Observations of the Properties of Physical Entities

Part 2—Shape & Size of Electron, Proton & Neutron

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Abstract. Part 2 cites and presents experimental data that reveal the existence, shape, and size of electrons, protons and neutrons. The Helicon Model of Elementary Particles is defined as a toroidal helical structure of charge fibers (one or more) that account for the electromagnetic energy (excited states) of elementary particles. The helicon is a physical model of a durable particle with specific geometry that describes its shape and size. A careful interpretation of scattering experiments performed by Arthur Compton and Robert Hofstadter gives precise agreement with the thin, flexible ring predicted by the Helicon Model. Plasma experiments of Winston Bostick, and S. C. Hsu and P. M. Bellan, provide additional data that support the Helicon Model of Elementary Particles.

Structure of the Electron. In 1897, J. J. Thomson discovered what appeared to be a stable elementary particle: the *electron* [reference **g** of Table 2a]. Furthermore, it could be deflected and detected by a "Cathode Ray Tube," a device which continues to be used today to generate images in television sets and computer displays. Since its discovery, the observed properties of the electron suggest that it is an *elementary particle* composed of a fundamental essence, *charge* (see Table 1 from Part 1), with physical properties.

For more than 100 years since Thomson's discovery, physicists have been proposing models of the electron that describe its physical characteristics. The validity of each model is then judged in terms of its ability to predict physical, electrical, and chemical properties. Models capable of predicting properties of a particle (*e.g.,* an electron or proton) with accuracy and precision gain greater credibility than others. Thus, observations and measurements of a particle's properties have a fundamental role in the development and validation of models.

Prominent Models of Elementary Particles. After a century of research and observations, few models remain serious contenders to describe the elementary particles. Two leading models are the well-promoted Standard Model of Elementary Particles and the more accurate, but little-known, Helicon Model of Elementary Particles. Table 2a in this report illustrates how the Helicon Model conforms with the experiments that measure shape and size of the stable elementary particles.

Helicon Model of Elementary Particles. A *helicon* is the model of a toroidal helical structure of charge fibers (one or more) revolving k turns around an imaginary toroidal form, where k also represents the energy level (excited states) of the elementary particle (*e.g.*, an electron or proton). Each toroidal helical fiber composed of circulating electric charge acts as a resistance-free conductor for the moving charge.

The fiber of the Helicon Model consists of positive charge (+) or negative charge (-), depending upon the nature and identity of the elementary particle.

The Helicon Model has also been called the Spinning Charged Ring Model or the Ring Model.

Figure 1 shows one shape of many possible shapes taken by the fiber. As shown, the charge fiber makes 25 turns in a path of one complete loop. This helicon represents a highly "excited" electron (or proton).

The helicon symbol for an elementary particle is $^{cn}h_k$ where c is the charge polarity, n is the number of split fibers, h signifies the helical structure, and k is the number of turns. Thus, $^{+1}h_2$ represents a proton in excited energy level 2, and $^{-1}h_1$ (or ^{-}h) represents an electron in its base energy state. The simplified helicon shown in Figure 2 has the symbol $^{-}h_0$ if the model represents an electron.

Figure 2 shows a simplified case of charge moving along a path in the shape of a circle. This does not correspond with any (unexcited) electron found in nature, but the simplified Ring Model with $k = 0$ can predict certain properties of the electron (or proton) with accuracy to about 4 significant digits (*e.g.*, the anomalous magnetic moment and the fine structure constant) [**m**].

Figure 3 shows the Helicon Model for a low state of energy that is commonly observed in experiments. With $k = 1$, the fiber path follows an elongated circle.

