The Electric Charge and Magnetization Distribution of the Nucleon: A Turing Wave Pattern?

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Abstract

Recent fits to nucleon form factor data show that the nucleon core has a Gaussian charge density distribution and peripheral periodicity of declining amplitude whose wavelength approximates the particle's Compton wavelength. This periodic feature was not anticipated by quark models, but its characteristics do match those of a three-dimensional Turing wave pattern produced in certain nonlinear reaction-diffusion systems. Almost three decades prior to these observational findings, the novel physics methodology of subquantum kinetics had predicted this type of electric field distribution for the nucleon, theorizing that subatomic particles may be Turing patterns or dissipative structures that emerge from an underlying reaction-diffusion matrix. This model, which is now confirmed by particle scattering data, provides new insights into the origin of charge, spin, nuclear binding, particle diffraction and electron orbital quantization.

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1. Introduction

According to classical field theory, the electric and gravitational field of a subatomic particle arises from a point source at the particle's center, the field potential ideally rising to an infinite value as this center is approached. Even in the modern era of physics and astrophysics, the assumption that a gravitational field singularity exists at the center of a particle is a fundamental prerequisite to allow the formation of a black hole singularity. Einstein, however, was against the idea of point field sources, believing that the idea of a continuous field continuum coexisting with mass or charge points led to a fundamental inconsistency of physical field theory as a whole.(1) He envisioned particles as "bunched fields," regions in which the field density was particularly high.

At least in the case of electric charge and spin, particle scattering experiments have shown the bunched field idea to be a more correct view. Measurements of the resulting particle scattering angles and the transferred momenta Q yield a function $F(Q^2)$, called the form factor, which is the Fourier transform of the charge distribution of the target nucleon. Model fits to the form factor data indicate that charge density is spatially distributed and that it reaches a finite value at the particle's center. Initially, particle scattering experiments analyzed momentum transfers at relatively low particle momenta, e.g., $Q^2 < 1$ $(\text{Gev/c})^2$. At these low energies, relativistic Lorentz contraction effects of the probe particle along the direction of particle momentum transfer could be neglected without posing a problem. Consequently, early model fits were able to make reasonably good fits to form factor data by predicting a simple exponential decline of charge density with increasing radius, $\rho \sim e^{-\alpha r}$. Examples include Galster's model published in 1971, Platchkov's 1990 representation of the 1980 Paris potential model, and Schmieden's 1999 fit to the Mainz Microtron data.(2 - 4) All predicted that charge density should form a sharp central cusp, rising to a finite central value; see figure 1.(5)

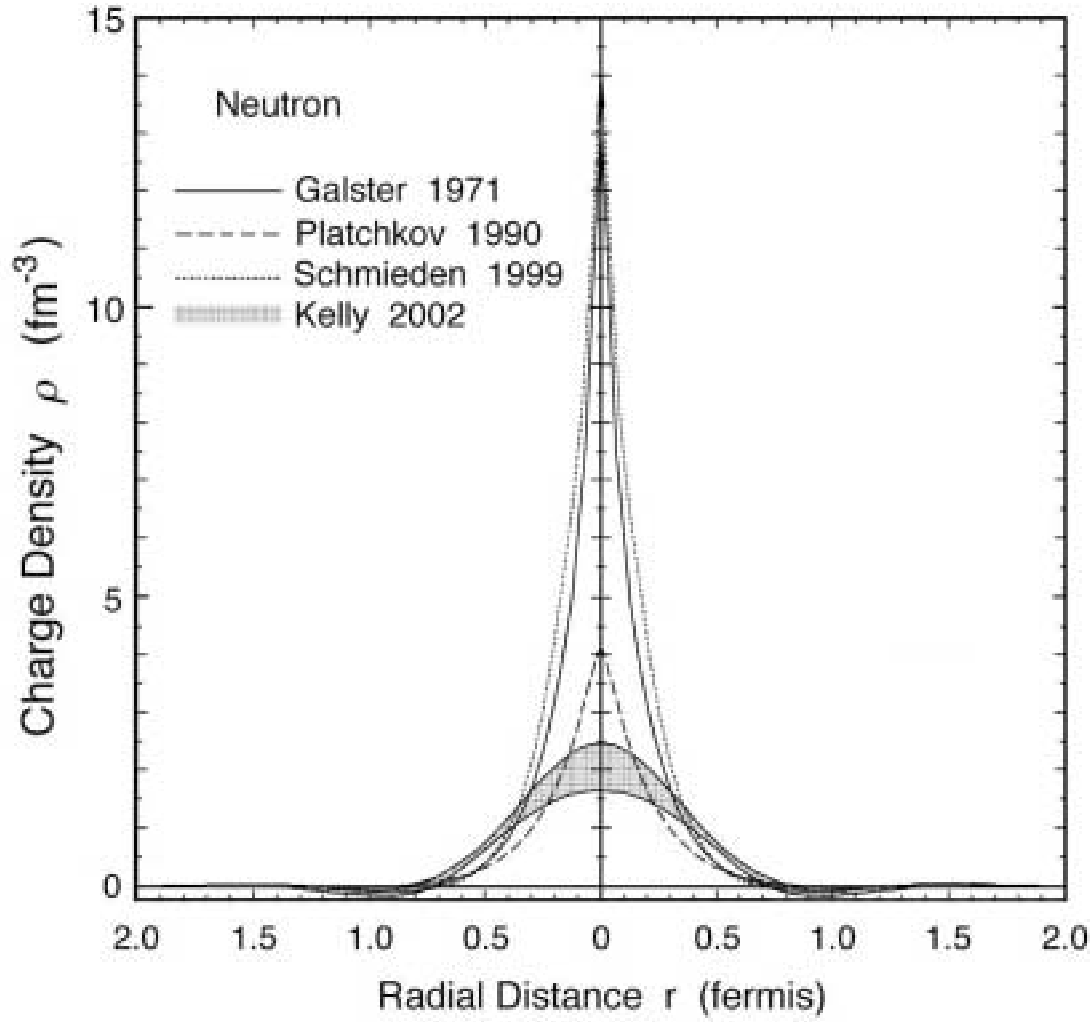

Figure 1. The relativistic neutron charge density model of J. Kelly made to fit Jefferson Lab data (shaded profile) compared to three nonrelativistic exponential model fits to earlier data sets (after Kelly, 2002, Fig. 12).

