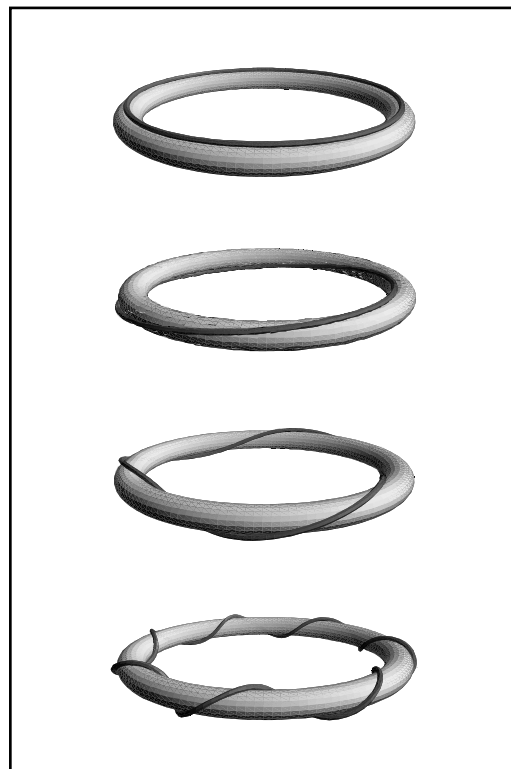
$$h = 2\pi K_0 / c = 6.62608 \times 10^{-34} \quad (7b)$$

$$E = ch/(2\pi R) = ch/\lambda = h\nu \quad (7c)$$

The relationship between energy and frequency shown in equation (7c) has been very important in Quantum Theory. A textbook states that “A relation between energy and frequency...was established by Planck’s treatment of blackbody radiation and by Einstein’s explanation of the photoelectric effect”[4]. But now, this “quantum hypothesis” and the unit of the quantum  $h$  have been obtained as features of the Ring Model. Any theory (*e.g.* the Ring Model) that obtains a fundamental physical constant must be considered superior to another that postulates it (*e.g.* the Quantum Theory).

### ***Some Comparisons of the Two Approaches.***

Wavelength of Emissions. Schrödinger wrote a wave equation for the Bohr model of the hydro-



**Figure 2.**

Charged Fiber in Several Energy States

Charge moves along fiber in shape of circular solenoid.

Fiber is shown with 0, 1, 3, and 7 turns around toroid (top to bottom).

Torus is shown only as visual aid and is not part of the spiral electron (helicon).

Fiber with 1 turn represents an electron in a non-excited state (natural energy level). Fibers with 2 and higher number of turns correspond to electrons with excited states (enhanced energy levels). Fiber with 0 turns does not correspond with any electron shape found in nature.

gen atom. He started with the general wave equation (1) and imposed two postulates to create a specific wave equation that now bears his name.

The *first postulate* inserted by Schrödinger into his famous equation is the *energy and frequency* relationship (7c). Analysis of the Ring Electron, given above, supports this feature of the Schrödinger wave equation.

The *second postulate* inserted by Schrödinger was Bohr's postulate on the *quantization of angular momentum*. French explains this postulate in terms of the Bohr atom where

an electron in an atom could not be in any arbitrary orbit, but only in orbits for which one could write:

$$m v \times 2\pi R = nh \quad (8)$$

where  $n$  is an integer. We [showed] how this represents a quantization of the 'action' as described by the phase integral. In Bohr's theory there is no way of explaining why the electron should fail to radiate so long as it remains in such a quantum state, since it is still, on Bohr's view, an accelerated point-charge. The wave-mechanical description really does away with this difficulty, however, since we now think of a wave whose wavelength is  $\lambda = h/mv$ . Putting  $mv/h = 1/\lambda$ , Bohr's quantum condition becomes

$$2\pi R/\lambda = n \quad \text{or} \quad 2\pi R = n\lambda \quad (9)$$

Thus the allowed orbits are just those that will exactly accommodate the de Broglie waves, allowing a perfect join when the circuit is complete. In such a picture, there is no suggestion of progressive motion... [2, p. 184].

The Bohr Model of the atom just described is based on an electron in orbit around the atomic nucleus. But the Ring Model of the atom places an electron at a fixed location and distance from the atomic nucleus. The models are very different physically but both models predict the wavelengths emitted by an electron bound in hydrogen. *In the Ring Model, electron wavelengths are properties of its physical size instead of a postulate.*

Spin of Particles and Atoms. For the Ring Model, the spin (angular momentum) of an electron is obtained from the definition that angular momentum equals the product of electromagnetic mass, velocity, and radius. The electromagnetic mass  $m$  of the free electron is equipartitioned between its electrostatic and magnetostatic components where the former depends upon charge velocity and the latter does not—providing the factor  $\frac{1}{2}$  in equation (10) [8].