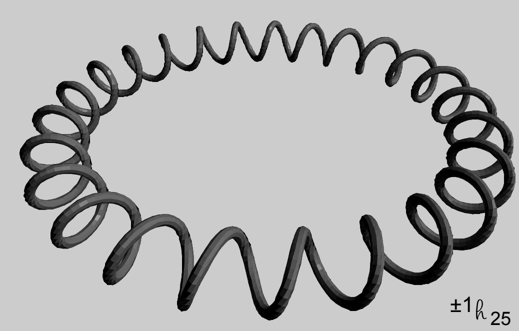


Figure 1. Helicon
Single fiber with $k = 25$

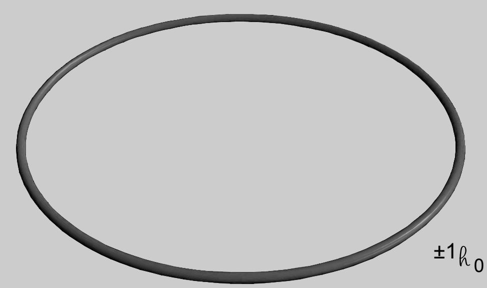


Figure 2. Simplified Helicon (Torus)
Single circular fiber with $k = 0$.

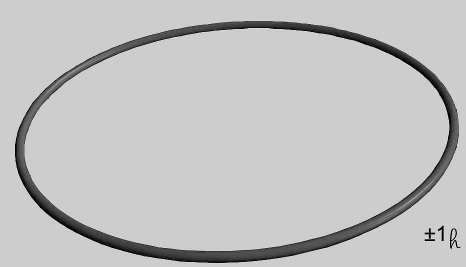


Figure 3. Helicon.
Single elongated fiber with $k = 1$

Split fibers, usually a division of the charge into three fibers with phase relationships, are associated with the short-life elementary particle. Helicons with split fibers will be illustrated in a latter part of this report.

Explanations for Table 2a. Shape and size of Electron, Proton and Neutron. The following sections identify various properties of the Helicon Model and show how the measured properties of fundamental particles conform to the model. (Properties 1 through 6 were previously presented in part 1 of this report.)

Property #7–Existence of the Electron. In the late nineteenth century, many experiments indicated the existence of the electron, but no doubt was left after 1897 when J. J. Thomson "deflected...an electron beam in crossed electric and magnetic fields":

> The direct observation of this basic charge carrier was finally achieved in experiments with the low-pressure gas discharge tube [**g**].

Property #8a–Shape of the Electron (torus). In 1915, A. L. Parson deduced the shape of an electron from chemical data, specifically the magnetic nature of bonding between two atoms of hydrogen. Parson described the structure of an electron with both electric and magnetic properties:

> The essential assumption of this theory is that the electron is itself magnetic, having in addition to its negative charge the properties of a current circuit.... Hence, it will be spoken of as a *magneton*. It may be pictured by supposing that the unit negative charge is distributed continuously around a ring which rotates on its axis (with a peripheral velocity of the order of that of light...); and presumably the ring is exceedingly thin [**h**, *p*. 3].

Prominent physicists noted that many experiments supported, even demanded, the "Ring Electron." 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." 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 electrostatic forces, behaves like a small magnet. The assumption of the ring electron removes many outstanding difficulties [**i**].

About the same time, scattering experiments analyzed by Arthur Compton confirmed the deductions of Parson and Allen:

> The phenomena of scattering were found to be qualitatively accounted for, within the probable errors of observation, if the electron was considered to be a flexible ring of electricity with a radius of 2 x 10^{-10} cm [**j**].

Parson's conjecture that *the ring is very thin* (see quotation above) has been validated in

Table 2a. Observations of the Properties of Physical Entities
Experimental Data Related to the Helicon Model

Shape and Size of Electron, Proton and Neutron

#	*Property*	*Symbol*	*Value or Characteristic*	*Ref.*
7	existence of the electron	$^{-}h_0$ e	indefinitely stable charge = $-1.6021892 \times 10^{-19}$	**g**
8a	shape of an electron (magnetic effects)	h_0	helicon (torus)	**h,i,j**
8b	shape of an electron (plasma imaging)	h_k	helicon (helical coil with *k* loops)	**k,l**
9	size of an electron (free electron)	$^{-}R_0$	3.86607×10^{-13} meter (from measured moment)	**m**
10	size of an electron (in aluminum)	$^{-}R_1$	1.85×10^{-12} meter (from radiation scattering)	**j**
11	existence of the proton	$^{+}h_0$ p	indefinitely stable charge = $+1.6021892 \times 10^{-19}$	**n**
12	shape of a proton	$^{+}h_0$	ring shape inferred from scattering of electrons	**o-s**
13	size of a proton (free proton)	^{+}R	2.10553×10^{-16} meter	**o-s**
14	existence of the neutron	n	unstable outside bound positions in a nucleus net charge is zero	**g**
15	components of the neutron	$^{-}h_1$, $^{+}h_1$	paired electron and proton in bound neutron free neutron disintegrates into electron & proton	**t**
16	shape of a neutron	$^{-}h_1$, $^{+}h_1$	two rings inferred from scattering of electrons	**o-s**
17	size of positive charge in a neutron	$^{+}R_n$	1.7×10^{-16} meter (at peak charge density)	**o-s**
18	size of negative charge in a neutron	$^{-}R_n$	5.7×10^{-16} meter (at peak charge density)	**o-s**