As early as 1938, Gregory Breit had proposed that the charge distribution of a nucleon rounds off at its center somewhat like a Gaussian curve.(6) Licht and Pagnamenta came to a similar conclusion in 1970. They noted that by taking relativistic effects into consideration, this central cusp would become smoothed into a Gaussian shape, although they did not explicitly graph this spatial variation. They noted that such a charge distribution would be consistent with expectation if the nucleon was theorized to consist of a cluster of quarks trapped in a potential well.(7) More recently, in 1995, Christov et al. used a chiral quark soliton model to predict the charge density distribution for the proton and neutron.(8) Their model also produced a Gaussian-like core which, when plotted in terms of surface charge density, yields the profiles shown in figure 2. While this model did predict a reasonably good fit to proton form factor data, it made a poor fit to form factor data for the neutron.

As particle scattering experiments began studying collisions at higher particle collision momenta ($Q^2 > 1$), it became necessary to use polarized particle beams and increasingly

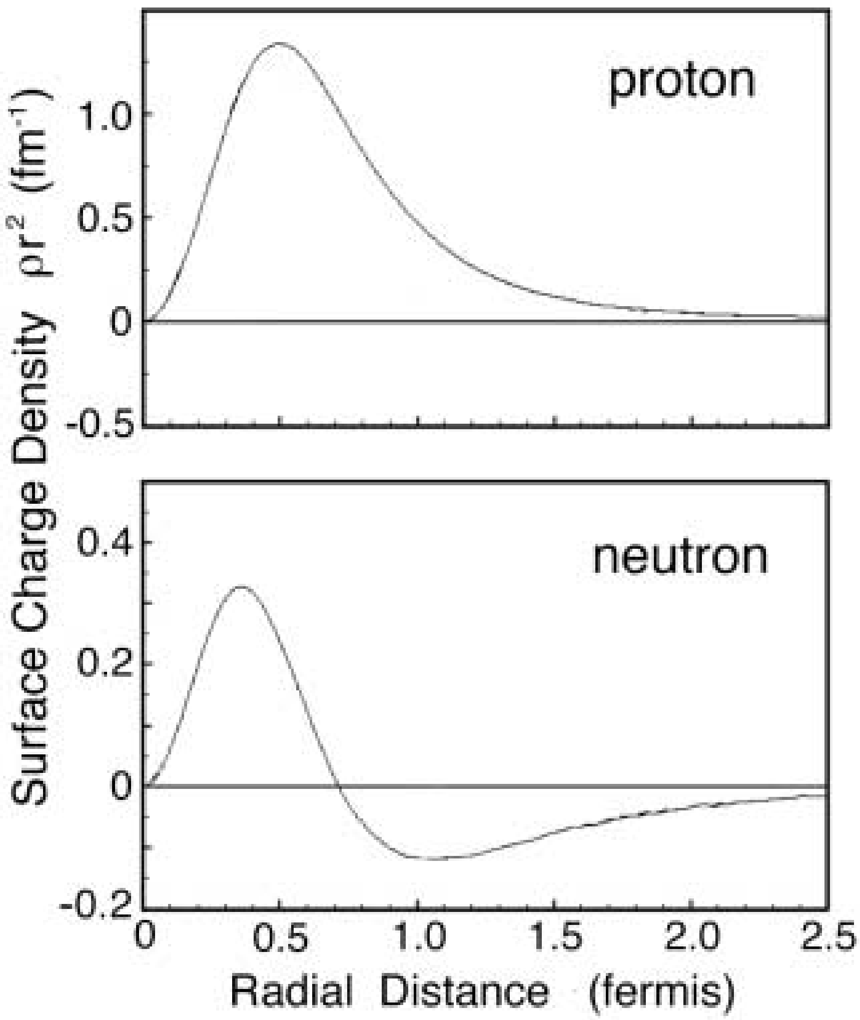

Figure 2. Surface charge density profiles for the proton and neutron predicted by the chiral soliton quark model.

important to take account of relativistic effects. These more recent experiments made it possible to more accurately assess the spatial variation of the nucleon's charge and magnetization density, and to distinguish amongst the various competing models. Kelly's study published in 2002, for example, cast doubt on the cusp models and instead pointed to a Gaussian charge density distribution modulated with a radial stationary wave pattern.(5) He used a method developed by Mitra and Kumari to perform a relativistic inversion of Sachs form factor data from recent scattering experiments that employed the recoil-polarization technique.(9 -11) In this way he was able to extract charge and magnetization densities for the neutron and proton. He obtained a good data fit by representing the radial variation of charge and magnetization density with a Laguerre-Gaussian expansion and obtained similar results with a Fourier-Bessel expansion. His charge density profiles for the proton and neutron are also shown in figures 3-a and 4-a. He found that his relativistic model made a better fit to data than the nonrelativistic models of Platchkov and Schmieden, although Galster's model fortuitously also made a good fit to the data. Figure 1 compares his charge density profile for the neutron to the nonrelativistic models of Galster,

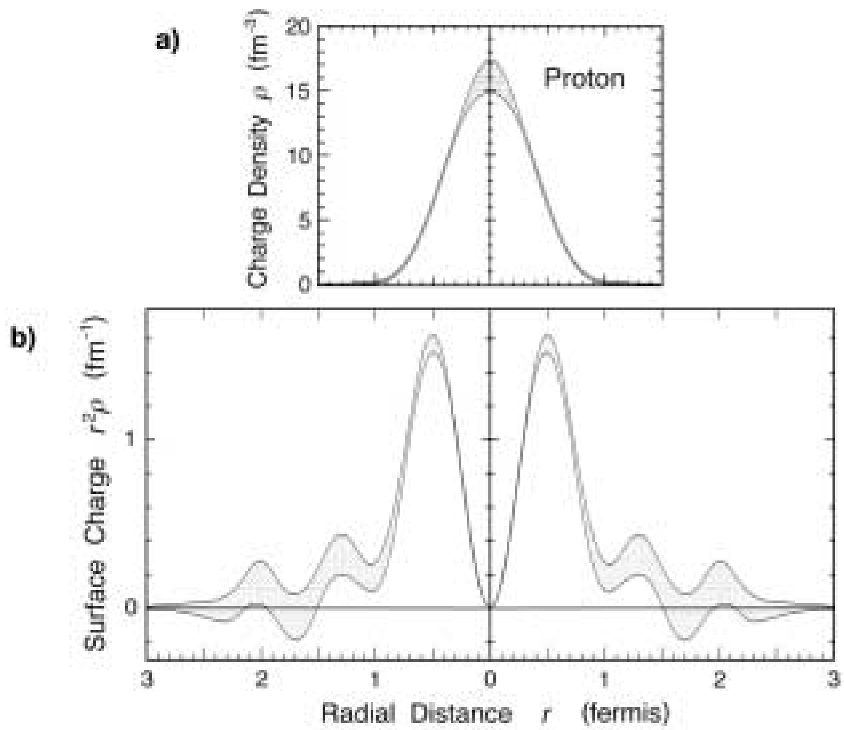

Figure 3. a) Charge density profile for the proton predicted by Kelly's preferred Laguerre-Gaussian expansion models and b) the corresponding surface charge profile (after Kelly, 2002, Fig. 5 - 7, 18).

