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The Quantum Condition and an Elastic Limit

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Abstract: Charles-Augustin de Coulomb introduced his equations over two centuries ago. These equations quantified the force and the energy of interacting electrical charges. The electrical permittivity of free space was factored into Coulomb's equations. A century later James Clear Maxwell showed that the velocity of light emerged as a consequence this permittivity. These constructs were a crowning achievement of classical physics. In spite of these accomplishments, the philosophy of classical Newtonian physics offered no causative explanation for the quantum condition. Planck's empirical constant was interjected, ad-hoc, into a description of atomic scale phenomena. Coulomb's equation was re-factored into the terms of an elastic constant and a wave number. Like Coulomb's formulation, the new formulation quantified the force and the energy produced by the interaction of electrical charges. The Compton frequency of the electron, the energy levels of the atoms, the energy of the photon, the speed of the atomic electrons, and Planck's constant, spontaneously emerged from the reformulation. The emergence of these quantities, from a classical analysis, extended the realm of classical physics into a domain that was considered to be exclusively that of the quantum.

Keywords: Atomic radii, photoelectric effect, Planck's constant, the quantum condition.

1. INTRODUCTION

One school of thought holds that the universe is constructed of continuous stuff. Newton's laws of motion and Einstein's theory of Special and General Relativity operate upon this continuum. Coulomb's equation describes the continuous nature of the electrical field. Maxwell employed Coulomb's equation and described the wavelike properties of light. Another school of thought holds that the universe is constructed of particle like things. These things were quantified with Planck's empirical constant. Einstein used Planck's constant and introduced the particle of light. Niels Bohr showed that an atom's electrons reside in discrete particle like energy levels [1] The philosophy of quantum mechanics precisely describes the lumpiness of the quantum realm. This philosophy could not explain why the quantum realm was lumpy. Max Planck searched for a classical principle that would establish the state of the quantum. It has been over a century since Planck's quest and no classical principle was discovered. The Copenhagen Interpretation of quantum physics was introduced in order to offer some explanation [2-4]. This interpretation describes a probability based reality. The everyday classical realm, of our experience, is only a subset of this mysterious reality. The classically wired human mind cannot intuitively grasp the condition of the quantum reality. This quandary has become the accepted norm.

Znidarsic refactored Coulomb's equation into the terms of an elastic constant K_e and a displacement R_c. The elasticity of the electron, like that of a rubber band, is greatest as it just begins to expand. It diminishes, from that maximum, with displacement. The Compton frequency, of the electron, emerges as this elasticity acts upon the mass of the electron. In general, the wave like properties of stuff emerge as a condition of this elastic constant.

It was assumed that the electron has a classical limit to its elasticity. An electron expels the field of another through a process of elastic failure. The displacement, of the elastic discontinuity, equals classical radius of the electron R_c. The wave number of the electromagnetic field was produced as an effect of this elastic discontinuity. In general, the particle like properties of things emerge as a condition of this wave number. The duality of matter and waves emerges as an effect of the interaction of the elastic constant and the wave number.

The elastic constant was used to determine the speed of a longitudinal mechanical wave in the nucleus. The quantum condition emerged when the speed of this longitudinal nuclear wave was set equal to the speed of transverse electronic wave. In more general terms, the quantum condition was described as a point where the speed of sound equals the speed of light. The speed match is conceptually equivalent that of one billiard ball directly impacting another. The second ball promptly adsorbs all of the kinetic energy and flies away at the speed of the impacting ball. One snap of sound is emitted. Likewise, a single photon is emitted, during the quantum transition. A prompt, single step, transfer of energy is a characteristic of a system of matched impedances. The particle like properties of things emerged, within stuff, at points of matching impedance. The analysis introduced an "impedance matching" interpretation of quantum physics. The quantification of this impedance match produced elements of the quantum condition within a subset of Newtonian mechanics.