References for Table 2a.

g. A. P. French, **Principles of Modern Physics**, John Wiley & Sons, NY (1958); pages 50-54 cite experiments of Geissler (1854), Plücker (1858-1862), Crooks (1879-1885), Perrin (1895), Thomson (1997), Townsend (1897), Wilson (1903) and Millikan (1910) as establishing existence and measuring properties of electron; page 264 cites Chadwick (1932) as establishing existence of neutron.

h. A. L. Parson, "A Magneton Theory of the Structure of the Atom," **Smithsonian Miscellaneous Collection,** Volume 65, Number 11, Publication No. 2371, *pp*. 1-80 (Nov. 29, 1915).

i. H. S. Allen, "The Case for a Ring Electron," **Proc. Roy. Soc.**, Volume 31, *pp*. 49-68 (1919).

j. A. H. Compton, "The Size and Shape of the Electron," **Physical Review Sec. Series**, Volume 14, No. 3, *pp*. 247-259 (1919).

k. W. H. Bostick, "The Morphology of the Electron," **Int. J. of Fusion Energy**, **3,** 1, 9-52 (Jan. 1985); "Mass, Charge, and Current: The Essence and Morphology," Physics Essays, **4**,1, 45-59 (1991).

l. S. C. Hsu and P.M. Bellan, **Phys. Rev. Lett. 90**, 215002,2003; "The Twisted Origin of Spheromaks," **APS News Ser. II**, Vol. 13, No. 2., *p*. 9 (Feb. 2004).

m. D. L. Bergman and J. P. Wesley, "Spinning Charged Ring Model of Electron Yielding Anomalous Magnetic Moment," **Galilean Electrodynamics**, Volume 1, No. 5 (Sep./Oct. 1990).

n. A. Watson, "News Focus, Exploring the Proton Sea," **Science**, Vol. 283, No. 5401, *pp*. 472-474 (22 Jan. 1999) cites experiments in 1919 of Ernest Rutherford and proton-proton collision experiments in 1930s.

o. R. Hofstadter, **Reviews of Modern Physics**, volume 28, *p*. 213 (1956).

p. W. E. Burcham, **Nuclear Physics,** *p*. 410, McGraw-Hill Book Co., Inc., NY-San Francisco (1963).

q. Olson, *et al.*, **Physical Review Letters**, **6**, 286 (1961).

r. R. Madey, *et al.,* "The Electric Form Factor of the Neutron," http://www/.jlabs.org/exp_prog/proposals/93/PR93-038.pdf (April 1, 1993).

s. A. Semanov, "Electromagnetic Structure of the Neutron and Proton (Popular Version of Paper K4.002)," 2002 APS April Meeting, Albuquerque, NM, http://www.aps.org/APR02/baps/vpr/layk4-2.html (April 21, 2002).

t. J. M. Robson, "The Radioactive Decay of the Neutron," **The Physical Review**, **83** (2) 349-358 (July 15, 1951).

two ways. First, the very narrow line width (or small variation of wavelength) in line spectra indicates a single (precise) circumference exists as the source of the waving fields of radiation. The charge distributed around the circumference of the electron determines the wavelength of emitted radiation—phenomenon called the Compton Effect and also the phenomena of line spectra.

Second, calculations show that the charge comprising an electron is compressed to a very thin fiber in order to contain the electromagnetic energy possessed by the electron [**m**].

