Modeling the Real Structure of an Electron

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Abstract. The philosophy of *structuralism* [1] asserts that science must use physical models in the quest to understand nature. According to structuralism and principles of the Judeo-Christian worldview, a proper and suitable model of matter must meet criteria of physical reality, truth, unity, and causality.

Actual properties of the electron are compared to the properties of point-like models used in theories such as relativity theory, quantum mechanics, and the Dirac theory of the atom. Comparison shows that only a *physical model* of the electron with finite size can explain the fundamental properties of the electron, i.e. charge, mass, spin, magnetic moment, and stability.

Worldview principles. Common Sense Science endorses the Judeo-Christian worldview that is based on some unprovable but reasonable assumptions:

- **Reality.** The universe is real, and we can understand the nature of that reality. Elementary particles are durable and continue to exist whether or not we *think* about them, e. g. Vedantic Philosophy, and whether or not we *observe* them, e.g. Quantum Reality.

- **Causality.** Events in the universe follow the 'law of cause and effect.' Every event has a preceding cause. For example, an electron with negative charge is attracted by a proton with positive charge and moves toward it. The electron moves toward the proton *because* of the Coulomb force between the two charged particles.

- **Unity.** Nature is unified in two major ways. First, the forces between objects follow the same laws of physics whether the objects are as large as galaxies or as small as atomic nuclei. Second, the design and structure of atoms is the same everywhere in the universe. Hot hydrogen gas emits the same colors of light whether the light comes from a distant galaxy or from a laboratory on earth.

Physical reality [2]. A principal goal of fundamental physical science, known by the shorter name of 'classical physics,' is to construct a theory of matter that describes physical reality in a way that is consistent with experimental observations and free of internal contradictions. Basic goals in a theory of matter are (1) to accurately describe the structure of physical objects and (2) to accurately describe the interactions between physical objects. A suitable and proper model of matter must meet these criteria:

- **Reality.** The principle of reality requires that models of elementary particles must be physical models with *structure* in order to describe and explain the physical nature of matter. Thus, except for a scaling factor, an ideal model must have the same physical structure as the object it describes. Where *mathematical equations* are used, only those equations may be used that are somehow related to the physical structure being modeled. For example, Gauss's flux law is a valid use of a mathematical equation to describe a physical structure.

  Mathematical *models* that ignore or make significant approximations to physical structure are inferior to physical models that imitate physical reality. Of course, mathematics has an important function in science, and Herrmann identifies useful roles of *mathematical models* when he remarks [3]:

  > Karl Popper notwithstanding, it is not the sole purpose of mathematical models to predict natural system behavior. The major purpose is to maintain logical rigor and, hopefully, *when applicable* to discover new properties for natural systems.

- **Truth.** The Scientific Method requires that models and theories conform to the 'law of non-contradiction.' In order to be valid, science must be true. Models of elementary particles, atoms, and all other forms of matter must be consistent with experimental data and validated laws of physics based on observed data. Features of the models and the associated theory of matter must also be self-consistent and free of self-contradictions.

- **Unity.** A general theory that simplifies and explains a large body of fundamental phenomena without contradiction or contrivance is preferred to numerous theories, multiple assumptions, significant approximations, and various models.

- **Causality.** There must be some mechanism for fundamental processes that occur within and between physical objects. Models must replicate the laws of physics on all scales for all times in accordance with the 'law of cause and effect' (and its implementing 'law of conservation of energy'), so that the order assumed to exist in the physical universe may be studied and described rationally. Evidence cited below shows that atoms and elementary particles in the real world have finite size and an internal distribution of charge. They passively respond to the presence of one another by changing their size and rest-mass energies as they interact with one another.

New structural model of the electron [2]. The criteria of reality, truth, unity, and causality are the foundations of Common Sense Science, and they have been applied to develop a structural model of the electron. A new physical model for electrons has been developed (and will soon be published) because prior classical models are incomplete or unable to accurately predict certain properties and because current quantum models are incompatible with some of the experimental data and violate the logical basis of science as expressed above and in Mach's Criterion for scientific theories:

> Only those propositions should be employed in physical theory from which statements about observable phenomena can be deduced.