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2. THE HISTORICAL FACTORING

The force between two electrical charges diminishes with the square of their separation. This force was quantified in (1) as the product of Coulomb's constant K_c and the reciprocal of the separation distance squared. Equation (1) reveals that the force between two electrons, separated by a displacement equal to the classical radius of the electron R_c, is 29.05 Newtons. (1)

$$Force = \frac{K_c Q^2}{r^2} \tag{1}$$

The energy contained by force field is proportional to the integral through which the force acts (2).

$$Energy = K_c \int_{\infty}^{r} \frac{1}{r^2} Q^2 dr \tag{2}$$

The solution of (2) gave the energy of the electromagnetic field as a function of displacement.

$$Energy = -\frac{K_c Q^2}{r} \tag{3}$$

Historically, Coulomb's constant K_c was factored into terms of electrical charge Q and the permittivity of free space e_0. The result (4) is Coulomb's equation [5].

$$Energy = -\frac{Q^2}{4\pi e_0 r} \tag{4}$$

Coulomb's equation is fundamental to our understanding of the natural realm. It has provided the basis for much of our classical technology. James Clerk Maxwell extended (4) and showed (5) that the speed of light emerges as a consequence of the permeability of free space e_o [6].

$$c = \sqrt{\frac{1}{e_o u_o}} \tag{5}$$

These wide ranging results are considered to be a crowning achievement of classical physics. These results did not, however, provide a causative explanation of the quantum condition. Planck's constant was an oddball. It did not emerge from the classical formulations.

2.1. A New Factoring

The electrical force was expressed in terms of an elastic force on a spring (6). The force produced by a spring equals the product of its elastic constant K and the displacement x. The elastic constant K is a function classical elasticity.

$$Force = -Kx \tag{6}$$

All materials, in the classical realm, have a limit in their elasticity. These classical materials in-elastically deform when they are compressed or stretched beyond this limit. This author assumed that the electric field is classical and completely inelastic. The load that the electric field can bear is limited. Electrons expel the electrical fields, of other electrons, through a classical process of elastic failure. Like a chain, the electrical field is as strong as it weakest link. A point of weakest link (for an external electrical field) exists at the edge of a discontinuity. The integral (7) expresses the force required to expel a substance. A factor of two accounts for two overlapping fields.

$$Force = 2p\int_{0}^{l} x\, dx \tag{7}$$

The electrical field is in-elastically expelled to a length equal to the classical radius of the election R_c (2.818×10^{-15} meters). This boundary condition was inserted into (8) as a limit of integration.

$$Force = 2p\int_{\infty}^{R_c} (x)\, dx \tag{8}$$

A solution of (8) gave (9). Equation (9) describes a force as the product of a pressure p and a surface R_c^2. A single rigid point exists upon this surface of elastic failure. The force, at this point, is a function a classical elastic limit.

$$Force = -p(R_c)^2 \tag{9}$$

The force between two electrons, compressed to within one classical radius of each other, is 29.05 Newtons. This force maximum F_m was simultaneously inserted into (9). The result (10) quantified the electrical force at the boundary of the discontinuity. The force that can be exerted by an electric field is determined entirely by its strength at a point of elastic failure. This strength varies inversely with r^2 as the discontinuity of an electron moves out of the field of another electrons. The product of the constants in (10) equals Coulomb's constant K_c. The resultant force equals that of equation (1). This is the force that is normally described by Coulomb's equation.

$$Force = -\left(\frac{F_m}{r^2}\right)(R_c)^2 \tag{10}$$

The elastic energy in (11) equals the integral of the distance through which the force acts. This is the energy necessary to move the elastic discontinuity of one electron through the field of another.

$$Energy = F_m (R_c)^2 \int_{\infty}^{r} \frac{1}{r^2} dr \tag{11}$$

The solution of (11) yields (12), the energy of the electric field. This energy is expressed in the mathematical form of a spring. Equation (12) is recursive in that the second integral of (9) produced the same mathematical form. The benefit of the double integration is that constants of the motion naturally emerge from the boundary conditions. The double integration, for example, has revealed that the factor of ½ does not appear as a coefficient in a formulation expressing the elastic energy in a medium that varies inversely with the square of its displacement. Equation (12) produces the same quantity of energy as does Coulomb's equation (4).

$$Energy = -\left(\frac{F_m}{r}\right)(R_c)^2 \tag{12}$$

Equation (12) and Coulomb's formulation (4) both express the energy associated with interacting charges. Both equations describe a large portion of classical reality. Equation (12) also expresses significant new results. The term (F_m/r) emerged within (12). The term (F_m/r) is the elastic constant K_e of the electric field. The elastic constant of the electrical field, like that of rubber band, diminishes from a maximum F_m with displacement. This elastic constant K_e establishes the wavelike properties of stuff.

The length R_c emerged within (12). The length R_c is an expression of the reciprocal of the wave number $(1/\lambda)$ of the electric field. The wave number determines the particle like properties of things. The duality expressed by two new constants is intrinsic to the quantum condition.