Property #8b–Shape of Electron (helicon). The preceding quotation of Compton suggests the electron is "flexible." In fact, any valid model must adequately accommodate variations or deformations due to interactions with other particles (or their energy fields). The Helicon Model of the electron has the inherent adaptation mechanisms to account for the full set of properties measured for the electron. Helicons with multiple fiber loops explain line spectra such as the Balmer Series. For the fundamental properties such as magnetic moment, force exerted on other particles, spin, and mass, the simple helicon with $k = 0$ fiber loops makes predictions accurate to about 100 parts per million. When more accuracy is required, a helicon with k greater than one (representing an actual electron shape) must be used.

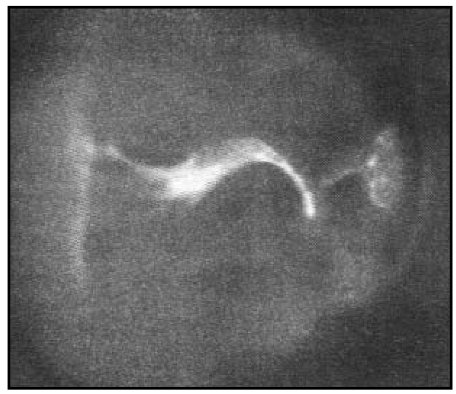
Compton's last post-graduate student was Winston Bostick, who continued the studies of stable configurations of electric charge (*i.e.,* electrons and plasma). Bostick proposed the helical structure of the electron:

> The author's [Bostick's] experimental work in plasma physics for the last 36 years has shown that under many different circumstances plasmas containing nonrelativistic or relativistic ***electrons can spontaneously organize themselves into force-free, minimum-free-energy vortex filaments*** of a Beltrami morphology. So abundant are these manifestations of nature's ability to create macroscopic filamentary structures that the author has been inspired to try a ***filamentary model of the electron*** in order to explain the existence of de Broglie waves, electron spin (via the Poynting vector), electron mass via electric and magnetic vectors, electron self-equilibrium and stability—ultimately ***equilibrated by the self-gravity of its own intense electric and magnetic fields***. The result is a concept of the electron, photon, and all other elementary onta (never say "particles") that philosophically brings the quantum theory, the prodigal son of physics, back into the family of classical physics.
>
> No vexing self-energy infinities occur. Newtonian lump point-mass and lump point-charge are banished. Since the ***electron's charge circulates as a continuous filament*** it will not radiate as it lies in a stationary atomic state. The concepts of onta of finite rest mass and zero rest mass are geometrically clarified as never before. The correct dispersion relationship for the de Broglie waves of a free electron are geometrically exhibited by the filamentary model with incandescent clarity. Since the model shows how all mass and momentum must be electromagnetic in character, it becomes obvious that all forces—the strong, the electroweak, the gravitational—must be electromagnetic in character. The mysterious strong short-range nuclear force will go the

> way of the epicycles of Ptolemaic astronomy. It is demonstrated that the de Broglie waves have an analogue in the inertial waves of fluid mechanics [**k**, emphasis added].

Guided by experience with circulating plasma, Bostick deduced an electron composed of a helical charge fiber. Recently, this shape was observed in plasma and described as a "helix [which] acts like a coiled current element or solenoid":

> THE TWISTED ORIGIN OF SPHEROMAKS. Researchers at the California Institute of Technology have made important progress in solving a longstanding mystery concerning the formation of spheromaks, self organizing toroidal plasma configurations that are superficially reminiscent of smoke rings. It is well known that current carrying plasmas embedded in an initial seed magnetic field can form spheromaks. The formation process is believed to involve some kind of dynamo process whereby the internal magnetic fields become rearranged or even amplified so as to achieve a stable minimum energy state for the internal magnetic forces. But until now, no one has definitively demonstrated just how a plasma transforms from an unstable, high internal energy configuration into a spheromak. The new experiment sheds light on the phenomenon by capturing images of plasmas as spheromaks form. The images show that plasma currents initially flow in straight lines along a confining magnetic field. ***Owing to an effect known as the kink instability, the plasma currents develop bends that twist into a helix. The helix acts like a coiled current element, or solenoid,*** which amplifies the original straight magnetic field. Above a certain threshold in the initial magnetic field, ***detached plasma spheromaks are formed.*** The researchers confirm the theory behind the effect by measuring the rapid amplification of the magnetic field inside developing plasma solenoids. Spheromaks are potentially promising routes to nuclear fusion, and insight into their formation will help in the design of future experiments and possibly even a clean, safe energy source. In addition, spheromak formation is important for explaining the behavior of plasma in the solar corona, as well as understanding the physics of jets that sprout from black holes, galactic nuclei, and other astrophysical objects. (S. C. Hsu and P. M. Bellan, *Phys. Rev. Lett.* **90**, 215002, 2003) [**l,** APS News, emphasis added].



