

Electron in the Ground Energy State—Part 1

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Abstract. The structure and internal motions of ground-state electrons are obtained from a physical Spinning Charged Ring (SCR) model. This new electrodynamical model accurately yields the fundamental and structural properties of the electron, including the exact distribution of charge density inside the ring. Equilibrium of charge distributed throughout the ring interior is a result of electromagnetic self-forces that control the structure and internal motions of charge. The model yields the electron rest-mass energy and the electron-positron annihilation energy with energies 510,999 electron-Volts. The model also yields the actual, non-anomalous radius and non-anomalous magnetic moment of the electron. The model predicts the gyromagnetic ratio of a *free* electron. A current issue in physics is resolved—how “potential energy internal to a particle system come[s] into the picture” [1]—by treating the electron as a system of potential energies and real mass-energies.

INTRODUCTION

The Standard Model of Elementary Particles treats the electron as a *quantum object* with wave-particle duality and inherent properties arbitrarily assigned in order to correspond with various empirical data. These properties are not related to any physical structure or internal motions of the electron itself. For many physicists, an electron is like a mysterious ‘black box’ that no one can enter in order to discover why the electron produces certain line spectra, spin, mass, a magnetic moment, wavelength, etc.

But classical physics, used here, treats an electron as a physical object with a definite size and shape of an elastic, non-viscous, non-granular material substance known as ‘electric charge.’ Electron properties are related to and predicted from its physical structure and motions (see Figures 1-5).



Figure 1. Electron Torus or Ring Structure

Our classical approach to particle physics is based on three ideas: the idea that elementary particles are physical objects with *structure*, and the idea that these physical objects are fundamentally *electrical* in character. Furthermore, the discovery that an electron has magnetic properties suggests to classical physicists that the electric charge carried by an electron must be in *motion*.

Some Basic Properties of the Electron. An *electron* is an *electromagnetic object* composed of one unit of negative electric charge e . The charge itself is confined to a small volume of space, but it produces a surrounding electric energy field distributed inside and outside of the volume occupied by the charge substance (See Figure 2 for the outside electric field). With the charge in motion, i.e., circulating in a current loop, then a surrounding magnetic energy field is also distributed inside and outside of the volume occupied by the charge substance (See Figure 3 for the outside magnetic field). A *spinning charged ring (SCR) model* has the same properties exhibited by an electron.

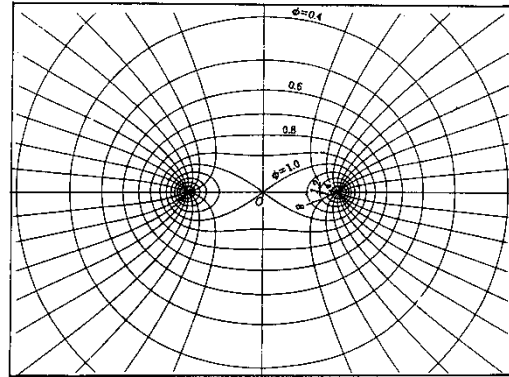


Figure 2 [2].
Electric Field and Force Lines
Outside a Charged Ring

Finite Size of Electrons. Charge cannot be confined to a point, line, or plane of zero volume, because compression of each segment of charge repels all other segments in accordance with Coulomb’s Law. Thus the electron is elastic, finite in size, and finite in mass-energy. Ivan Sellin wrote in 1982 that

“...a good theory of electron structure still is lacking.... There is still no generally accepted explanation for why electrons do not explode under the tremendous Coulomb repulsion forces in an object of small size. Estimates of the amount of energy required to ‘assemble’ an electron are very large indeed. Electron structure is an unsolved mystery, but so is the structure of most other elementary objects in nature, such as protons [and] neutrons...” [3].

Electrons are observed to exhibit magnetic fields and a measured magnetic moment—much like a current loop or electromagnetic coil. The “pinch effect” of its magnetic force is the physical mechanism that holds electrons together:

“The first experimental investigation of the interaction between coils carrying electric currents was performed by Ampere during the years 1820-5, and the work was continued by Oersted, Biot, and Savart. They found that two long parallel wires carrying currents in opposite directions repel one another, whereas *when carrying currents in the same direction they attract one another*, so that the direction of force is reversed when the current is reversed.” [4, emphasis added].

Since a single coil may be considered to consist of many bundled coils with the same total current, and this total current carried by the bundled coils is the same (in direction and magnitude) as the total current carried by the single coil, i.e., the SCR, the bundled coils attract one another and compress the electron—an observation commonly described as a “pinch effect” or “magnetic pinch effect.”

Characteristics of an Electron. Evidently, an electron consists of a material substance (electric charge) confined within the volume of a small ring *and* electromagnetic energy fields that extend indefinitely beyond the boundary of a thin ring. One part of the electron is a small ring-shaped particle consisting of electric charge, and another part is a standing-wave of electric and magnetic fields. An electron appears in some experiments to be a particle and in other experiments to be a wave. Without resorting to wave-particle duality, the spinning charged ring model explains why the electron sometimes looks like a particle and other times like a wave [5].