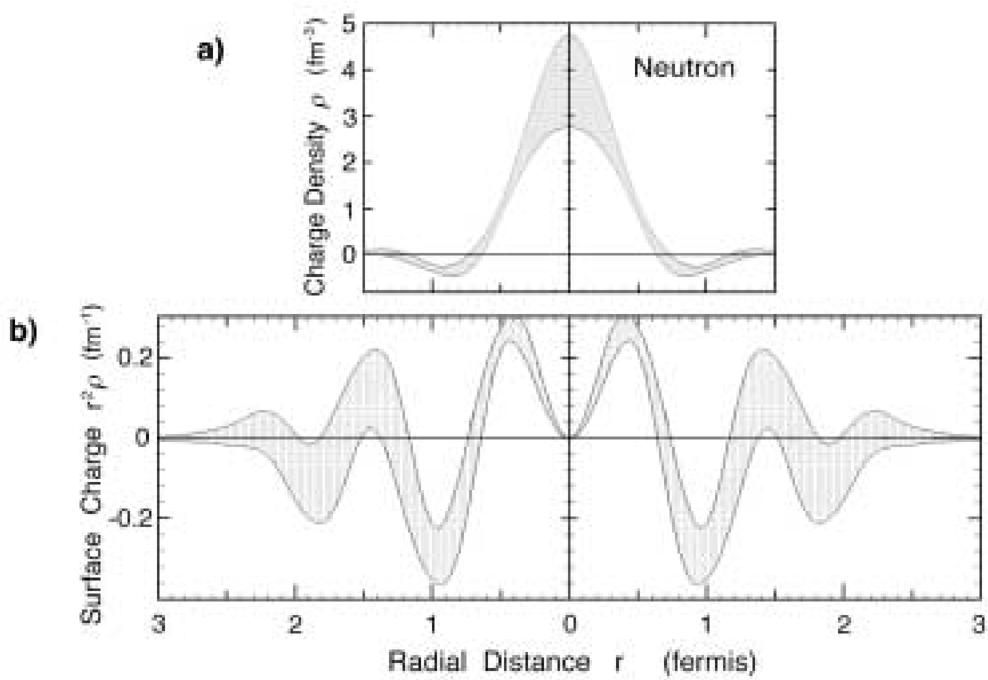

Figure 4. a) Charge density profile for the neutron predicted by Kelly's preferred Laguerre-Gaussian expansion models and b) the corresponding surface charge profile (after Kelly, 2002, Fig. 5 - 7, 18).

Platchkov, and Schmieden.

Other features that become apparent in Kelly's Laguerre-Gaussian expansion fit are the periodic charge density pattern that surrounds the nucleon's central Gaussian core, this being more apparent when surface charge density ($r^2\rho$) is plotted as a function of radial distance; see figures 3-b and 4-b. This integrates the amount of charge contained within an incremental spherical shell located a distance r from the particle's center and has the effect of enhancing the magnitude of the charge density ordinate values at large radii along with their associated periodicities. This peripheral periodic feature was not anticipated by earlier quark models, e.g., compare figures 3b and 4b with figure 2.

2. Early Prediction of the Nucleon Charge Density Profile.

Almost 30 years before Kelly had published his 2002 paper, a novel physics methodology called subquantum kinetics had correctly anticipated the electric field distribution within the neutron and proton. Figure 5 shows the electric potential distribution predicted for a proton and antiproton, as depicted in the theory's 1985 journal publication, which was further elaborated in its 1994 book publication.(12, 13) Comparing to figures 3 and 4, we see that as in Kelly's fit to form factor data, the proton's peripheral periodicity is depicted as being surrounded by a periodic field pattern whose amplitude declines with increasing radius.

Furthermore as in Kelly's charge density models, subquantum kinetics predicts that the proton and neutron would both have a positive core potential. In addition, as in Kelly's model, the proton's electric potential wave pattern is depicted as being positively biased compared to that of the neutron, and increasingly so as the center of the particle is approached. The degree of positive biasing for the proton's field pattern, or negative biasing for the antiproton, is indicated by the hatched region shown in figure 5. Subquantum kinetics identifies this biasing with the origin of the particle's long-range electric field. The neutron was predicted to have an unbiased electric field potential distribution. Its electric potential profile is evident in Figure 6.(14, 15)

Earlier unpublished papers on subquantum kinetics written between 1973 and 1980 had also anticipated many of the features reported by Kelly, depicting a Gaussian electric potential core surrounded by a periodic field pattern whose amplitude declines with increasing radius.(16, 17) However, the theory, being in an earlier stage of development, had at that time not investigated the formation of a particle's long-range electrostatic field and hence the generalized wave pattern for a particle was then depicted unbiased, similar to that of a neutron.

The subquantum kinetics prediction about the subatomic particle field was advanced at a time when fits to nucleon form factor data were instead modeling the nucleon's electric field as having an aperiodic cusp shape. Although Licht and Pagnamenta had earlier proposed that a nucleon with a Gaussian central charge distribution would make a good fit to form factor data, their quark cluster model, like the chiral quark soliton model fit later published by Christov et al., did not anticipate that the nucleon's charge or magnetization distribution should have a surrounding periodic component. Kelly with his relativistic Laguerre-Gaussian expansion fit to form factor data was the first to show in 2002 that charge and magnetization distributions for the nucleon were best characterized by a peripheral periodicity. Kelly has pointed out that unless this surrounding periodicity is included, his nucleon charge and magnetization density models will not make as good a fit to form factor data, in particular, data that has been derived when nucleons are probed with high energy electrons.(5) His findings lead us to conclude that the subquantum kinetics model offers a more detailed and accurate representation of the nucleon field than the aperiodic predictions of Licht and Pagnamenta and Christov et al.