Mach's Criterion for scientific propositions [4] is similar to the rules of logic employed in doing proofs in Euclidean geometry. In the development of a new scientific theory, the criterion forbids the use of any assumption or sub-theory proven false. In the case of the Standard Model of Elementary Particles certain assumptions employed were known to be false. The primary one was that all elementary particles were point-like or point-particles. Common sense tells us that no elementary particles are point-particles. Lucretius [5, pp. 13-14] shows that even early atomists held this view:

> ...if Nature had set no boundary to breaking things, the particles of matter had been so cracked and riven by time gone by that at no given moment could anything begin with them and fill out a full life-span.

Structure of the electron and its electromagnetic fields. Just as ordinary objects are composed of a material substance with size and shape, so also by the principle of unity and the philosophy of structuralism must an electron be composed of a material substance with size and a specific shape. After many years of observations, experiments, development of physical theory, applications of technology, and manufacture of electronic devices of all sorts, scientists and engineers alike agree that the electron is composed of one unit of a material substance called 'electrostatic charge.' Moreover, this 'charge' is the source and cause of a surrounding 'electrostatic field' composed only of pure electric energy (no charge being present). And the rotating motion of this same 'charge' is the source and cause of a surrounding 'magnetostatic field' composed only of pure magnetic energy (no charge being present). *Thus, the electron consists of both 'charge' and 'electromagnetic fields,' each having its own structure, which taken together define the electron.*

Point-like models. Point-like particles are used in theories such as relativity theory, quantum mechanics, and the Dirac theory of the atom. But a point-particle is only a figment of one's imagination. The small but finite size of elementary particles has been determined by measuring the deflection angles of electrons aimed at other charged particles. These electron scattering experiments described by Olson *et al.* [6] show that protons and neutrons have finite size, multiple charges inside, and a somewhat elastic charge distribution (Figure 1). And Arthur Compton [7] measured the finite size and shape of the electron.

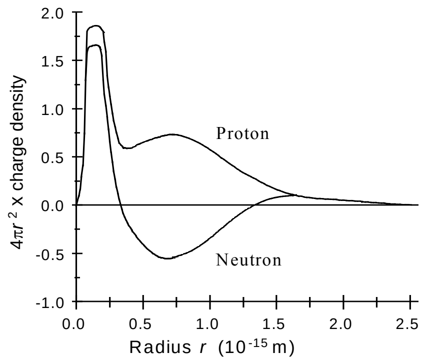

Figure 1. Charge densities in the proton and neutron extend to more than 1 x 10^{-15} meters. Evidently, the proton charge is entirely positive while the neutron has both positive and negative components of charge (after Olson, *et al.)* [6, p. 286].

Furthermore, *the point-like model of an electron (carrying one unit of charge) actually predicts the electron mass and its energy to be infinite and the electron spin and magnetic moment to be zero*, which are absurdities since many measurements of these fundamental properties show them to be non-zero and finite in magnitude.

Elastic finite-size particles [2]. While points cannot provide a physical mechanism for the exchange of energy between particles, a finite-sized object will change size and shape in response to the presence of another object. Consider a demonstration: when a spring is compressed by holding one end fixed-in-place and applying a force to the other end, the spring becomes smaller and potential energy is added to the spring. The spring with its resistance to the external force of compression provides a mechanism for storing energy. There is a cause-and-effect relationship: the spring is compressed because of the external force. The spring has releasable energy because it previously had been compressed.

Now, instead of a spring, consider if a point-object of zero size might store energy. Potential theory shows that a point cannot store energy. No compression is possible for a point, and *no energy can be stored in a point-object*. Although particle physicists assert the electron to be a point-object, and even perform mathematical operations on it, a point-object is incapable of the property of deformation needed to store energy. Particle physicists assume the existence of a point-object and its "inherent properties," but they cannot derive these properties from the laws of potential theory because the point-object has no physical mechanism capable of storing energy in any form. The point-object is therefore not a proper, rational model to explain the phenomena observed for objects of the physical world.

Modern theories of matter present the electron as a point-like particle and omit or subtract unwanted mathematical terms associated with infinite energy. Dirac [8, p. 148] stated that the aim is

> not so much to get a model of the electron as to get a simple scheme of equations which can be used to calculate all the results that can be obtained from experiment.

The point-electron is still a dominant feature of the modern model of the electron. In 1990, the Nobel Prize for physics went to Hans Dehmelt [9, p. 539] who wrote about the "structureless point particle predicted by the Dirac theory." Other statements published in the official journal of the American Institute of Physics demand that elementary particles be considered as point-like [10]:

> Physically, an elementary particle is regarded as a stable, point-like, structureless entity (structureless except for having mass, spin and other possible quantum numbers), which in its free state, moves on a world line with momentum *k.*
>
> ... a particle is a point object that moves on a world line (as [Eugene] Wigner emphatically told [Arthur] Broyles).