Truth in Physical Science. For at least 2,300 years, natural philosophers have sought to understand the real nature of matter and proposed various models of the elementary particles. By the criterion of truth, the best model of the electron is that model which most accurately predicts the measurable properties of the electron, especially the fundamental properties of charge, mass, magnetic moment, and spin. Strangely, many prefer to model the electron as a point-particle [6], even while knowing that *a charged point-like particle erroneously predicts its charge density to be infinite, its mass to be infinite, its magnetic moment to be zero, and its spin to be zero!* The new SCR model proposed here is free of singularities that are imbedded in models of point-like particles.

Furthermore, a valid model of the electron must conform to the *universal law of conservation of energy* and to the *causality* that is commonly observed in ordinary experience. Yet many students of nature insist that by chance, ‘quantum fluctuations’ spontaneously occur in the sub-atomic domain and the Big Bang occurred at least once to energize the entire universe—provided that these events conform to the so-called *law of chance* as formulated in the Heisenberg Uncertainty Principle! These same students of nature ignore the *universal law of conservation of energy* which prohibits random, chance events in nature! [7]

In contrast to popular mathematical and statistical models, the spinning charged ring (SCR) model is established upon a sound foundation of empirical data and well-established laws of electrodynamics, and therefore it more accurately conforms to the actual physical structure of the electron.

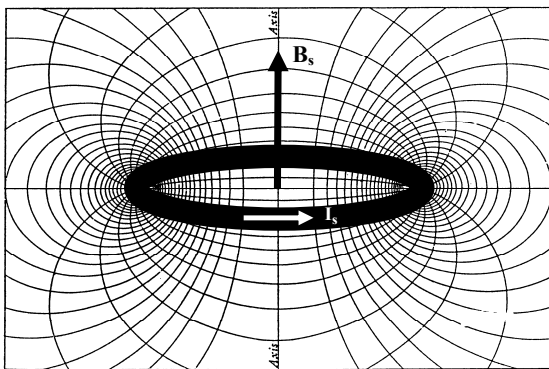


Figure 3 [8].
Magnetic B_{s0} -Field outside a current loop. Directions of the spinning current I_s and the B_{s0} field are shown.

The First Spinning Charged Ring Model. The first SCR model was proposed for the electron by A. L. Parson in 1915 [9]. His model consisted of charge moving along the circumference of a thin torus ring. While the preceding model (a *sphere*) had only one degree of freedom, radius R , Parson's *spinning ring* has three degrees of freedom, radius R , half-thickness r , and rotation rate ω , providing more opportunity for characteristics of the ring model to conform to the measured parameters of the electron. Basic geometry of the SCR is shown in Figure 4.

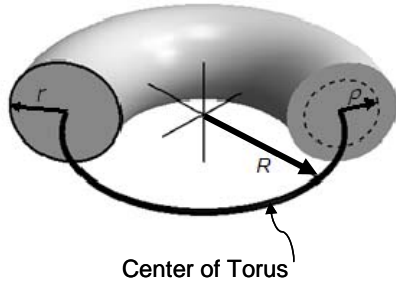


Figure 4.
Geometry of Spinning
Charged Ring Model in the
Ground Energy State

As a proposed basic constituent of ordinary matter, the spinning ring model gave promise of explaining many of the electron properties measured in various materials. At a meeting of the Physical Society of London held October 25, 1918, Dr. H. S. Allen, *M.A., D.Sc., University of Edinburgh* presented “*The Case for a Ring Electron*”[10]. At this meeting, “Dr. H. S. Allen discussed the arguments in [favor] of an electron in the form of a current circuit capable of producing magnetic effects. Then the electron, in addition to exerting electric forces, behaves like a small magnet. The assumption of the ring electron removes many outstanding difficulties...”

Nevertheless, Parson's ring electron [9] and more recent SCR models proposed by Iida [11], Bostick [12], Kanarev [13], and Bergman and Wesley [14] all have one common defect: *Charge cannot be confined to a surface sheet of zero volume, because compression of each segment of charge repels all other segments with infinite force in accordance with Coulomb's Law, and in this case the electron would explode!*

EQUATIONS OF THE NEW SCR MODEL

Distribution of Interior Charge. With equilibrium of charge spread throughout the *ring interior*, instead of an infinitesimal sheet of zero volume, the new Spinning Charged Ring model proposed here removes the singularities present in all the original SCR models and also present in the Standard Model of the electron.

In the new SCR model, charge density and motion are determined from the condition that *expansion* from electric “repulsion” pressure and *compression* from magnetic “pinch” pressure are equal everywhere inside and on the SCR as the only way to ensure equilibrium inside and at the surface of the ring. A necessary condition for equal but opposite pressures inside the ring is that charge velocity v_s is the speed of light c .

Two Step Approach. According to the new SCR model, electrons are *elastic* rings of circulating charge that change size when acted upon by the electric and magnetic fields of other charge particles. We wrote the equations of energy and attempted to obtain a simultaneous solution in terms of equations for the large radius R , the small radius r , the

velocity v_s of charge moving in the ring, and the distribution of charge throughout the interior of the ring. Unfortunately, a solution of this elastic system involves differential equations that we could not solve, even with the aid of a computer program [15]. So, we turned to a ‘two step approach.’

