

# Fine-Structure Properties of the Electron, Proton and Neutron

**David L. Bergman**

Common Sense Science

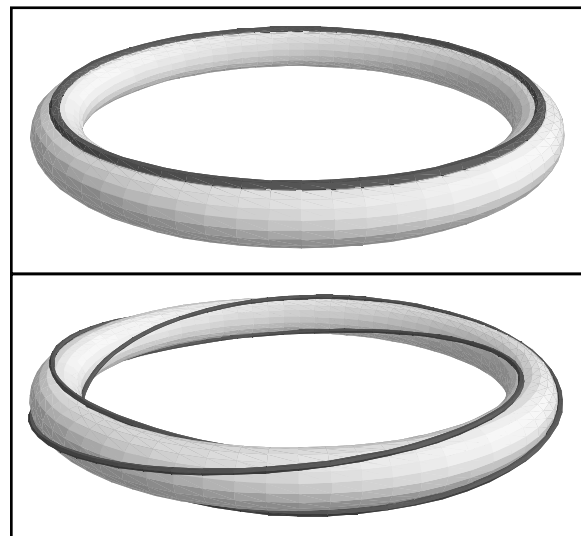
PO Box 767306

Roswell, GA 30076-7306

**Abstract.** Using the helicon model, properties of the electron, proton and neutron were calculated and updated, accurate to about five significant figures. The Helicon Model of Elementary Particles makes highly successful predictions based on the partitioning and conservation of energy and accurately accounts for all mass, energy and angular momentum (spin) without necessitating the insertion of a neutrino. A new analysis of neutron beta-decay shows the physical mechanisms at work inside the neutron before, during and after disintegration by emission of the electron.

**Understanding Matter.** Common Sense Science is a body of theory regarding matter and forces that describes physical reality using geometric models, absolute time and Galilean space in a way that is consistent with experimental observations and free of internal contradictions. The foundational principles of CSS theory are based upon the *law of cause and effect*, *conservation of energy*, and the assertion that *the universe and natural phenomena are fundamentally electrical in character*. These principles have led to the development of more accurate physical models for elementary particles, nuclei, atoms and molecules, and the derivation of a new universal force law that applies on all scales ranging from the sub-atomic to the cosmic domain.

**Basic Structure of Matter.** “The Bergman [1] spinning ring model of the electron is so successful that it probably comes close to representing the actual dynamical structure of the electron. Contrary to most submicroscopic models of elementary particles, that have to depend upon hypothetical forces, the Bergman model depends only upon



**Figure 1.**

The helicon model (bottom) represents a refinement of the torus model (top).

The torus model is a single thin fiber of charge shown as a thin dark line. The helicon model can be three split fibers of charge as shown spiraling around the form of a torus (included only for better visualization).

Dimensions of the charge fibers shown above are not to scale.