Shapes of Competing Models. The early physical models, *spheres* proposed by Abraham and Lorentz, did not and cannot account for the electron's spin and magnetic moment. (Tables of physical data often include a value of the "classical electron radius" based on the spherical models. But this table entry is not data, and many references to the "classical electron" use this terminology in order to *assume* and *claim* that Classical Physics could not produce a viable model of the electron.)

Models of *vortices* in an aether [**1**] can be adjusted to predict the properties of an electron *or* a proton, but *not both* since this model relates the particle energy directly with size instead of the correct inverse relationship. And models consisting of *electromagnetic field* *energy without charge* [**2**] cannot explain the origin of inertial mass.

The Standard Model of Elementary Particles presents a particle as a "*quantum object*" endowed with the power to alternate between a wave and a particle, generate force-carrying particles without conserving energy, and to show itself with the properties of mass, charge, spin, and magnetic moment while in its particle state that is supposed to be "point-like." This model has *no shape* and is non-physical, consisting only of *a set of assumptions* that lead to a few correct predictions but also violate several laws of physics (see Table 1). Acceptance of the quantum electron is the equivalent of a religious belief in the power of nature but has no scientific or explanatory basis.

<u>Property #9–Size of a Free Electron</u>. At this date, the best imaging tools, based on the electron microscope technology, cannot produce images as small as an atom. The resolution of current imaging devices is greater than the size of atoms and electrons by several orders of magnitude. However, the size of an electron can be derived from measurements of the electron magnetic moment and the definition of magnetic moment—which is equal to the product of the electron current and the area enclosed by the current. From this formula, ***the measured value of a free electron's magnetic moment yields an electron radius of 3.86607 x 10^{-13} meters*** [**m**, equation (28)]. This radius also leads to the correct magnitude of the electron spin [**m,** equation (35)] and explains the measured Compton Wavelength $\lambda_C = R = h/(2\pi mc)$ [**m**]. In contrast, the quantum electron (with radius equal to zero) predicts the electron magnetic moment and electron spin are both zero, clearly *not* in agreement with measurements.

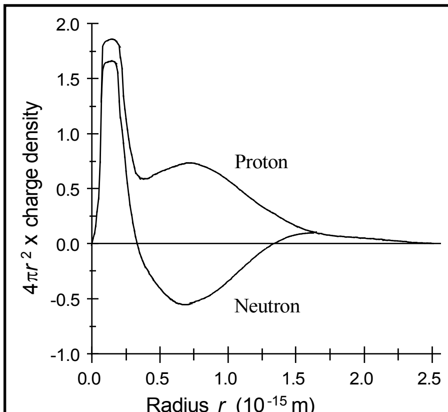


Figure 4.
Charge Distribution in Nucleons
(after Olson, ref. [**o**])

<u>Property #10–Size of an Electron in Aluminum</u>. Compton's scattering experiment on an electron in aluminum measured the electron radius and found a radius larger than the radius of a free electron [**j**]. As explained above, in the Helicon Model the electron fiber is extremely flexible, and its size can expand or contract depending upon the magnitude and vector orientation of electromagnetic fields from nearby particles. Compton's measurements clearly demonstrate that *the electron size is finite*—not point-like as in the quantum electron of the Standard Model.

<u>Property #11–Existence of the Proton</u>. Lord Rutherford's experiments led to an atomic model with protons in the middle of atoms. In 1911, Lord Rutherford proposed

> ...an atomic model whose essential features have stood the test of time: …the solar… model of the atom. The central element of this model is an atomic nucleus smaller than the atom itself, within which both the positive charge [protons] and virtually all the mass are concentrated [**3**].