In ‘Step 1’ we placed constraints on the model that apply to a free (isolated and unbound) electron in the ground-energy state only, as if the electron were *rigid*, i.e. the mass of the model is set to the electron rest-mass, large radius R is set to a constant and is not variable, small radius r is set to a constant and is not variable, and magnetic moment μ_e is set to a constant and is not variable. With these constraints we obtained the distribution of charge and charge density from the condition that the electron charge fiber is in equilibrium. This paper is concerned only with Step 1, and the properties of the electron apply only to a free electron in the ground energy state. ‘Step 2’ will build upon the findings of ‘Step 1’ to derive an *elastic model* of the elastic electron in excited energy states.

Simulating the SCR model. A computer program, Mathematica [15], was used to simulate the SCR model in order to achieve 16 digits of precision for all output computations. Values of the fundamental physical constants in Table 1 were taken from CODATA 2006 [16].

| | |
|---|-------------------------------------|
| π | 3.141592653589793 |
| electron charge, e | -1.6021764874 |
| speed of light, c | 299792458 |
| electron mass, M_e | $9.1093821545 \times 10^{-31}$ |
| electron mass-energy, $\mathcal{U}_e = M_e c^2$ | $8.187104386449624 \times 10^{-14}$ |
| permeability, μ_o | $4\pi \times 10^{-7}$ |
| fine structure constant, α | $7.29735253765 \times 10^{-3}$ |
| Planck’s constant/ 2π , \hbar | $1.05457162853 \times 10^{-34}$ |

Table 1. Fundamental Physical Constants from CODATA 2006 [16]

Notations used in this paper. Names of field and energy variables have been chosen in agreement with *Classical Electrodynamics*, 2nd edition, page 34 by J. D. Jackson [17]. Use E for Electric field intensity, use B for Magnetic field intensity, \mathcal{W} for work done, \mathcal{E} for Potential Energy, and \mathcal{U} for Mass equivalent energy. \mathcal{W} is the work done *on* the charge and its fields in a “thought experiment” that assembles charge segments brought from infinity into the shape of a spinning charged ring. Jackson argues that the potential energy \mathcal{E} in the fields is equal in magnitude to work \mathcal{W} done on the fields but opposite in sign, i.e. $\mathcal{E} = -\mathcal{W}$.

Notations for the potential energy \mathcal{E} of four energy sub-systems that make up an electron are as shown for the following electromagnetic energy fields.

\mathcal{E}_{ei} \mathcal{E} represents ‘potential energy’. Subscript e indicates ‘electric energy’. Subscript i indicates ‘inside the ring’.

\mathcal{E}_{eo} \mathcal{E} represents ‘potential energy’. Subscript e indicates ‘electric energy’. Subscript o indicates ‘outside the ring’.

\mathcal{E}_{si} \mathcal{E} represents ‘potential energy’. Subscript s indicates ‘spinning/magnetic energy’. Subscript i indicates ‘inside the ring’.

\mathcal{E}_{so} \mathcal{E} represents ‘potential energy’. Subscript s indicates ‘spinning/magnetic energy’. Subscript o indicates ‘outside the ring’.

Rule of Signs for Electromagnetic Potential Energy. “Electric potential energy is negative if the [charge segments] have opposite sign and *positive if the [charge segments] have the same sign*” [18].

Since the spinning charged ring is composed of charge segments of the same sign, \mathcal{E}_{ei} and \mathcal{E}_{eo} have *positive* electric potential energy both inside and outside the ring.

“Positive mutual potential energy corresponds to repulsion between two [charge segments]” [18].

Magnetic potential energy. Charge segments moving in the same direction *attract* the two segments. It follows that magnetic potential energy is...*negative* when the current elements have the same sign. Thus, \mathcal{E}_{si} and \mathcal{E}_{so} have *negative* magnetic potential energy both inside and outside the ring.

DISTRIBUTION OF INTERIOR CHARGE

Charge density and motion are determined by the condition that pressure from electric “repulsion” pressure and magnetic “pinch” pressure are equal throughout the SCR as the only way to ensure *equilibrium* inside and at the surface of the ring.

Location of Electric Charge. The new SCR model proposed here consists of electric charge *distributed inside* an electron in the shape of a very thin torus. We will show that the volume charge density is greatest at the center of the ring and decreases gradually at locations closer to the ring surface where it becomes zero as illustrated in Figure 5a. The interior charge produces two electric potential energy fields, one with an inside electric potential energy \mathcal{E}_{ei} and another with outside electric potential energy \mathcal{E}_{eo} .

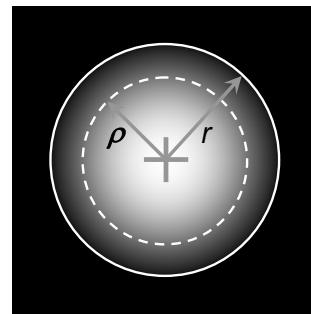


Figure 5a.

Cross-section of ring showing high charge density at the center decreasing to zero at the surface $\rho = r$ where the density is zero.