Property (SI MKS units)	Free Electron	Free Proton	Bound Electron in Neutron	Bound Proton in Neutron	Isolated Neutron
Electrostatic Energy (Joule)	$4.0983 \times 10^{-14}$	$7.5251 \times 10^{-11}$	$2.2542 \times 10^{-11}$	$5.2719 \times 10^{-11}$	$7.5261 \times 10^{-11}$
Magnetostatic Energy (Joule)	$4.0888 \times 10^{-14}$	$7.5077 \times 10^{-11}$	$2.2490 \times 10^{-11}$	$5.2597 \times 10^{-11}$	$7.5087 \times 10^{-11}$
Potential Electric Energy (Joule)	N/A	N/A	N/A	N/A	$-3.4501 \times 10^{-13}$
Potential Magnetic Energy (Joule)	N/A	N/A	N/A	N/A	$-1.5804 \times 10^{-13}$
Mutual Potential Energy (Joule)	N/A	N/A	N/A	N/A	$-5.0305 \times 10^{-13}$
Total Energy (Joule)	$8.1871 \times 10^{-14}$	$1.5033 \times 10^{-10}$	$4.5032 \times 10^{-11}$	$1.0532 \times 10^{-10}$	$1.5053 \times 10^{-10}$
Mass (kilogram)	$9.1094 \times 10^{-31}$	$1.6726 \times 10^{-27}$	$5.0105 \times 10^{-28}$	$1.1718 \times 10^{-27}$	$1.6749 \times 10^{-27}$
Magnetic Moment (Joule/Tesla)	$-9.2848 \times 10^{-24}$	$5.0566 \times 10^{-27}$	$-1.6880 \times 10^{-26}$	$7.2179 \times 10^{-27}$	$-9.6624 \times 10^{-27}$
Radius (meter)	$3.8661 \times 10^{-13}$	$2.1055 \times 10^{-16}$	$7.0287 \times 10^{-16}$	$3.0054 \times 10^{-16}$	N/A
Shape, $\log_e(8R/r)$	428.932	428.932	428.932	428.932	N/A
Spin Rate (radians/second)	$-7.7544 \times 10^{+20}$	$1.4238 \times 10^{+24}$	$-4.2652 \times 10^{+23}$	$9.9750 \times 10^{+23}$	N/A
Current (Amp)	-19.773	36307	-10876	25436	N/A
Capacitance (Farad)	$3.1354 \times 10^{-25}$	$1.7076 \times 10^{-28}$	$5.7003 \times 10^{-28}$	$2.4374 \times 10^{-28}$	N/A
Inductance (Joule/Amp)	$2.0940 \times 10^{-16}$	$1.1404 \times 10^{-19}$	$3.8069 \times 10^{-19}$	$1.6278 \times 10^{-19}$	N/A
Magnetic Flux (Weber)	$-4.1405 \times 10^{-15}$	$4.1405 \times 10^{-15}$	N/A	N/A	N/A
Mutual Inductance (Joule/Amp)	N/A	N/A	N/A	N/A	$5.7130 \times 10^{-22}$
Coefficient of Coupling	N/A	N/A	$2.2949 \times 10^{-3}$	$2.2949 \times 10^{-3}$	$2.2949 \times 10^{-3}$
Compton Wavelength (meter)	$2.4291 \times 10^{-12}$	N/A	$1.8884 \times 10^{-15}$	N/A	$1.8884 \times 10^{-15}$
Resonant Frequency 1 (Hertz)	$1.23416 \times 10^{+20}$	N/A	$1.5876 \times 10^{+23}$	N/A	$1.5876 \times 10^{+23}$
Compton Wavelength (meter)	N/A	$1.3229 \times 10^{-15}$	N/A	$4.4163 \times 10^{-15}$	$4.4163 \times 10^{-15}$
Resonant Frequency 2 (Hertz)	N/A	$2.2661 \times 10^{+23}$	N/A	$6.7883 \times 10^{+22}$	$6.7883 \times 10^{+22}$
Beta Decay Energy (Joule)	N/A	N/A	N/A	N/A	$1.2534 \times 10^{-13}$
Equivalent in MeV	N/A	N/A	N/A	N/A	0.78235
g-2 factor	2.00232	2.00232	N/A	N/A	N/A
Spin (Angular Momentum) (kilogram-meter <sup>2</sup> /second)	$5.2729 \times 10^{-35}$	$5.2729 \times 10^{-35}$	$5.2729 \times 10^{-35}$	$5.2729 \times 10^{-35}$	$2 \times 5.2729 \times 10^{-35}$ (see text)

Table 1. Properties of the Electron, Proton, and Neutron.

well-known forces. For the first time a model of the electron is presented that is held together by (Weber) electrodynamic forces alone.” [2]

The basic structure of this model is a thin ring of circulating charge (see figure 1). Although the torus model of the electron explains the origin of many properties observed by experimenters, a slight deviation from this shape must be recognized if the model is to explain precise observations of all the electron properties. CSS proposed the helicon model [3] as a physical model that makes accurate predictions of all properties of elementary particles [4, 5]. Table 1 presents many of these predictions for the electron, proton, and neutron. (Note that Table 1 is a revision and extension of properties predicted in reference [6], where the more simple structure of a torus was assumed.)

**Fine-Structure of Energy Levels of the Atom.** ‘Fine-structure’ is a common term used by physicists to describe the closely spaced energy levels of groups of optical spectral lines of elements like hydrogen and helium. Generally, use of the word ‘structure’ would suggest that a physical shape exists in the source that produces the line spectra. CSS has shown that a causal relationship exists between a particle and the energy in line spectra from the particle [7]. By extending this concept, the present paper shows how the parti-

Property	Torus	Helicon
Shape	$\ln(8R/r) = \pi/\alpha$	$\ln(8R/r) = (\pi/\alpha) + (1/2)$
Electrostatic Energy (Joule)	$E_e$	$E_e (1 + \alpha/2\pi)$
Magnetostatic Energy (Joule)	$E_m$	$E_m (1 - \alpha/2\pi)$
Other Properties	See Reference [1]	See Reference [1]

Table 2. Equations Modified for Helicon Model

tioning of energy in a helicon particle causes a corresponding property as listed in Table 1. In contrast with the helicon model, the reader is reminded that in the Standard Model of Elementary Particles, the particles are not physical objects with structure, but instead are considered to be quantum objects with *inherent* properties unrelated to any physical structure. There is no structure in a point-particle.