Andrew Watson noted:

> When the proton was discovered by Ernest Rutherford in 1919, it was thought to be an indivisible basic building block of matter…. Early proton-proton collision experiments in the 1930s revealed that the proton was more than an infinitesimally small 'point-charge': it had a finite size and presumably some kind of structure [**n**].

Property #12–Shape of a Proton. The 'shape' of a proton describes its spatial distribution of electric charge. Scattering experiments provide data used to determine the shape of nucleons (protons and neutrons). Hofstadter's highly-acclaimed scattering experiments in the 1950s measured scattering angles of proton-electron collisions. Interpretations of this scattering data were made to suggest where charge is distributed in a particle of finite size. Figure 4 shows the proton charge distribution inferred from Hofstadter's data [**o, p**]. Extensive analysis and difficult calculations were performed to infer the distribution of electric charge and magnetic moment of the nucleons. Robert Hofstadter

> ... is best known for his work on determining the distribution of charge and magnetic moment in the nuclei of atoms and of the nucleons themselves, for which he was awarded a Nobel Prize in 1961 [**4**].

More recently, scattering experiments on nucleons have been performed by the Department of Energy's Thomas Jefferson National Accelerator Facility [**r, s**] providing more data that is still being analyzed. Analysts of experiment number E93-038 report that:

> E93-038 has been able to measure the neutron electric form factor more precisely than ever before and to infer the charge density with much better resolution.
>
> ...from the electric form factor, the density of the charge within the neutron was deduced.
>
> Jefferson Lab experiment E93-038 found that distributions of oppositely charged quarks [in neutrons] don't quite cancel each other out leaving a positively charged interior and negatively charged surface. These findings agree qualitatively with the theory of quark-quark interactions, but rigorous theoretical calculations of neutron (and proton) structure will be required [**5**].

It may be noted that these findings, as described, are fully consistent with the Helicon Model of the neutron [**6**].

<u>What is the Actual Distribution of Electric Charge</u>? Figure 4 represents some conclusions for the positive charge of protons somewhat concentrated at two positions around the particle's center. Some aspects of these conclusions are challenged here, especially the *spread* of the charge locations and even the existence of the charge shown at the larger radius. The proton secondary peak of charge density at 0.7×10^{-15} meters is explained as

the result of probing electrons that were *too big*:

> Later studies, made at 188 MeV on a target of hydrogen gas, gave a radius for the proton of about 7 x 10^{-14} cm. The structure seen in the distribution of scattered electrons results from the diffraction of the incident electron waves by the charge and magnetic moment of the nucleus. To reveal the nucleus in greater detail, shorter wavelengths were needed, which in turn required higher electron energies [**4**].

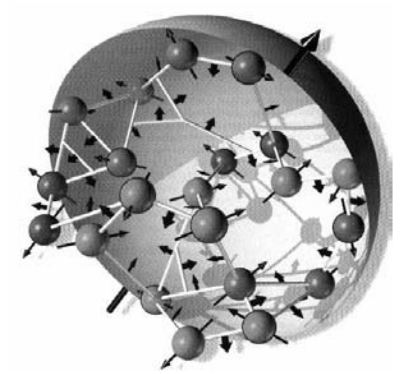


Figure 5.
Standard Model of Proton

Quantum Model of Proton showing Up Quarks, Down Quark, Strange Quarks, Anti-quarks, Gluons, and associated spin ½ or spin 1.

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The reader can observe for himself the large spread in the the proton secondary peak at 7 x 10^{-14} cm—a spread that can be caused by poor resolution of the measuring device (*i.e.*, the size of the probing electrons). The location of the peak and the spread of the resulting values reflect the large size of the electron, not the proton, since scattering depends upon the *combined size* and distribution of the two interacting charges. Subsequent experiments by Hofstadter and the new Jefferson Lab experiment used higher energy electrons to reduce the resolution problem. The secondary peak for the proton is an *artifact* of the experimental conditions, and the peak at this radius is not real. The secondary peak's existence at 7 x 10^{-14} cm is the result of the combined size of the target proton and the probing electron of energy 188 MeV whose radius at this energy is about 1 x 10^{-13} cm according the the Helicon Model [**7**].