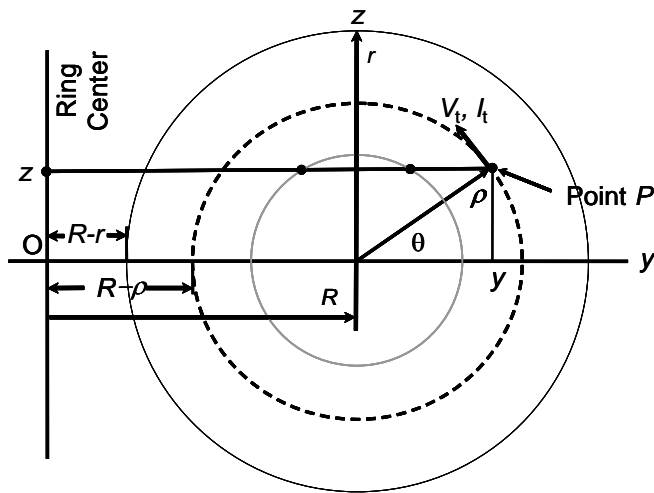


Figure 5b.

Cross-section of ring showing the geometry to compute the charge distribution as a function of ρ . The directions of the twisting current I_t and charge velocity v_t are shown.

The x-axis is out of the page
and through the origin O.

Current and Motion of Charge. Circulation of charge along the ring circumference is a spinning current I_s that produces the magnetic field B_s as shown in Figure 3. This spinning current produces two potential energy fields: an inside field with magnetic potential energy \mathcal{E}_{si} and an outside field with magnetic potential energy \mathcal{E}_{so} .

Twisting Current and Solenoidal Field? When we began our research on the new SCR model, we did not know if the electron charge inside the ring rotated with an angular velocity v_t where the rotating angle θ is shown in Figure 5b. So we included twisting current I_t in the following ‘equal pressure’ case considered next and eventually found that *twisting velocity v_t , twisting current I_t , and magnetic field B_{ti} are all equal to zero.* (Note that the inside twisting magnetic field and the inside spinning magnetic field are everywhere orthogonal and so can be treated separately.)

Magnetic B_{ti} -Field for Equal Pressure Case of Charge Density λ_ρ . A solenoidal (twisting) current, if present in the electron, would circulate in the ring volume of $0 < \rho \leq r$. However, we will show next that a balance of pressures from circulation of spinning current inside the ring can only be achieved by the condition that the twisting current is zero, i.e. non-existent.

Consider a circular solenoid with the geometry shown in Figures 5a and 5b where λ_ρ is the charge density at radius ρ . With λ as a function of ρ , we get the B_{ti} -field inside the ring that is produced by a twisting current I_t with angular velocity v_t/r where this angular velocity is *not* a function of $\rho \leq r$. Velocity v_t is not the linear twisting velocity of an arbitrary point in the ring, but rather the linear twisting velocity of an arbitrary point on the surface of the ring. The linear twisting velocity of an arbitrary point in the ring at radius ρ is, of course, $v_t \rho / r$ since v_t / r is the angular twisting velocity of all bits of

twisting charge at radius ρ everywhere in and on the ring. From the geometry of the model,

$$\rho = \sqrt{(y - R)^2 + z^2} \quad (1)$$

$$y = R + \rho \cos \theta \approx R, \text{ as } R \gg r \geq \rho \quad (2)$$

The magnetic B_{ti} -field inside the ring is obtained by using Ampere's Circuital Law:

$$B_{ti} = \frac{\mu \int_{\rho=0}^{\rho=r} \lambda[\rho] \frac{v_t}{r} \rho (2\pi R) d\rho}{2\pi y} = \frac{\mu v_t}{r} \mathbb{I}_{\rho r} \quad (3)$$

where $\mathbb{I}_{\rho r}$ is the following integral:

$$\mathbb{I}_{\rho r} \equiv \int_{\rho}^r \rho \lambda[\rho] d\rho \quad (4)$$

and where ρ is the radius of the circle through the point P , at which we want to compute B_{ti} , which circle is parallel to the x - y plane, and has its center on the z -axis having z coordinate z . The inner circle is the path of a segment of charge which both enters and leaves the circles we are using in connection with the determination of B_{ti} by using Ampere's Circuital Law, but since its path makes the same angle in entering and leaving, its net contribution to the integral is nil.

Twisting Current. From the geometry of the model, Figure 5b, and Ampere's Circuital Law

$$I_{t\rho} = (2\pi R)H_{ti} = (2\pi R)B_{ti}/\mu \quad (5)$$

$$= \int_{\rho}^r \rho \frac{v_t}{r} (2\pi R) \lambda[\rho] d\rho \quad (6)$$

where $I_{t\rho}$ is the twisting current passing through the ring between radius ρ and r , and v_t/r is the constant angular velocity of twisting current, *not* constant linear current.

From (3), (4), and (5) we obtain

$$B_{ti} = \frac{\mu I_{t\rho}}{2\pi R} \quad (7)$$

$$I_{t\rho} = \frac{2\pi R v_t}{r} \mathbb{I}_{\rho r} \quad (8)$$

where twisting current $I_{t\rho}$ is just I_t if $\rho = 0$.