**The Fine-Structure Constant.** The fine-structure constant  $\alpha$  is a unitless numerical constant whose value is approximately equal to  $1/137$ . The constant is actually a combination of other constants  $\{\alpha = e^2/(8\pi^2\epsilon_0 ch)\}$  that is part of the equations for the energy levels of optical line spectra. It also shows up as the ratio of the two dimensions of the torus ring electron:  $\ln(8R/r) = \pi/\alpha$  [1, equation 36]. And as such, this physical property of the helicon's proportioning is the causal or underlying reason for the fine-structure constant's value. Furthermore, the proportioning of the helicon's dimensions is determined by the energy partitioning between the electrostatic and electromagnetic field energies.

**An Accurate Model Predicts Accurate Properties.** A model of an electron must be accurate if the model is to be able to make accurate predictions. Predictions of the original torus ring model "agreed to observations to 3 or 4 places" [1]. But the helicon ring refinement with helical fibers of charge is able to make predictions of particle properties accurate to about 5 significant figures, as given in Table 1. The new distributions of charge in the helicon, as specified by its size, shape, and dimensional proportions, require slight modifications to some equations. The equations shown in Table 2 for a more accurate model were given in 1990 in the original paper on the Ring Model [1].

**CSS Model of the Neutron.** The CSS model of the neutron was presented in reference [6]. The model consists of a paired electron and proton in a common plane and sharing a common axis. Mutual forces between the electron and proton ensure that their magnetic moment vectors are aligned so that the currents of the two particles circulate in the same direction. Actual charge motions are in opposite direction. (This statement corrects an error-in-direction shown in previous articles.)

Comparison of Table 1 (this article) and a similar table in reference [6] reveals some differences in properties listed for the neutron. The updated values listed in this paper correct earlier calculation errors and incorporate the refinement of the more accurate helicon shape.

**Neutron Beta-Decay.** French [8] states that “The neutron...is spontaneously radioactive,” thus claiming that neutron disintegration is self-generated and happens without apparent external cause. However, he admits to an exception for neutrons found in space: “Neither the neutron nor the proton is found free in nature, *except in such transient forms as cosmic radiation*” [8, page 265, emphasis added]. So, French seems to believe that a neutron changes from a particle to a radiating wave, and then it becomes stable.

CSS, however, asserts that the “wave-particle duality” explanation is neither compelling nor necessary. Evidence indicates that the binding energy that holds the proton and electron together in a neutron is strong enough to allow neutrons to exist indefinitely *in space* where collisions with another particle are rare. But in other environments, the (positive) binding energy (negative of Mutual Potential Energy equals  $-5.0305 \times 10^{-13}$  Joules as shown in Table 1) is weak enough to allow the electron (beta particle) to escape where confluences with other particles exert forces upon the neutron.

**Conservation of Energy During Neutron Disintegration.** Whenever a neutron beta-decay event is triggered, the electron emerging from a radioactive source carries energy away from the parent atom or neutron. This beta-decay energy consists of the electron’s kinetic energy of motion plus the radiant energy emitted by the accelerated electron [9]. The total beta-decay energy available is derived from the mass-energy difference between the neutron and its products of disintegration, one electron and one proton. For this reason, *i.e.*, loss of energy by radiation, the total beta-decay energy has never been found to reside solely in the electron and its recoil velocity. Table 3 show how the total energy of a neutron is conserved and partitioned for the stable and disintegrated cases, *i.e.*, the two stable end points representing the start and completion of neutron beta-decay.

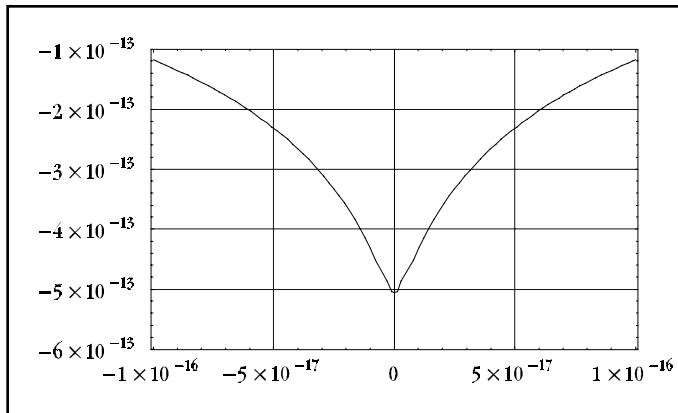
Obviously, the partitioning of energy continuously changes between the start and the end of the neutron beta-decay process. As the rings separate, some energy is lost from the two-ring system due to radiation from the rapid acceleration of the electron (the particle with less inertial mass). Using a computer simulation of the CSS neutron model, the many equations of energy that govern the motions of neutron disintegration have been solved.