But the electron, proton, and neutron each have measured amounts of spin (angular momentum) and magnetic moment. These features can only exist because the particles have structure and a finite, non-zero size. So, a self-contradiction in the common theory and a violation of Mach's Criterion are evident: On one hand, the particles are said to be point-like; on the other hand, they are known to have a finite size with a spin $p = mvR$, magnetic moment $\mathbf{m} = \pi R^2 I$, (where radius R is *not* zero), and a measurable distribution of charge.*

Even when a point-particle model is used for physical calculations, the particle is also said to have a *wavelength* λ that must be used in other calculations. Additional evidence that elementary particles have a finite size was provided by Hofstadter [11] whose experiments showed that protons and neutrons have a measurable finite size, an internal charge distribution (indicative of internal

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*These well-established equations of mechanics and electricity give the relationship between an object's size and its spin and magnetic moment. The same equations predict, without discontinuity, that the object's spin and moment become zero in the limit as its size approaches a point. But the non-zero measured values of spin and moment provide compelling evidence that the particles indeed are not point-like.

One physicist, a journal editor, defends a supposed reality of a point-electron by writing "I believe that the scattering results show no structure for the electron of the order of 10^{-13} meters." This weak argument ignores evidence that (1) scattering experiments of Nobel laureate Hofstadter had to use high velocity electrons to reduce their size and make them small enough to probe the smaller protons and neutrons [11], (2) physical evidence is not established upon what one person doesn't know, (3) a good scientific approach considers all experimental data, not just data from scattering experiments, and (4) much evidence, cited above, exists in theory and experiment to establish a finite size for the electron.

structure), and elastically deform in interactions. Since 1961, when Hofstadter received the Nobel Prize in physics, there has been no reasonable doubt that fundamental particles have a finite size.

The point-electron model used for convenience has additional problems of structure called a "mystery" by Sellin [12, p. 212]:

> 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.

Concentration of the electron charge in a point would require an infinite amount of energy and an infinite force to balance the outward directed Coulomb force. If the rest-mass energy is infinite, then the equivalent mass $m = E/c^2$ must (by common theory) also be infinite. But the rest-mass of an electron has been measured, and it is not infinite. Evidently, the point-particle assumption is rendered invalid by the well-known rest-mass of an electron.

Bowman defended the point-particle assumption but nevertheless reluctantly conceded (twice) the contradiction between the size and mass features of the point model [13]:

> The divergences mentioned above [regarding a point-electron versus its finite rest-mass] are well known and occur with the [quantum] model of an electron.
>
> It is simply not true that a finite, non-zero size is required for particle spin and magnetic moment. The Dirac equation accurately describes the behavior of charged elementary spin-1/2 particles and predicts their associated magnetic moments. The Spin-Statistic Theorem relates the particle species' possible particle occupation numbers to the species spin. Quantum field theory also explains why all particles of a given species have the *exact same* values for mass, charge, spin, magnetic moment, parity, *etc*. No such constraints come from classical physics however. (Why a given species of particles has the mass that it does *is* somewhat problematical in that the calculations for predictions of particle masses are extremely complicated and hard to perform and have met with mixed success.)

The preceding quotes reveal circular reasoning in a theory that ultimately depends upon the theory itself (the quantum model of the electron) and a fabricated mathematical equation (the Dirac equation instead of equations for proven laws of physics). Worse yet, for the theory, the assumption of point-like electron size leads to a contradiction-in-logic between its size and mass that is far more serious than the reluctant admission that the mass is "divergent" and "somewhat problematical."

Quantum features of electrons. Bowman asserted in his comment above that "Quantum field theory also explains why all particles of a given species have the *exact same* values for mass, charge, spin, magnetic moment, parity, *etc*. No such constraints come from classical physics however."

However, in actual fact, the Standard Model used by advocates of quantum theory starts by *assuming* that the point-like electron has inherent properties and makes no explanation whatsoever for these fundamental properties. But the classical models of the electron, including the spinning charged ring (SCR) model actual do *explain* the quantum properties of the electron by application of the laws of electricity and magnetism [see reference 14].