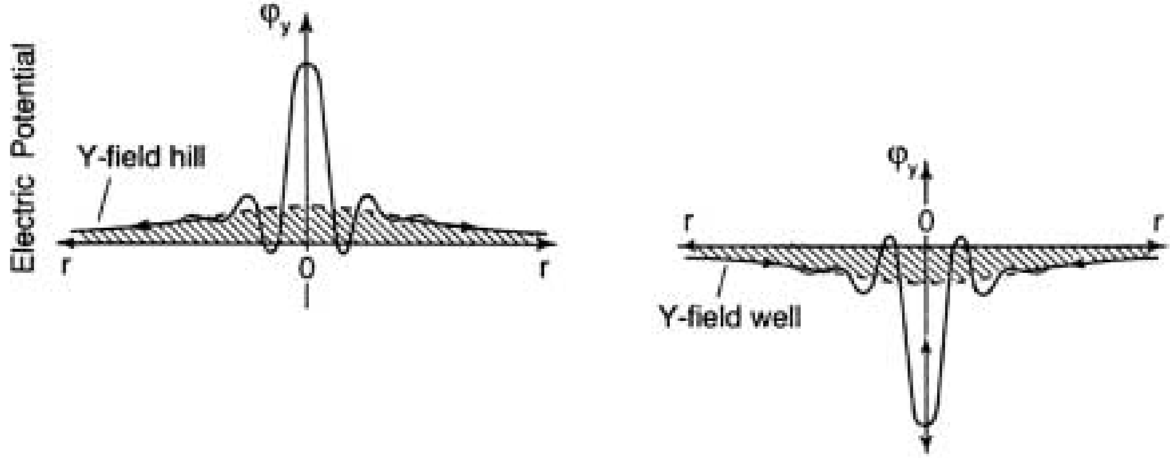

Figure 5. Radial electrostatic potential profiles for a charged subatomic particle, positive matter state (left) and negative antimatter state (right). The characteristic wavelength would equal the particle's Compton wavelength.

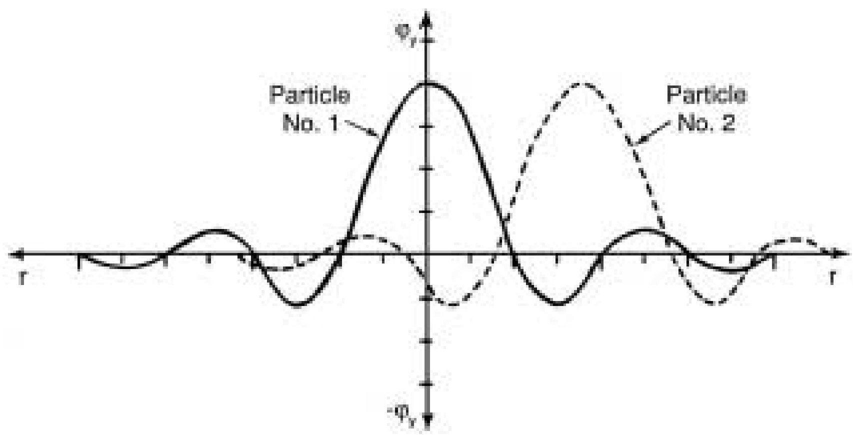

Figure 6. Illustration of the electric field profile of a neutron (Particle No. 1). In close proximity, two such nucleon electric fields could interlock to form a nuclear bond, producing an unstable di-neutron nucleus, in the case of neutron-neutron binding, or a stable deuteron nucleus in the case of proton-neutron binding.

Subquantum kinetics chooses the wavelength of the nucleon's periodic field to be equal to the particle's Compton wavelength, λ_0 = 1.32 fermis (1.32×10^{-13} cm), that is:

$$\lambda_0 = \hbar c/E_o = \hbar/m_o c, \qquad (1)$$

where m_o is the nucleon's rest mass. Kelly models the nucleon to have a somewhat shorter wavelength of ~0.5 λ_0 - 0.7 λ_0 (~0.7 fermis for the proton and ~0.9 fermis for the neutron). However, the form factor data that he used to fit his models was obtained by bombarding nucleons with relativistic electrons having Lorentz factors approximating the nucleon rest mass energy. So at the moment of collision the nucleon's potential energy would momentarily double causing the form factor data to predict a particle wavelength half as long as would be expected on the basis of the nucleon's rest mass. So Kelly's nucleon models do not portray the particle's inherent wavelength, but one that arises as a result of the act of measurement.

For the purpose of energy conservation, subquantum kinetics requires that the wavelength of the subatomic particle's electrostatic potential profile be chosen to equal λ_0, the wavelength of its gamma ray precursor, e.g., a photon energy of $2hc/\lambda_0$ being transformed into the particle and antiparticle matter state in the course of pair production. In this way, the creation of a subatomic particle from a precursor photon is essentially a change of propagation geometry, an initially linear wave propagation mode (photon) changing into a radial wave propagation mode (particle) as the particle's newly created electric potential field expands radially outward from its core. Collision with a heavy nucleus provides the needed boundary condition to absorb the photon's forward momentum and effect the resulting change of wave geometry.

The wave pattern that results is not a standing wave pattern produced by the linear superposition of two oppositely propagating waves, nor is it a linear wave packet of the sort envisioned in wave mechanics. It is a time independent electric potential wave pattern that emerges as a stable solution of nonlinear reaction-diffusion processes which are basic to the subquantum kinetics approach. A subatomic particle may be said to have simultaneously both wave and particle characteristics since its field pattern is characterized as having both a well-defined core and a surrounding periodicity. Hence there is no need to speak of a wave-particle dualism. By realizing that the central field of a subatomic particle is characterized by such a periodicity, it becomes possible to easily explain particle diffraction effects; see section 4.

How do Kelly's findings fair in the context of the quark model? To represent the nucleon's wave-like electric charge distribution one would have to postulate a corresponding wave-like patterning in the probability distribution of up and down quarks. Thus in the proton two up quarks with an electric charge of +2/3 would be theorized to occupy predominantly the Gaussian core region and one down quark with a charge of -1/3 to occupy predominantly the surrounding negative well to give a net charge of +1. In the neutron a single up quark would be theorized to occupy predominantly the central Gaussian core and two down quarks to occupy mainly the surrounding well, thereby giving a net charge of zero. However, the quark model did not itself anticipate the wave-like character of the nucleon's charge and magnetization distribution. These findings have been imposed a posteriori as requirements that the quark model must satisfy in order to be realistic. But even then, one has difficulty imagining what would cause three quarks to move about in such a fashion to generate the observed spherically symmetric wave patterns. Quarks themselves, or the "gluons" theorized to bind them together, have no script to tell them they should behave in this manner. Such subatomic particle periodicities, however, do emerge as a natural consequence of the subquantum kinetics approach.