Charge in the Ring. Since the entire ring is filled with charge, we also have that charge q equals the integral over the volume of the ring of charge density $\lambda[\rho]$. Since $R \gg r$ the volume of the ring is the same as the volume of a cylinder with the same dimensions.

$$q = \int_0^r \int_0^{2\pi} \lambda[\rho] (2\pi R) \rho \, d\phi \, d\rho$$

$$= (4\pi^2 R) \mathbb{I}_{0r} \quad (9)$$

where

$$\mathbb{I}_{0r} \equiv \int_0^r \rho \lambda[\rho] d\rho \quad (10)$$

From (9) and (10)

$$\mathbb{I}_{0r} = \frac{q}{4\pi^2 R} \quad (11)$$

with $\{(2\pi R) \rho \, d\rho \, d\phi\}$ being the volume element dV of the cylinder.

Charge Between $\rho = 0$ and $\rho = \rho$. Let $q_\rho[\rho]$ represent the charge in the volume between $\rho = 0$ and $\rho = \rho$. Then

$$q_\rho[\rho] = \int_0^\rho \int_0^{2\pi} \lambda[\rho] (2\pi R) \rho \, d\phi \, d\rho$$

$$= (4\pi^2 R) \mathbb{I}_{0\rho} \quad (12)$$

where

$$\mathbb{I}_{0\rho} \equiv \frac{q_\rho[\rho]}{4\pi^2 R} \quad (13)$$

so that $q_\rho[\rho] =$ the electron charge e when $\rho = r$. Thus we have the inside magnetic B_{ti} -field from the twisting current:

$$B_{ti} = \frac{\mu v_t / r}{4\pi^2 R} (q - q_\rho[\rho]) \quad (14)$$

Inside Magnetic Field B_{si} from Spinning Current. William Smythe gives the inside magnetic B_{si} -field for current I_s in a straight line [19, p. 296, equation (3)]: $B_{si} = (\mu I_s) / (2\pi a)$ where a is the distance from the center of the line/wire.

Consider the B_{si} -field of a wire of length $L = 2\pi R$ and radius r . If the wire radius r is much smaller than its length L , then the result applies also to a thin, spinning charged ring. For Figure 5b,

$$B_{si} = \frac{\mu I_{s\rho}}{2\pi\rho} \quad (15)$$

where $I_{s\rho}$ is the spinning current through the circle of radius ρ centered at the axis of the wire and lying in a plane perpendicular to this axis which evidently is given by

$$I_{s\rho} = 2\pi v_s \int_0^\rho \lambda[\rho] \rho \, d\rho \quad (16)$$

where λ is the volume charge density inside the ring.

Substituting spinning current $I_{s\rho}$ into equation (15) gives the inside magnetic field B_{si} as:

$$B_{si} = \frac{\mu v_s q_\rho[\rho]}{4\pi^2 \rho R} \quad (17)$$

Charge Density $\lambda[\rho]$ and Charge $q_\rho[\rho]$ as Functions of r . Let the charge density $\lambda[\rho]$ of the ring be expressed as a Laurent series with b -coefficients b_{res} , b_0 , b_1 , and b_2 which are to be determined:

$$\lambda[\rho] = \frac{r b_{res}}{\rho} + b_0 + \frac{b_1 \rho}{r} + \frac{b_2 \rho^2}{r^2} \quad (18)$$

where equations and graphs of $\lambda[\rho]$ are valid only for $r \geq \rho > 0$. Then the charge $q_\rho[\rho]$ must be

$$q_\rho[\rho] = 4\pi^2 R \int_{\rho=0+}^{\rho=\rho} \lambda[\rho] \rho d\rho \quad (19)$$

$$q_\rho[\rho] = 4\pi^2 R \left(b_{res} r \rho + \frac{b_0 \rho^2}{2} + \frac{b_1 \rho^3}{3r} + \frac{b_2 \rho^4}{4r^2} \right) \quad (20)$$

Note that $q_\rho[\rho]$ is a polynomial in ρ which vanishes at $\rho = 0$, but $q_\rho[\rho]$ is the charge on the circle defined by $\rho = 0$, and this is evidently the entire charge on this circle, whence there is *no* physical (charge) singularity there, even though $\lambda[\rho] = -\infty$ at $\rho = 0$. Note also that if $\lambda[\rho]$ had a pole of order greater than one, this line charge density would not vanish; and charge density must vanish as no charge can reside on a one-dimensional subset of the ring because the Coulomb force would then be infinite.

Electric Field Intensity Inside the Ring. Let A represent the surface area of the ring with radius ρ .

$$A = (2\pi R)(2\pi\rho) = 4\pi^2 R\rho \quad (21)$$

Let E represent the electric field intensity over the range $0 < \rho \leq r$. Then E becomes

$$E = \frac{q_\rho[\rho]}{\epsilon_0 A} = \frac{q_\rho[\rho]}{4\pi^2 \epsilon_0 R\rho} \quad (22)$$

where ϵ_0 is the *permittivity of free space* and $\epsilon[\rho] = \epsilon_0$ for $0 < \rho \leq r$ as the negative charge is not granular.