What qualifies as science? Although it is *logically* acceptable to formulate and propose a mathematical equation to describe natural phenomena, Mach's Criterion for *scientific theories* requires invalidation of any theory that is contrary to observed facts. The proper scientific objective is a description of truth, and the legitimate method of validating a postulate is, at a minimum, an application of the 'law of non-contradiction.' The Standard Model of Elementary Particles is invalidated by Mach's Criterion and the 'law of non-contradiction.'

The significance of a physical model has become apparent: It is impossible to derive such fundamental properties as the stability, spin, mass or magnetic moment of an electron from an infinitesimal point, so modern theory *postulates* that point-like electrons are inherently stable, and the experimentally measured values for mass, spin, and magnetic moment are supposed to be *inherent* properties.

Wave-like properties of an electron. In addition to the particle-like properties that the electron is known to exhibit, many other observations reveal that the electron has wave-like properties associated with *electromagnetic fields*. This has been demonstrated in experiments involving wave interference, diffraction, and force interactions between charged particles.

Spinning twisting ring model of the electron. A new STR model (see figures 2 and 3) announced here consists of a fiber of electrical charge uniformly distributed throughout the interior of a torus ring. In the STR model, electrical charge moves along the circumference of a ring with major radius R as in the Spinning Charged Ring Model [14, 15]. In the new model, all of the charge also twists with uniform angular velocity as shown in figure 3. The movement of charge in the fiber is like a solenoidal current consisting of a spinning component I_s and a twisting component I_t.

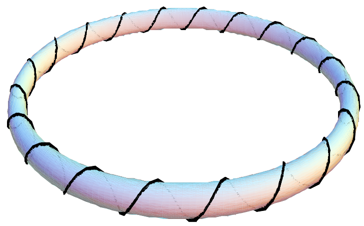

Figure 2.
New Model. Exterior View of Spinning Twisting Ring (STR) in Ground Energy State.

One unit of electric charge fills a fiber compressed into the shape of a torus (ring). The continuous black line represents the motion traced by a small segment of charge moving helically at the surface of the ring. Dimensions of the ring are not shown to scale.

The electron as a system of moving charge energy and field energy components. Potential energy is energy that is stored in a *system*. In the STR model of the electron, the system consists of compressed and moving *electrical charge,* uniformly distributed in the entire volume beneath the surface of a torus, and energy stored in *electric and magnetic fields* both surrounding the torus and located inside the torus. The electromagnetic fields self-generated by the moving charge then act upon the moving charge to create a balance of forces on the charge and make the entire system stable.

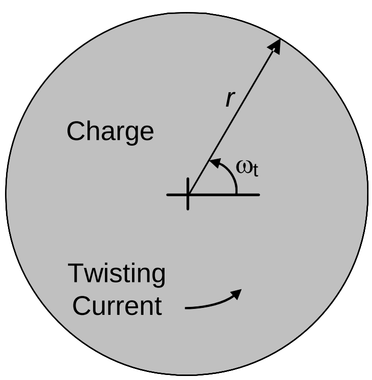

Figure 3.
Cross-section of Spinning Twisting Ring.

Charge is uniformly distributed in the cross-section of radius *r*. Twisting current I_t is from charge rotating with angular velocity ω_t.

The 'law of conservation of energy' applies to the entire electron system. As a result of energy conservation, *causality* is imposed by the forces on the structure, motion, and processes involving an electron.

The electron as a particle. In the STR model, charge is the material substance of the electron particle. The charge has a physical structure defined by the size, shape, and motions of the charge. The charge also stores energy (and equivalent mass) that came from the original energy that was needed to compress the electron into its size and toroidal shape. Since the charge is in motion, both electric energy and magnetic energy are stored in the charge located inside the torus.

The electron extended beyond the boundaries of its charge. Charge located inside an electron creates electric and magnetic fields that extend from the interior of the particle and *occupy the surrounding void*. These external fields are the cause of the electron's wave-like properties and its interactions with other charged objects.

Energy components of the electron. Using the new model, the character and resultant properties of the electron have been derived from its energy fields:

- E_{eo}. Potential Energy of electrical field outside the torus.
- E_{so}. Potential Energy of magnetic field outside the torus from spinning current.
- E_{ei}. Potential Energy of electrical field inside the torus.
- E_{si}. Potential Energy of magnetic field inside the torus from spinning current.
- E_{ti}. Potential Energy of magnetic field inside the torus from twisting current.

In future papers, David L. Bergman and Dennis P. Allen, Jr. will derive equations for these potential energies and show how they lead to the size, structure, and internal motions of an electron consisting of a charged particle with extended electromagnetic fields.

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