3. The Subquantum Kinetics Approach

Considering that subquantum kinetics has accurately anticipated many key aspects of the nucleon's charge distribution decades before they were revealed in particle scattering experiments, what is it that subquantum kinetics postulates that allows it to generate these special wave patterns? As in the quark theory, subquantum kinetics attempts to explain subatomic particles by postulating the existence of subquantum constituents. Whereas the quark theory postulates the need of just three quarks to explain the formation of a nucleon, subquantum kinetics proposes the existence of a very large number of subquantum units, called etherons, forming a reacting medium. The term etherons is used here to be consistent with the subquantum kinetics terminology, but other terms could be employed such as "dark energy units." Whereas quarks are theorized to be spatially mobile, the etherons of subquantum kinetics are postulated to both diffuse through space and to react with one another in a specified manner.[18, 19] Thus subquantum kinetics envisions subatomic particles to be steady-state reaction-diffusion concentration waves that emerge from a pre-existing sea of reacting and diffusing etherons.

Subquantum kinetics was inspired from work on open chemical reaction systems such as the Brusselator investigated by Prigogine, Nicolis, Lefever, and others, as well as work done on chemical wave phenomena observed in the Belousov-Zhabotinskii reaction; see figures 7 and 8.[20 - 24] Under the right conditions, the concentrations of the variable reactants of these reaction systems spontaneously self-organize into stationary reaction-diffusion wave patterns called *dissipative structures*. They are termed "dissipative" because the initial growth and subsequent maintenance of these patterns is due to the activity of the underlying energy-dissipating reaction

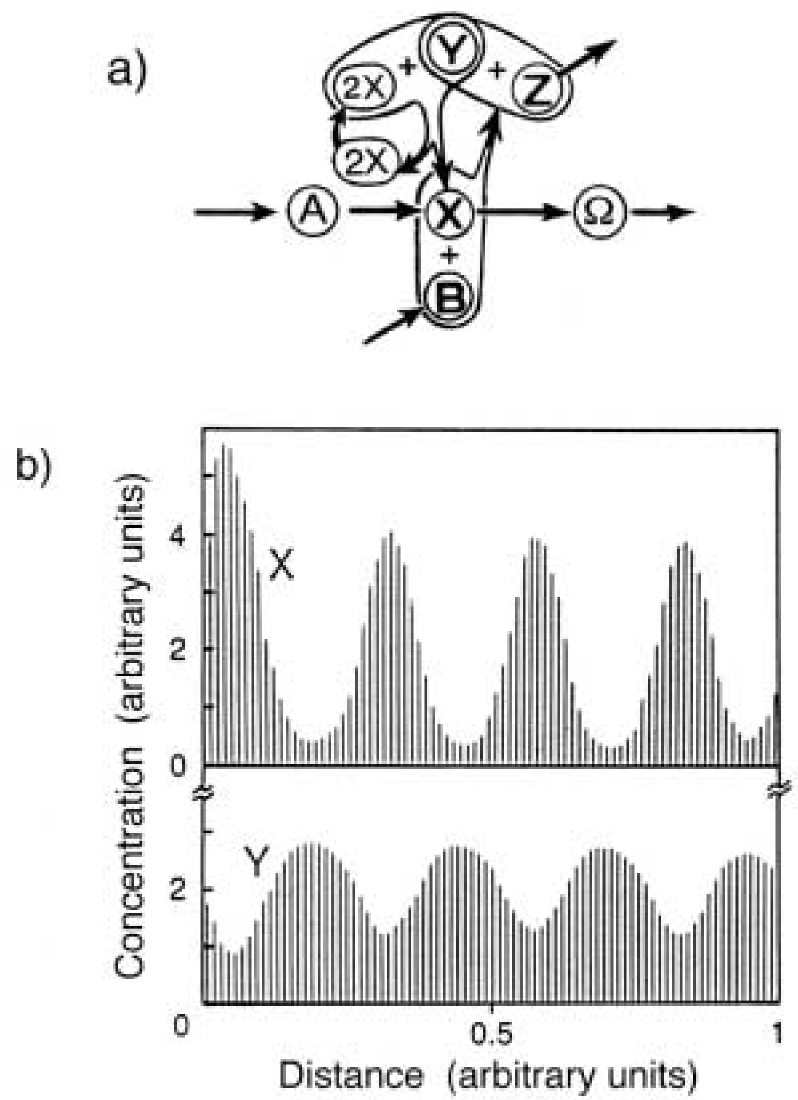

Figure 7. a) The Brusselator reaction system. b) One-dimensional computer simulation of the concentrations of the Brusselator's X and Y variables (after Lefever, 1967).

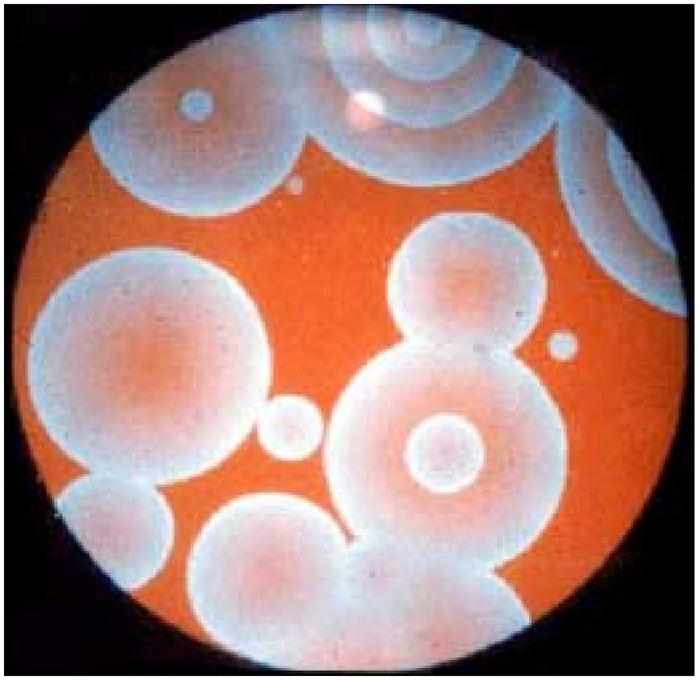

Figure 8. Chemical waves formed by the Belousov-Zhabotinskii reaction (photo courtesy of A. Winfree).