Pressure Inside the Ring. Now clearly, $P = P_{ei} + P_{si} + P_{ti}$, where P is the total pressure at radius ρ ; and P_{ei} , P_{si} , and P_{ti} are, respectively, the electric pressure, the magnetic pressure from spinning current, and the magnetic pressure from twisting current, all at radius ρ . But at radius ρ we have

$$P_{ei} = \sigma E = \sigma \left(\frac{q_\rho}{\epsilon_0 (2\pi\rho)(2\pi R)} \right) = \frac{\sigma q_\rho}{4\pi^2 \epsilon_0 \rho R} \quad (23)$$

where

$$\sigma(\rho) = \lambda(\rho) d\rho = \frac{dq_\rho}{(2\pi\rho)(2\pi R)} \quad (24)$$

is a uniform surface charge density on the curved surface of the cylinder of radius ρ which is equivalent to volume element

$$dV = d[(2\pi R)(\pi\rho^2)] \quad (25)$$

multiplied by $\lambda[\rho]$ and then divided by the surface area of the cylinder of radius ρ to convert it from an infinitely thin shell of charge to an infinitely thin shell of charge per unit area (having curved surface area $[(2\pi\rho)(2\pi R)]$).

On the other hand, inside magnetic pressure $P_{si} = -\sigma v_s B_{si}$ in view of the fact that the magnetic field B_{si} and the surface charge velocity v_s are at right angles to each other and the magnetic “pinch” effect is inwards while the electric repulsion is outwards (and hence has a plus sign affixed while the inward magnetic pinch pressure has a *negative* sign affixed).

Conditions for Equilibrium. Ring stability, in and at the surface of the ring, requires that the charge is in equilibrium and will not expand or contract against the ambient vacuum. For the charge to be in *equilibrium*, total pressure P must be zero throughout the ring interior and at its surface.

No Twisting Current. The pressure equation P evaluated at the circular axis of the ring, that is, at radius $\rho = 0$, shows that the inside magnetic field B_{si} from spinning current and the inside electric field E_i are zero there, but the inside magnetic field B_{ti} from twisting current is not zero there. But then, for zero pressure, it must be that, for radius $\rho = 0$, the inside magnetic pressure from spinning current $P_{si} = 0$ since both inside electric pressure P_{ei} and inside magnetic pressure P_{si} from spinning current are zero along with the sum of all three of the inside pressures (at $\rho = 0$, in particular, too), and the inside magnetic pressure from twisting current $P_{ti} = -(\sigma v_t B_{ti})$, whence $v_t = 0$ since σ is not zero, by assumption being a small surface of charge—not vanishing though—and the inside magnetic field B_{ti} from twisting current is (as just pointed out) not zero at radius $\rho = 0$, but the product is zero at radius $\rho = 0$. So the velocity of twisting charge $v_t = 0$ at radius $\rho = 0$, and hence the velocity of twisting charge $v_t = 0$ for all radius ρ , as it is not a function of radius ρ . *This result means there is no twisting component of current I_t .*

Spinning Charge Velocity. Consider next the situation at the rim, that is at radius $\rho = r$ which is the surface of the ring. Since the velocity of twisting charge $v_t = 0$, the value of permeability $\mu[r]$ (the value of permeability μ at the rim) must be μ_0 , the permeability of empty space, since the charge density of the ring at the surface must vanish to insure a continuous distribution of charge at the rim and then over all space as outside the ring there is assumed to be no charge. However, the zero-pressure equation yields the velocity of spinning charge $v_s = c$, *the speed of light*, since the permittivity of the vacuum $\epsilon_0 = 1/(\mu_0 c^2)$ with ϵ_0 substituted into P_{ei} .

Permeability Inside the Ring. Thus, with both $v_t = 0$ and $\mu_o[r] = \mu_o$, it follows from the zero-pressure equation, having made these two substitutions, that $\mu_o[\rho] = \mu_o$ for all ρ between zero and r including zero and r .

Substituting A from equation (21) and $q_\rho[\rho]$ from equation (20) gives the electric E -field as a function of the b -coefficients in the Laurent series [20]:

$$E = \frac{q_\rho[\rho]}{\epsilon_o A} = \frac{b_{\text{res}} r}{\epsilon_o} + \frac{b_0 \rho}{2\epsilon_o} + \frac{b_1 \rho^2}{3\epsilon_o r} + \frac{b_2 \rho^3}{4\epsilon_o r^2} \quad (26)$$

The inside magnetic pressure from the spinning current is

$$P_{\text{si}} = -\sigma v_s B_{\text{si}} = -\frac{\mu_o v_s^2 \sigma q_\rho[\rho]}{4\pi^2 R \rho} \quad (27)$$

Using our equation for P_{ti} obtained from the Lorentz force we find that the inside pressure from twisting pressure is zero:

$$P_{\text{ti}} = -\sigma v_t B_{\text{ti}} = -\frac{\mu_o \sigma v_t^2 (q - q_\rho[\rho])}{4\pi^2 R r} = 0 \quad (28)$$

since the twisting velocity v_t is zero.