Particles Bound in Neutron		After Particles Separate	
Energy of Bound Electron	$4.5032 \times 10^{-11}$	$8.1871 \times 10^{-14}$	Energy of Free Electron
Energy of Bound Proton	$1.0532 \times 10^{-10}$	$1.5033 \times 10^{-10}$	Energy of Free Proton
Mutual Electric Energy	$3.4501 \times 10^{-13}$	$1.2535 \times 10^{-13}$	Energy of Beta Decay
Mutual Magnetic Energy	$-1.5804 \times 10^{-13}$	—	—
Total Energy of Neutron	$1.5054 \times 10^{-10}$	$1.5054 \times 10^{-10}$	Total Energy of Neutron

**Table 3. Partitioning of Energy in Neutron Before and After Beta Decay**

Properties of an electron and proton for a stable neutron (before beta decay) and the energy of the free particles plus radiated energy (after beta decay). Note that total energy of the neutron is conserved.

One result of the simulation is the graph in Figure 2 showing the mutual potential energy for separations up to  $10^{-16}$  meters. For the case of free particles separated by much greater distances, the mutual energy between them becomes zero.



**Figure 2.** Mutual Potential Energy of Neutron as a function of separation of particles along their common axis. A minimum of potential energy occurs at zero where the electron and proton are coplanar.

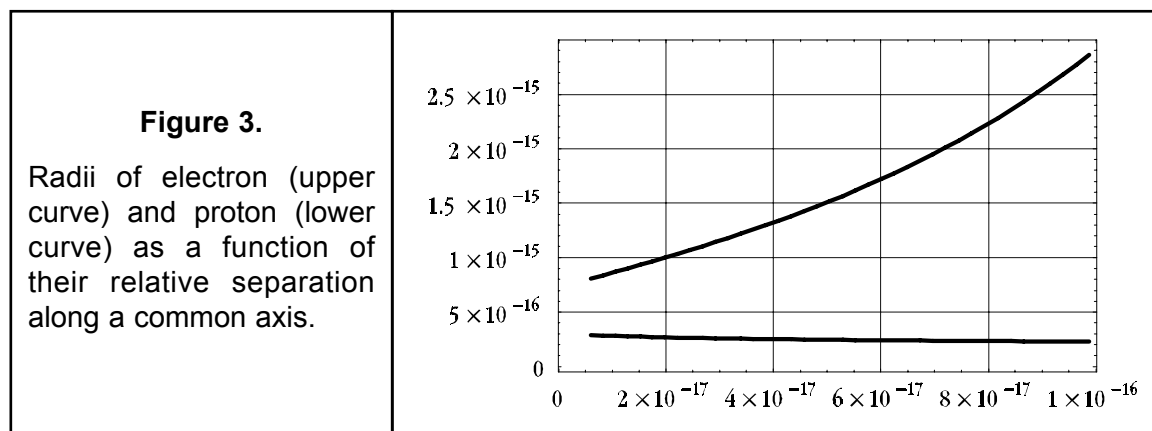
Neutron internal motions, including beta-decay, are completed in a fraction of a pico second since the relative velocity of moving particles approaches the speed of light. In the CSS neutron model, this high velocity is expected because any induced magnetic force from

motion of one ring is causally related to the static electric force from the charge of the other ring. In general, magnetic force becomes as strong as electrostatic force when charge moves at the speed of light. Consequently, the magnetic force that limits relative velocity of separating rings by ‘back electromotive force’ will be of the same order of magnitude as the driving force from the charge circulating in both rings at the speed of light.

The so-called ‘half-life’ of a neutron outside a nucleus is said to be about  $13 \pm 2$  minutes. This number is not related to the velocity of separation but to the likelihood of a radiation triggering event, as shown by Boudreaux [10].

Another result of the simulation is a comparison of the electron and proton size as a function of their relative separation along their common axis. See Figure 3 for the dimensions of the particles near the region of stability when the particles are coplanar and coaxial.