For charge moving along the Ring Electron circumference with velocity  $c$ , the angular momentum  $p_s$  is

$$p_s = mvR/2 = mcR/2 \quad (10)$$

From equations (7) and (28) of reference [8], the possible values of spins for electrons are

$$p_s = nh/2 \quad (11)$$

where  $n$  takes on the values  $n = 1, 2, 3...$  for corresponding excited states as shown in the Figure 2. Comparison of equations (8) and (11) show that the two models predict the same spins. However for  $n = 1$ —the natural energy state—only the Ring Model gives the correct value observed in experiments on the free electron.

Chance or Causality. As an abstract, mathematical equation, the Schrödinger Equation allows interpretations of its solutions that physical models prohibit:

The Schrödinger Equation for the wave function of a free particle arises directly from the Einstein-de Broglie relations and is, in a sense, equivalent to them. However, until suitable boundary conditions and requirements concerning the continuity of solutions are imposed, the properties of the wave function are not completely described by the Schrödinger Equation.... The probabilistic hypothesis of Born and the generalizations developed by him, Bohr, Dirac, Heisenberg, and others in the period from 1925 to 1930, are a precise formulation of a fundamentally new concept of natural processes which has emerged from the study of systems of atomic size [4, p. 59-60].

In contrast, the Ring Model limits predictions to *causal* relationships, and has successfully predicted the line spectra associated with hydrogen [10] and other wave emissions of the electron.

Planck's Constant and Uncertainty in Schrödinger's Equation. Modern physics and the Schrödinger Equation have been dominated by a *law of chance* known as the Heisenberg Uncertainty Principle (HUP). This has been detrimental to legitimate science because HUP is grossly in error as shown by much experimental data analyzed by Wesley [14, see Chapter 6, pp. 152-166, titled "Failure of the 'Uncertainty Principle'"].

Role of Planck's Constant in Material Particles. The Table summarizes fundamental relationships governed by Planck's Constant and gives a conclusion that only two of the four cases are valid. Evidently, this fundamental physical constant characterizes a system of rotating charge, e.g. the spinning charged ring.

The first row of the Table is the quantization of motion (or energy) changes during chance events, according to the Heisenberg Uncertainty Principle. Empirical evidence shows the HUP to be in error [14, 15].

The second row of the Table gives the relationship between an electron's wavelength and its angular momentum. This researcher cannot reconcile the wavelength-momentum relationship with the empirical values spin in physical models. The equation for wavelength was used to constrain the orbits of the Bohr model, but is not universally valid.

The third row of the Table gives the relationship, equation (7c), between an electron's self-energy and the frequency of radiation emitted by the electron. This is an expected relationship that was derived from the geometry of the Ring Model. The energy-frequency relationship holds for a *compression* model where a smaller size of a physical particle means it has more energy, and a shorter wavelength and higher frequency. But in QM and the SE, the relationship has no physical basis and is only a mathematical relationship.

**Table**  
Fundamental Relationships Governed by Planck's Constant

Equation with Planck's Constant	Validity	Bohr Model, SE, and QM	Ring Model
$h = 2\pi \Delta p \Delta x$	Not valid [14,15]	Inherent in SE, Bohr Model, and QM	Not Used in Ring Model
$h = \lambda p$	Not generally valid (applies only to orbiting electron)	Wavelength selected to match de Broglie waves & momentum postulate	Not Used in Ring Model
$h = E/\nu$	Valid (Eq. 7c)	Postulated by Planck and used by Bohr and Einstein	Obtained from self-energy of Spinning Charged Ring
$h = e\phi$	Valid [9, 13]	Not used by the Bohr Model	Obtained from laws of electromagnetism

The fourth row of the Table gives the relationship between an electron's electric charge and its magnetic charge. The product of electric charge  $e$  and magnetic charge (or flux)  $\phi$  is a constant  $h$  for a rotating electromagnetic system [9, 13]. This writer concludes that this condition on rotating systems is the fundamental relationship of Planck's Constant.

**Conclusions.** From the foregoing analysis it appeared, at first glance, that the Schrödinger Wave Function Equation developed to explain waves emitted by Bohr's orbiting electron model would not be very different, if at all, for the Wave Function of the Ring Model.

- ♦ The general wave equation (1) certainly applies to both models.
- ♦ The Energy-Frequency relationship applies equally to both models.
- ♦ The quantization of angular momentum is the same in both models.
- ♦ Both models predict the same wavelengths of line spectra [10].

But when other considerations are included, the Ring Model is a much better predictor of physical reality: The Ring Model explains the meaning of Planck's Constant and has accurately predicted the Compton Wavelength[10], line spectra[10], Photoelectric Effect[11], and blackbody radiation[11] with one physical model and consistency with the *law of cause and effect*. The Schrödinger Equation is less successful in predicting these phenomena, offers postulates instead of facts, violates logic, and, according to the standard interpretation, embraces spontaneous events governed by a *law of chance* known to be greatly in error[14, 15].

An unbiased assessment of these facts implies that electrons are small physical particles that closely resemble the Spinning Charged Ring Model, and these electrons are a source of electromagnetic waves.

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