The primary peak of proton charge density occurs at a radius of 0.2 x 10^{-15} meters (see Figure 4). The *reduced* spread of this peak, compared to the secondary peak, is consistent with the improved resolution that was obtained using higher energy achieved by the Stanford Mark III accelerator, reaching 1 GeV in 1960 [**4**]. Evidently, the *spread* of the proton primary peak is also an artifact of the the experimental apparatus. The true spread of the peak may well be less than shown in Figure 4. This analysis, supported by the analysis of electron spectra cited above, indicates that the proton peak must be small. Evidently, like the electron charge distribution, *the proton charge density is highly concentrated near a well-defined radius, i.e.,* ***a very thin ring.***

<u>Sphere or Ring Shaped</u>? Some reports refer to a nucleon *surface*, suggesting a sphere. However, the experimental apparatus appears to be constructed for measuring scattering of the probing electrons from a single direction, making it difficult to derive information on other spherical angles by controlling particle polarization. The data provide information on the density variation along the direction of motion of the probing electron, and *this information is fully consistent with the charge density of a ring-shaped object*.

<u>Property #13–Size of a Proton</u>. The radius of a free proton is known from measurements of the proton magnetic moment and the definition of magnetic moment—which is equal to the product of the proton current and the area enclosed by the current. From this formula, ***measurements of the proton magnetic moment indicate the proton radius is 2.10553 x 10^{-16} meters*** [**6, 8**]. The same result is obtained from the electron radius divided by 1836.15, the ratio of proton to electron rest-masses for free particles. The reader should note the excellent agreement of the Helicon Model with experimental results shown in Figure 4 for the proton.

In contrast, it is difficult to even imagine how the size and shape of the Standard Model of the Proton shown in Figure 5 could be measured experimentally. The proton model of Figure 5 predicts *spin* correctly but fails to predict many other properties measured for the proton.

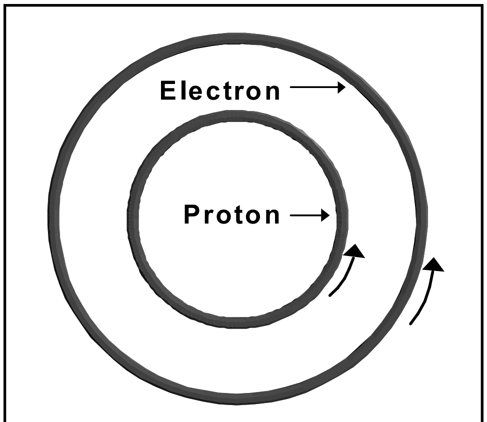

Figure 6. Helicon-Based Concept of a Neutron

The neutron is not an elementary particle but a paired electron and proton. This coaxial and coplaner configuration, with the same direction of particle rotation, stores the maximum excess energy called *beta decay energy*. Arrows show direction of moving charge. (Thicknesses of fibers are not to scale.)

Property #14–Existence of the Neutron. French described the discovery of the neutron:

> The idea that there might exist a neutral particle of almost the same mass as the proton was given public utterance by Rutherford and others in 1920. It was then regarded as a close combination of a proton and an electron—an idea that has been definitely abandoned [by the Standard Model, but not by Common Sense Science]. Such a particle, it was recognized, would be able to pass almost unimpeded through matter, being immune from the Coulomb forces that scatter and retard all other types of particles. The existence of the neutron was finally established by Chadwick (1932) from a study of the balance of energy and momentum when beryllium was boarded with alpha particles. It became clear that the bombardment resulted in the emission of a neutral particle with a mass closely equal to that of the proton.... More refined measurements showed that the neutron is slightly heavier—by about 0.1%—than the proton [**g**].

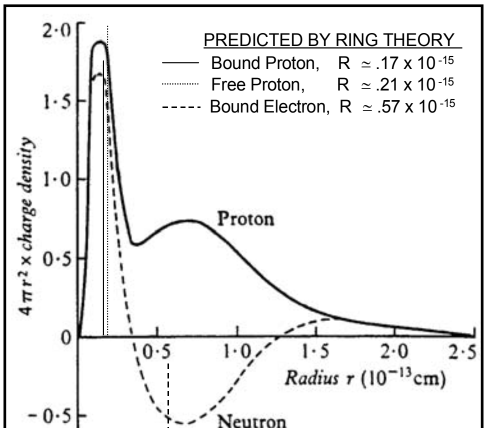

Figure 7.
Charge Distribution in Nucleons

Locations of the proton and electron in the helicon-based Nucleon Model agree with the scattering measurements of Hofstadter [**o**] as reported by Burcham [**p**].