processes. Alternatively, they are referred to as *Turing patterns*, in recognition of Turing who first predicted their existence in 1952.[25]

The Brusselator, for example, is defined by the following four kinetic equations:

$$\begin{aligned} A &\xrightarrow{k_1} X, && \text{a)} \\ B + X &\xrightarrow{k_2} Y + Z, && \text{b)} \\ 2X + Y &\xrightarrow{k_3} 3X, && \text{c)} \\ X &\xrightarrow{k_4} \Omega. && \text{d)} \end{aligned} \qquad (2)$$

which specify the reactions of six species, of which two, X and Y, are allowed to vary in space and time, A, B, Z and Ω being held constant. The letters specify concentrations of the species and k_i represent the kinetic constants of the reactions. This system defines two global reaction pathways which cross-couple to produce an X-Y reaction loop; see figure 7-a. One of the cross-coupling reactions, (2-c), is autocatalytic and prone to produce a nonlinear increase of X, which is kept in check by its complementary coupling reaction (2-b). Computer simulations of this system have shown that when the reaction system is supercritical, an initially homogeneous distribution of X and Y can self-organize into a wave pattern of well-defined wavelength in which X and Y vary reciprocally with respect to one another. The concentration pattern produced by the computer simulation of the Brusselator in a one-dimensional reaction volume is shown in figure 7-b. Although three-dimensional computer simulations have not yet been carried out, they would show that under supercritical conditions the Brusselator would give rise to a particle-like structure having a Gaussian central core surrounded by a pattern of concentric spherical shells of declining amplitude.

Subquantum kinetics postulates that similar reaction-diffusion processes take place among subquantum units termed etherons which form a space filling medium and that variations in the

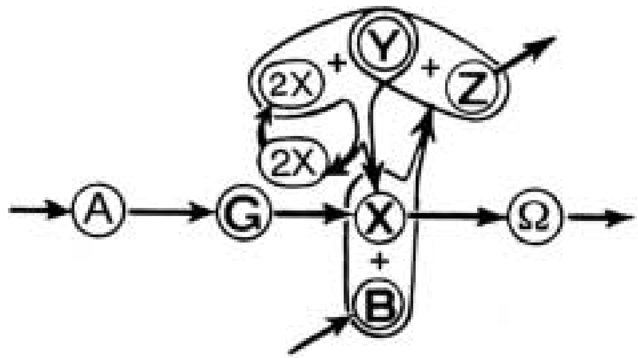

Figure 9. The Model G ether reaction system investigated by subquantum kinetics.

concentrations of these etheric substrates form observable electric and gravitational potential fields which, in turn, form material particles and energy waves. It postulates a nonlinear reaction system similar to the Brusselator called Model G:

$$
\begin{aligned}
A &\xrightarrow{k_1} G, && \text{a)} \\
G &\xrightarrow{k_2} X, && \text{b)} \\
B + X &\xrightarrow{k_3} Y + Z, && \text{c)} \qquad (3) \\
2X + Y &\xrightarrow{k_4} 3X, && \text{d)} \\
X &\xrightarrow{k_5} \Omega, && \text{e)}
\end{aligned}
$$

Steps (a) and (b) in reaction system (3) above substitute for step (a) in reaction system (2). The Model G reaction system is diagrammed in figure 9. Based on reaction system (3), we may write the following set of partial differential equations to depict how reaction intermediate variables G, X and Y vary as a function of space and time:

$$
\left.
\begin{aligned}
\frac{\partial G}{\partial t} &= k_1 A - k_2 G + \mathcal{D}_g \frac{\partial^2 G}{\partial r^2} \\
\frac{\partial X}{\partial t} &= k_2 G + k_4 X^2 Y - k_3 B X - k_5 X + \mathcal{D}_x \frac{\partial^2 X}{\partial r^2} \\
\frac{\partial Y}{\partial t} &= k_3 B X - k_4 X^2 Y + \mathcal{D}_y \frac{\partial^2 Y}{\partial r^2}
\end{aligned}
\right\} \qquad (4)
$$

The $\mathcal{D}_i$ values represent the diffusion coefficients of the respective variables.

Spatial variations in G concentration are postulated to represent a gravitational potential field. Mutually correlated spatial variations in X and Y concentration are postulated to represent an electric potential field. A subatomic particle results when reactants X and Y become organized to form a time-independent, reaction-diffusion wave pattern, whose radial cross section is depicted in figures 5 and 6. No ad hoc assumptions need be introduced to produce these dissipative structures; they follow naturally from the interplay of the reactions specified above in reaction system (3). Subquantum kinetics has predicted that all subatomic particles, electrons and positrons included, should have a Gaussian electric potential core and surrounding periodic electric field. The recent finding that this type of spatial pattern makes a good fit to nucleon charge form factor data is evidence that the electric field pattern of a nucleon may be a Turing wave pattern, one that is generated from reaction and diffusion processes continually taking place among the constituents of a space-filling subquantum medium. Unlike the linear wave packets of quantum mechanics, these subatomic dissipative structures would not spread out over time. Just as fast as X and Y etherons diffuse out from their respective shells, the nonlinear reactions (3) rebuild the structure's form; entropy is kept at bay in this periodic steady state.

Subquantum kinetics differs from the quark theory in several respects, one being in the manner in which it handles the origin of charge and spin. The quark theory does not attempt to explain how electric charge or spin arise. It merely assumes them to be physical attributes present in quarks in fractional form and which in triplicate summation appear as corresponding properties detectable in the nucleon. The practice of ascribing charge and spin to quarks has met with some objection in the past in that no fractional charge unit (±1/3 or ±2/3) characterizing an unbound quark has ever been experimentally observed. Also quark theory predicts that spin-aligned protons should interact 25% more frequently than spin-unaligned protons, but particle scattering experiments find that the discrepancy is 20 fold greater, the former being found to interact five times more frequently.[26] A spin magnetization that is a property of the particle as a whole and not present in any hypothesized subquantum constituents would be more consistent with these experimental results.