Outside Magnetic Potential Energy. The ring carries one unit of charge $q = e$ so that the electron has a current that depends upon the ring radius R and charge velocity $v_s = c$.

$$I_s = \frac{qc}{2\pi R} \quad (29)$$

Smythe gives the equation for outside magnetic inductance L_{so} for the ring [19, p. 340]:

$$L_{\text{so}} = \mu_o R \left\{ \log \left[\frac{8R}{r} \right] - 2 \right\} \quad (30)$$

where μ_o is the outside permeability of magnetic flux in a vacuum. The outside magnetic potential energy $\mathcal{E}_{\text{so}} = -L_{\text{so}} I_s^2 / 2$. Using equation (29) and equation (30) the magnetic potential energy is:

$$\mathcal{E}_{\text{so}} = -\frac{\mu_o c^2 q^2 \left(\log \left[\frac{8R}{r} \right] - 2 \right)}{8\pi^2 R} \quad (31)$$

where the sign is chosen for *negative* magnetic potential energy in accordance with the Rule of Signs.

The mass-equivalent energy \mathcal{U}_{so} being real energy that is positive is

$$\mathcal{U}_{\text{so}} = |\mathcal{E}_{\text{so}}| = +\frac{\mu_o c^2 q^2 \left(\log \left[\frac{8R}{r} \right] - 2 \right)}{8\pi^2 R} \quad (32)$$

Outside Electric Potential Energy. For a thin ring where $r \ll R$ it can be shown [2, p. 376] that the capacitance C is:

$$C = \frac{4\pi^2 \epsilon_0 R}{\log \left[\frac{8R}{r} \right]} \quad (33)$$

Outside electric potential energy \mathcal{E}_{eo} is the negative of work \mathcal{W} done by an external force applied to assemble one unit of charge, initially located at infinity, into the shape of a torus with outside electric potential energy \mathcal{E}_{eo} .

$$\mathcal{E}_{eo} = + \frac{q^2}{2C} = + \frac{q^2 \log \left[\frac{8R}{r} \right]}{8\epsilon_0 \pi^2 R} \quad (34)$$

where the positive sign is chosen according to the Rule of Signs. Permittivity ϵ_0 is replaced by permeability μ_0 using the relationship $\epsilon_0 = 1/(\mu_0 c^2)$ for later use of combining electric and magnetic energies:

$$\mathcal{E}_{eo} = + \frac{c^2 \mu_0 q^2 \log \left[\frac{8R}{r} \right]}{8\pi^2 R} \quad (35)$$

Since real energy \mathcal{U} , like mass, is always positive,

$$\mathcal{U}_{eo} = |\mathcal{E}_{eo}| = + \frac{c^2 \mu_0 q^2 \log \left[\frac{8R}{r} \right]}{8\pi^2 R} \quad (36)$$

Charge density λ at ρ as a Function of radius ρ . The charge density $\lambda[\rho]$ at the surface of the ring where $\rho = r$ must be zero. Replacing ρ with r , in equation (18) and setting $\lambda[\rho] = \lambda[0] = \text{zero}$ yields the residue b_{res} of the Laurent series:

$$b_{\text{res}} = -b_0 - b_1 - b_2 \quad (37)$$

Substituting b_{res} into equation (18) gives λ as a function of ρ , b_0 , b_1 , and b_2 , while b_{res} has been eliminated:

$$\lambda[\rho] = b_0 + \frac{(-b_0 - b_1 - b_2) r}{\rho} + \frac{b_1 \rho}{r} + \frac{b_2 \rho^2}{r^2} \quad (38)$$

Convert charge density $\lambda[\rho]$ to a dimensionless variable by setting $\rho_r = \rho/r$:

$$\lambda_{\text{dv}}[\rho_r] = \frac{1}{\rho_r} (1 - \rho_r) \{ b_0 + b_1 (1 + \rho_r) + b_2 (1 + \rho_r + \rho_r^2) \} \quad (39)$$

Charge as a Function of ρ . Substituting into equation (20) gives q_ρ as a function of ρ :

$$q_\rho[\rho] = 4\pi^2 R \left\{ (-b_0 - b_1 - b_2) r \rho + \frac{b_0 \rho^2}{2} + \frac{b_1 \rho^3}{3r} + \frac{b_2 \rho^4}{4r^2} \right\} \quad (40)$$

When $\rho = r$, $q_\rho[r]$ includes all of the charge q in the ring:

$$q = q_\rho[r] = -\frac{1}{3} (6b_0 + 8b_1 + 9b_2) \pi^2 r^2 R \quad (41)$$

Solving for b_0 yields

$$b_0 = \frac{1}{6} \left(-8b_1 - 9b_2 - \frac{3q}{\pi^2 r^2 R} \right) \quad (42)$$

With b_0 substituted into equation (40), we obtain

$$q_\rho[\rho] = \frac{1}{3r^2} \rho \left(q(6r - 3\rho) + \pi^2 R(r - \rho)^2(4b_1 r + 3b_2(2r + \rho)) \right) \quad (43)$$

where b_0 has been eliminated.