Property #15–Components of a Neutron. Experiments on neutrons reveal that neutrons have a negative magnetic moment [a topic in a later part of this report]. The negative sign indicates that the vector of magnetic moment is in a direction opposite to the vector of angular momentum, strongly hinting that a negatively charged circuit (perhaps an electron) predominates to produce a net magnetic moment that is negative. The measured moment of the neutron, being negative, indicates that a negative charge circulates over a larger area than the positive charge—which was also revealed by Hofstadter's scattering experiments (see Figure 4). These characteristics are consistent with the Helicon Model, but they are unexplained by the Standard Model.

<u>Zero Net Charge of Neutrons</u>. The net electrostatic charge of a neutron is *zero* so that a moving neutron has very great penetrating power in materials consisting of charged particles, *e.g.*, penetration through several inches of lead [**9**]. Since a magnetic moment depends upon moving charge, *zero net charge* implies that ***positive and negative charges are paired***. This explanation is more consistent with other measured neutron properties than is a model based upon postulated existence of some neutral material or substance.

<u>Robson's Experiment with Free Neutrons</u>. *Empirical evidence shows that any neutron escaping the atomic nucleus will produce an electron and proton that appear simultaneously* [**t**]. Since the electron and proton have equal but opposite charge, a neutron consisting of one electron and one proton would have zero net charge. One can no longer escape the conclusion that *the components of a neutron are one electron and one proton*. Any other conclusion is based upon speculation about powers of elementary particles to change their identity.

<u>**Property #16–Shape of a Neutron**</u>**.** The shape of a neutron must be the composite shape of its components in some relational and angular relationship. Figure 6 illustrates the helicon-based concept and geometry of the neutron. The energy limitation of the probing electrons (due to the accelerator) could have caused the apparent spreads in the neutron's charge-density peaks, as explained above for proton measurements. But energetic helicons subject to the laws of electricity and magnetism *will not spread*, but maintain their shape [**10**]. Again, we conclude that *both positive and negative charge densities in the neutron have a sharply defined distance associated with a very thin ring*.

<u>**Property #17–Size of Positive Charge in a Neutron**</u>**.** The proton radius shown in Table 2a was derived from size-adjustments of the neutron component particles as they are brought together in a coplanar and coaxial configuration. The derivation accounted for each particle's magnetic moment, self-energies, the beta-decay energy, mutual energy of coupling, and the adjustment of particle currents and sizes. The result is the correct prediction of the neutron mass—which is greater than the sum of component masses, and includes electromagnetic mass of mutual coupling of the two particles. The derivation and results are reported in reference [**6**]. The radius of positive charge in the neutron is predicted by this double helicon model to be 1.7×10^{-16} meter. This result agrees with the measurements of Hofstadter's scattering experiment (see Figure 7).

<u>**Property #18–Size of Negative Charge in a Neutron**</u>**.** Like the proton alteration described above, the *electron* radius shown in Table 2a was derived from size-adjustments of the neutron component particles as they are brought together in a coplanar and coaxial configuration. The derivation accounted for each particle's magnetic moment, self-ener-

gies, the beta-decay energy, mutual energy of coupling, and the adjustment of particle currents [**6**]. The radius of negative charge in the neutron is predicted by the double helicon model to be 5.7 x 10^{-16} meter. This result agrees with the measurements of Hofstadter's scattering experiment (see Figure 7).

Conclusion. The Helicon Model of Elementary Particles accurately describes and predicts the measured data regarding the existence, shape and size of electrons, protons and neutrons.

Acknowledgments. A. L. Parson was the first to publish a Ring Model [**h**]. Winston Bostick proposed that the electron fiber took the path of a toroidal helix [**k**]. Glen C. Collins developed the definition and terminology of a helicon. Eric Baxter derived the parametric equations that specify the surface of helicons, and Mark Evans provided source code for creating computer-generated images of helicons (*e.g.,* Figures 1-3).

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