**Neutron Spin.** Based on the helicon model and an understanding of how energy is partitioned, the neutron should not be considered an elementary particle but a composite, consisting of two particles: one electron and one proton. These two particles are loosely



**Figure 3.**

Radii of electron (upper curve) and proton (lower curve) as a function of their relative separation along a common axis.

bound together by electric and magnetic forces with a *coefficient of coupling* equal to 0.0022949 (see Table 1). Evidently, small perturbations imposed on one of the particles has a miniscule effect on the other such that the neutron does not behave as a solitary body.

In the Standard Model of Elementary Particles, the *spin* of electrons, protons, and neutrons is  $\frac{1}{2} (\hbar/2\pi)$  “[a]ccording to Dirac theory which assumes structure-less, spin  $\frac{1}{2}$  particles...” [11]. And, electromagnetic resonance methods are used to measure the *magnetic moment* of particles inside atoms and neutrons:

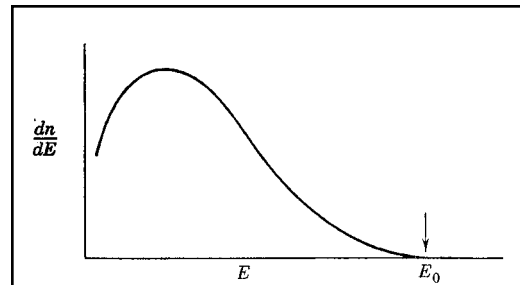
The method of magnetic resonance has been successfully applied to measure the magnetic moment of neutrons and of various nuclei. The principle feature of this method is the observation of transitions, caused by resonance of an applied radiofrequency field with the Larmor precession of the moments around a constant magnetic field [12].

Other experiments measured the *ratio* of spin and magnetic moment—called the gyromagnetic ratio—which yielded a constant value. Guided by Dirac theory, the constant relationship between spin and moment, and many measurements of magnetic resonance, the neutron was assigned a spin value of  $\frac{1}{2} (\hbar/2\pi)$ . But this deduction of neutron spin is erroneous.

*Individual particles* are stimulated when the particle is “in resonance” with an external electromagnetic field whose wavelength (called the Compton wavelength) matches the wavelength of the particle with the same circumference. The two particles of a neutron have two different wavelengths (see Table 1). *This means that the measurements made on a neutron to determine its spin were actually measuring the spin of one of its particles. Since an electron (and proton) bound in a neutron has spin  $\frac{1}{2}$ , experimenters erroneously reported a neutron spin of  $\frac{1}{2}$  but were actually measuring electron (or proton) spin.*

**Birth of the Neutrino.** When examining the phenomenon of neutron beta-decay, twentieth-century physicists interpreted the data to infer a very different model of the neutron in their attempts to explain the problems of beta-decay. French describes the two problems that bothered physicists in the year 1930 about neutron beta-decay:

Quite generally, beta-particle emission converts an atom of well-defined mass and energy into another atom of smaller mass and energy. We should therefore expect a definite amount of energy to be carried away by the electron. What happens is totally different. If the beta-particles emerging from a radioactive source are analyzed, by magnetic deviation or some other means, so as to obtain their energy spectrum, a curve of the kind shown...will typically be obtained. The kinetic energy  $E_0$  is the available energy as deduced from the mass difference of the initial and final atoms. This total energy is almost never found on the electron; an indefinite fraction of it seems to disappear in the



The general form of a typical beta-ray spectrum.  $E$  is the electron kinetic energy. [Editor's note: Figure is from original quote.]

decay process. And energy is not the only thing that apparently fails to be conserved. We have noted that the proton, the neutron, and the electron are all particles of spin  $\frac{1}{2}$  ( $\times h/2\pi$ ); this being so, it is impossible for spin angular momentum to be conserved if a neutron decays into a proton and an electron and nothing else, since the vector sum of proton and electron spins can only be 0 or 1. These facts created a cruel dilemma for physicists around 1930. To abandon the treasured laws of conservation of energy and angular momentum seemed unthinkable; yet the only way to avoid it was to postulate that, in the process of each beta-decay, an unobserved (and apparently unobservable) particle carried away the balance of energy and momentum. The lesser of two evils was chosen, and so the “neutrino” was born.

**Conclusions.** In the twentieth century, physicists added an unobserved particle, the neutrino, to the particle inventory of the Standard Model in their attempts to conserve both energy and angular momentum of the neutron. In contrast, the CSS model of the neutron conserves both energy and spin by the physical mechanisms of elastic, finite-size helicon particles: one electron and one proton—without the need to invent the neutrino. Using physical structured models and electromagnetic forces, the CSS helicon-based model successfully and accurately explains and predicts the properties of the electron, proton and neutron.

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