Convert $q_\rho[\rho]$ to a dimensionless variable by setting $\rho_r = \rho/r$:

$$q_{\rho_{dv}}[\rho_r] = \frac{1}{3} \rho_r \left(-3q(-2 + \rho_r) + \pi^2 r^2 R(-1 + \rho_r)^2(4b_1 r + 3b_2(2 + \rho_r)) \right) \quad (44)$$

Summary and Continuation. Equations for the electric potential energy \mathcal{E}_{e0} outside the electron and the magnetic potential energy \mathcal{E}_{s0} outside the electron are displayed above. But the equations for electric potential energy \mathcal{E}_{ei} inside the electron and magnetic potential energy \mathcal{E}_{si} inside the electron are both functions of the charge density and depend upon the b -coefficients that enter into the Laurent series established above. The b -coefficients will be evaluated in Part 2 of this paper.

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References and Notes.

- [1] C. K. Whitney, "Editor's Comment," *Galilean Electrodynamics* **19** (5) 100 (2008).
- [2] P. Moon, and D. E. Spencer, *Field Theory for Engineers*, D. Van Nostrand, New York (1961).
- [3] I. Sellin, "Atomic Structure and Spectra," *McGraw Hill Encyclopedia of Science and Technology*, Volume 1, p. 857 (1982).
- [4] B. I. Bleaney and B. Bleaney, *Electricity and Magnetism*, Oxford at the Clarendon Press (1957).
- [5] D. L. Bergman, "Models of the Electron," *Galilean Electrodynamics*, **2** (4) (1999).
- [6] P. A. M. Dirac, "Classical Theory of Radiating Electrons," *Proc. Roy. Soc.*, **168** p. 148 (1939).

- [7] D. L. Bergman and G. C. Collins, "The Law of Cause and Effect," *Foundations of Science*, **2** (3), (August 2004).
- [8] A. Gray, *Absolute Measurements in Electricity and Magnetism*, p. 213, MacMillan and Co., London (1921).
- [9] A. L. Parson, "A Magnetron Theory of the Structure of the Atom," *Smithsonian Miscellaneous Collection* **65** (11) 1-80, Publication No. 2371 (Nov. 29, 1915).
- [10] H. S. Allen, "The Case for a Ring Electron," *Proc. Roy. Soc.*, **31**, pp. 49-68 (1919).
- [11] S. Iida, "A Persistent Electric Current Model of the Electron with a New explanation for $g = 2 (1 + \alpha/2\pi)$," *Journal of the Physical Society of Japan* **37** (1183-1190) (Nov. 1974).
- [12] W. Bostick, "Mass, Charge, and Current: The Essence and Morphology," *Physics Essays* **4** (1) 45-59 (1991).
- [13] P. M. Kanarev, "Plank's Constant and a Model for the Electron," *Galilean Electrodynamics* **17**, Special Issues No. 2, GED-East, 30-36 (2006).
- [14] D. L. Bergman & J. P. Wesley, "Spinning Charged Ring Model of Electron Yielding Anomalous Magnetic Moment," *Galilean Electrodynamics* **1** (5) (1990); D. L. Bergman, "Spinning Charged Ring Model of Elementary Particles," *Galilean Electrodynamics* **2** (2) (1991).
- [15] S. Wolfram, *Mathematica Version 8.0.1* (2011).
- [16] Physical Measurement Laboratory of NIST, "CODATA Internationally recommended values of the Fundamental Physical Constants," <http://physics.nist.gov/constants>, (2006).
- [17] J. D. Jackson, *Classical Electrodynamics, Second Edition*, John Wiley & Sons (1975).
- [18] Wikipedia, "Electric Potential Energy," http://en.wikipedia.org/wiki/Electric_potential_energy, retrieved on 2 September 2011.
- [19] W. R. Smythe, *Static and Dynamic Electricity 3rd Ed.* McGraw-Hill, NY (1968).
- [20] The value for E from equation (26) for $\rho = 0$ is not zero, but E must vanish for $\rho = 0$ by symmetry (hence a discontinuity there) since, if not, in what direction will the E vector be at $\rho = 0$? Any non-zero vector will spoil the ring symmetries! However, a potential for E may be obtained by indefinitely integrating (ρE) with respect to ρ , and it will have an arbitrary additive constant. This potential will be undefined at $\rho = 0$, but it may be defined at that value of ρ so that it is everywhere continuous in and on the ring, and we can give a fixed value to the arbitrary constant that makes this potential zero at $\rho = 0$. But then the question comes up: what is more physically real, electric fields or electric potentials? Maxwell in his "A Treatise ..."

(volume one and page 15) explains that Green coined the term ‘potential’ and based his whole theory of electricity on it, but his work went unnoticed by mathematicians for years, and by the time it was recognized, Green’s main theorems were mostly re-proven by Gauss, Sturm, Chasles, and Thompson.

- [21] The second author (Dr. Allen) acknowledges the help of the Holy Spirit of God, source of all Wisdom and Knowledge, and the Spirit of Truth together with His Most Chaste Spouse, without Whom this author’s work on the electron ring model could not have been successfully accomplished.
- [22] T. G. Barnes, *Foundations of Electricity and Magnetism, Third Edition*, Thomas G. Barnes (1997).
- [23] T. G. Barnes, “A Classical Foundation for Electrodynamics,” *Creation Research Society Quarterly*, **14** (1) 38-45, (June 1977).

To be continued. Part 2 of this paper will be published in the May 2012 issue of *Foundations of Science*.