In subquantum kinetics, the postulated reactants have no charge or spin. These are properties associated only with subatomic particles and emerge only at the time when the particle is created. Mathematical analysis of the Brusselator, which is applicable to Model G, indicates that electrical charge appears in the particle abruptly as a secondary bifurcation of the primary bifurcating branch that allows the formation of the particle. Here we use terms that are commonly employed in describing the behavior of nonequilibrium chemical reaction systems, but apply the terms to subatomic particle formation. In other words, let us assume that the X and Y reactants are initially uniformly distributed in a field-free vacuum state and that the ether reaction system operates sufficiently far from equilibrium that its bifurcation parameter β surpasses critical thresholds β_o and β'; see figure 10. The uniform state will be unstable so that an emerging zero-point energy fluctuation (X-Y fluctuation) will tend to grow in size and spontaneously break the prevailing symmetry, moving the reaction system to a new steady state in which its X and Y reactants are inhomogeneously distributed as a reaction-diffusion wave pattern. This periodic steady state electric field pattern would constitute a material particle. In the case where a proton is formed, the particle's wave pattern will be characterized by a maximally high-Y concentration and maximally low-X concentration at its core, extending outward as a periodic field of wavelength λ_o alternating in X/Y polarity and declining in amplitude with increasing radial distance. The proton appears as the lower branch of the bifurcation diagram because here we are plotting the magnitude of the X reactant which is negatively correlated with electric potential.

At this intermediary stage, the particle's field pattern will be unbiased; no charge will be present. But, as the core wave pattern grows in amplitude, threshold β' will be surpassed and this primary branch will itself bifurcate dictating a rapid transition to a new stable state where the proton's electric potential field pattern is positively biased (or negatively biased in the case of an antiproton). In its charged state, the proton's mean Y concentration will be increased and mean X concentration decreased from their pre bifurcation values, this bias being indicated in figure 6 by the hatched region. This biasing arises because in the particle's core Y is being produced in an excess amount and X is being consumed in an excess amount. In fact, subquantum kinetics

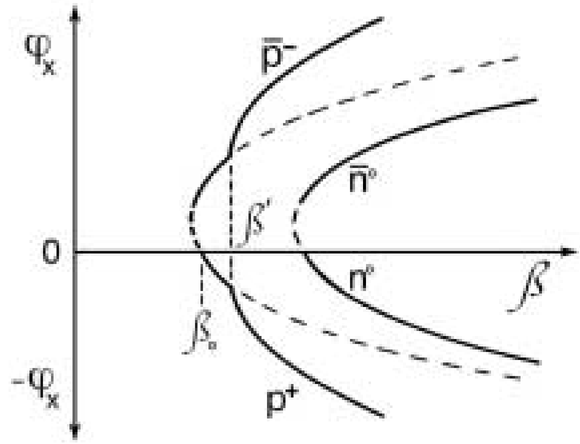

Figure 10. A hypothetical bifurcation diagram for nuclear particles. Beyond the primary bifurcation threshold $ß_o$, a fluctuation emerging from the uniform steady state leads to the creation of a subatomic particle, and beyond the secondary bifurcation threshold $ß'$ leads to the emergence of its electrostatic charge.

identifies these excess productions and consumptions with the particle's charge, for they are ultimately responsible for the biasing of the particle's electric field pattern. Thus charge follows as a direct consequence of the behavior of equation system 2; there is no need to introduce additional ad hoc assumptions. In the Brusselator, where a similar wave pattern biasing phenomenon results in these excess productions and consumptions, mathematical treatments refer to X and Y as being "nonconserved" in the transition to the biased periodic steady state.(27)

This biased X-Y electric potential field declines in magnitude inversely with increasing radial distance to form the charged particle's long-range electric potential field. The subquantum kinetics approach reproduces all the classical laws of electrostatics and gravitation; see references 17 and 18. It gives an explicit description of what charge is and how it comes into being within the subatomic particle, something that the quark theory does not attempt to do.

The neutron's existence as an uncharged particle may be explained if there is no accessible secondary bifurcation of its primary branch solution. The neutron would form, but would remain uncharged. Its electric potential Turing pattern would remain unbiased, as is observed. It is significant that model fits to neutron form factor data show that the neutron's core charge density is about one fifth of that of the proton. This is completely consistent with the bifurcation analysis shown in figure 10. Namely, since a particle's charge emerges when its X-Y electric field amplitude has departed further from its uniform steady state value and has passed the secondary bifurcation point, the resulting dissipative structure will necessarily have a larger core field amplitude than a neutral particle which is stable at a point below such a secondary bifurcation point. As an alternative to the bifurcation diagram mapped out in figure 10, one might imagine that only the neutron is directly accessible from the vacuum state (uniform steady state) and that the proton state is spontaneously accessible only as a secondary bifurcation of the neutron's primary branch. The energy difference of this neutron-to-proton transition would emerge as a high energy electron. Hence neutron beta decay could be a secondary bifurcation transition.

In discussing the charge distribution found for the neutron, some have commented that the neutron's core is positively charged and is surrounded by a negatively charged shell and that these neutralize one another to yield a net zero charge for the neutron. But this explanation misses the point. Regardless of whether one deals with a proton or neutron, the nucleon's electric potential distribution is periodic in either case — a positive core being surrounded by a potential well, which in turn is surrounded by a potential hill, then by a potential well, and so on. The reason that the proton projects a long-range positive electric field and the neutron has no electric field is that the proton's periodic field is biased positively, whereas the neutron's is not, leaving its potential wells to remain in a negative balance to its potential hills.

The terms positive and negative charge may also be used to describe the X and Y concentration maxima and minima that form the neutron's electric field Turing pattern. For example, the excess production of Y per unit volume and excess consumption of X per unit volume in the neutron's core could be identified as the positive charge density that forms its corresponding high-Y/low-X concentration (positive electric potential). Similarly, the excess consumptions and productions in the adjacent spherical shell could be identified as the negative charge density that forms the concentration pattern producing this adjacent electric potential well. However, it should be kept in mind that the charge density that produces the proton's long-range electric field is distinct from and additional to the positive and negative charge densities that produce the structure of its "unbiased" Turing wave. The former emerges as the particle's secondary bifurcation, while the latter emerge as a result of its primary bifurcation.

The peak-to-peak magnitude of a particle's Turing wave would decline approximately as the square of increasing radial distance since the concentration maxima attained in each shell depend on the magnitude of the X and Y radial diffusive flux vectors which themselves decrease according to $1/r^2$. The maxima and minima in Kelly's neutron charge density model appear to exhibit such an inverse square decline. It is more difficult to visibly make out the amplitude decline in his proton charge density model since it has relatively subdued peaks. It would be interesting to perform a data fit of a modification of his model in which the first few surface charge oscillations plotted at $r \gtrsim 1$ fm become negative on their dips while maintaining their current positive average bias.

Radial etheron fluxes would extend between the particle's core (e.g., high-Y/low-X) and its adjacent spherical shell (e.g., low-Y/high-X). That is X would be continually flowing into the core and Y would continually be flowing out of the core. Judging from a similar phenomenon occurring in macroscopic systems, these flows would likely develop a vortical motion and would be accompanied by a rotational wave pattern. In the case of subquantum kinetics, these rotating X-Y modulations would manifest as rotating electric fields which would give rise to magnetic effects. Hence they may be identified with particle spin. Since the particle's electric field is periodic, its spin magnetization would also be expected to be periodic which is in agreement with Kelly's findings.

4. Particle Diffraction and Orbital Quantization

If the subatomic particle's electric potential field is modulated with a fundamental wavelength equal to the particle's Compton wavelength, as subquantum kinetics proposes, then the results of particle diffraction experiments are easily explained.[18, 19] A nucleon (or electron) would be expected to diffract from a grating in a manner identical to deBroglie's postulated phase wave:

$$\lambda_p = \hbar/\text{mv}. \qquad (5)$$

In other words, the particle's advancing Turing wave pattern would establish an electric potential interference pattern at the site of the diffraction grating that would be identical to that produced by a phase wave.

For example, suppose that the nucleon and its extended Turing wave pattern approaches the diffraction grating at velocity v. In the grating's rest frame, this Turing wave will appear to have a wavelength $\lambda'_0 = \lambda_0(1 - ß^2)^{½}$ due to the Lorentz length contraction effect, where $ß = v/c$. As the approaching Turing wave field impinges on the diffraction grating, it appears as a traveling wave moving forward at velocity v and, in so doing, excites an electric potential oscillation at the grating's surface at a frequency:

$$f_e = v/\lambda'_0 = v/\lambda_0(1 - ß^2)^{½}, \qquad (6)$$

This oscillation in the grating frame of reference radiates fields outward at the speed of light from multiple slit locations, each having a wavelength λ_v given as:

$$\lambda_v = c/f_e = \frac{c}{v}\lambda_0(1 - ß^2)^{½}. \qquad (7)$$

These grating fields may be called "velocity waves" since their wavelength depends on the velocity of the particle's Turing wave pattern relative to the grating frame in which they are generated. When the Compton wavelength, relation (1), is substituted into equation (7), the wavelength of the velocity wave is found to be numerically equal to that of de Broglie's phase-wave, equation (5):

$$\lambda_v = \hbar/mv = \lambda_p. \qquad (8)$$

But instead of traveling along with the particle, these waves are instead produced locally in the grating frame of reference. This has the advantage of avoiding the frame of reference paradoxes inherent in de Broglie's pilot wave model in which the particle's present periodic state must be defined by an environmental scattering event that is to take place some time in the future.*

These velocity waves collectively produce an electrostatic potential interference pattern in front of the grating whose presence is sustained by the continuous impingement of the nucleon's Turing wave. This induced interference pattern produces electrostatic forces on the nucleon which influence its subsequent trajectory, guiding it as it scatters from the grating's surface. That is, the electrostatic potential gradients forming this interference pattern exert forces on the electrostatic potential gradients of the nucleon's dissipative structure, thereby steering the particle toward regions of constructive interference. These steering forces, which would be electrostatic in nature, would operate just as readily on neutral particles as on charged particles. Since the velocity wave interference pattern requires some time to be established and must already be in place to influence the particle's trajectory as the particle nears the grating, we may conclude that the Turing pattern's periodicity extends a considerable distance outwards from the particle core, perhaps hundreds of Compton wavelengths.

It has also been noted that orbital motion of an electron's wave pattern directly results in orbital quantization in accordance with Bohr's formula ($n\lambda_0 = n\hbar/m_0v$) with no need of additional assumptions.[18] Also subquantum kinetics proposes that in close proximity the periodic potential fields of two nucleons, e.g., a proton and neutron, can become interlocked, the proton's positive core becoming trapped in the negative potential well surrounding the neutron's core and the neutron's positive core becoming trapped in the potential well surrounding the proton's

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* The discovery that the Turing pattern adequately accounts for the phenomenon of particle diffraction was made after this dissipative structure representation of subatomic matter had already finalized, hence indicating the predictive potential of this approach.

positive core; see Figure 6. Thus nuclear binding is attributed to the operation of very strong attractive and repulsive electrostatic forces which come into play when nucleons are in close proximity to one another.

5. Conclusion

The subquantum kinetics dissipative structure model has successfully anticipated an astounding array of characteristics for the subatomic particle's core field. These are summarized in Table 1. Of these, the confirmation of the Turing wave periodicity is particularly significant since subquantum kinetics has proposed that this is responsible for the phenomena of particle diffraction, electron orbital quantization, and nuclear binding.[18, 19] Considering that it correctly anticipated the nucleon's observed periodic field, the subquantum kinetics model must be considered to offer a more accurate description than the quark model. In addition it offers an explanation for the structure of the electron and positron, nuclear binding, particle diffraction and electron orbital quantization.

Although we can never hope to measure the shape of the particle's gravity field by means of particle scattering data, experimental evidence that points to the existence of electrogravitic coupling would lead us to conclude that the particle's gravity field, like its electric field, also has a central Gaussian shape. This is consistent with subquantum kinetics which predicts that there should be a close coupling between charge and gravity (between X-Y concentration polarity and G concentration polarity). If the particle's gravity field is Gaussian, then we may rule out the possibility that black hole singularities might form. Einstein would undoubtedly agree.

Table 1
Subquantum Kinetics Particle Field Predictions Versus Observation

Characteristic	Subquantum Kinetics Prediction	Best Model Fit to Observational Data
Gaussian core	Yes	Yes
Spherical symmetry	Yes	Yes
Surrounding electric field periodicity of declining amplitude	Yes, the Turing wave	Yes
Wavelength equals the Compton wavelength	Yes	Somewhat less, due to probe particle effect
Positive electric field bias for the proton	Yes	Yes
Positive potential for the neutron core	Yes	Yes

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