3. THE COMPTON FREQUENCY OF THE ELECTRON

The Compton frequency F_c of the electron is 1.236×10^{20} Hertz. It emerged, in (13), as the elastic constant of the electric field acts upon the mass of the electron. Harmonics of the natural frequency n appear within standing waves.

$$F_c = \frac{n}{2\pi}\sqrt{\frac{K_e}{M_e}} \tag{13}$$

The radii of the hydrogen atom exist as multiples of the ground state radius (n^2R_h) where $(R_h=0.5292 \times 10^{-10}$ meters). The elastic constant was expanded to the ratio of force maximum F_m to these radii. The result (14) expresses the radii of the hydrogen atom as harmonics n of the Compton frequency of the electron.

$$F_c = \frac{n}{2\pi}\sqrt{\frac{F_m/(n^2R_h)}{M_e}} \tag{14}$$

The electronic Compton frequency emerged as an effect of the simple harmonic motion of the electron. The deBroglie wave was interpreted, by Louis de Broglie, as a beat in the Compton frequency [7]. The deBrogle wave is fundamental to the Schrödinger wave equation. These interpretations, in combination, provide a classical foundation for all of chemistry and most of physics.

4. THE SPEED OF HYDROGEN'S ELECTRONS

A type of notation emerged from early spectroscopy. This notation describes a traveling wave as the cosine of the difference of its wave number $(2\pi/\lambda)$ and its angular frequency ω. Harmonics n, of the natural frequency, do not emerge within traveling waves. Wave numbers exist at harmonics of the fundamental length n. This notation was presented in (15).

$$Y = \cos\left(\frac{2n\pi}{\lambda}x - \omega t\right) \tag{15}$$

The angular frequency ω was expressed as the square root of the elastic constant K_e over the mass of the electron M_e. The length of the wave number R_c was extracted from the reformulation of Coulomb's equation (12). These terms were inserted into (15) and produced (16).

$$Y = \cos\left(\frac{2\pi n}{R_c}x - \sqrt{\frac{K_e}{M_e}}t\right) \tag{16}$$

A solution of (16), the angular frequency over the wave number is (17). The result (17) was multiplied by 2π in order express the transverse speed s_a an electrical wave.

$$s_a = \frac{R_c}{n}\sqrt{\frac{K_e}{M_e}} \tag{17}$$

The elastic constant of the electron was expanded as the ratio of F_m over the radii of the hydrogen atom (n^2R_h). The result (18) produced the speed of hydrogen's electrons.

$$s_a = \frac{R_c}{n}\sqrt{\frac{F_m/(n^2R_h)}{M_e}} \tag{18}$$

The simplification of (18) clearly expresses the circumferential speeds of the electrons in the hydrogen atom in (19). [8]. These speeds equal $(2.18\times10^6$ meters/sec) divided by the integer n squared [8].

$$s_a = \frac{R_c}{n^2}\sqrt{\frac{F_m/R_h}{M_e}} \tag{19}$$

An elastic constant and wave number emerged as terms within a refactored of Coulomb's equation. The electron oscillates at its Compton frequency as its elastic constant acts upon its mass. The speeds of the electrons, within the hydrogen atom, were produced as a product of the electronic Compton frequency and a wave number. The argument is circular, in that, the radii of the hydrogen atom (n^2R_h) had to be injected ad-hoc into (18).

5. THE SPEED OF SOUND IN THE NUCLEUS

A type of notation emerged from early spectroscopy. This notation describes a standing wave as the cosine of the product of cosine wave number $(2\pi/\lambda)$ and the sin of its angular frequency ω. This notation was presented in (20).

$$Y = \cos\left(\frac{2\pi}{\lambda}x\right)\sin\left(n\omega_n t\right) \tag{20}$$

It was assumed that electrical force balances the nuclear force within the nucleus and that the electrical force is expelled from the nucleus. The electrical elastic constant K_e was used, under this condition, to compute the harmonic angular frequency of the nucleons. The nuclear wave number $(K_f = 1.36\ \text{fm}^{-1})$ was extracted from the existing literature. [9]. The density of the nucleons is constant. The nuclear wave number is an effect of this density. These terms and the mass of a nucleon $(9.109 \times 10^{-31}$ kg) were inserted into (20) and produced (21).

$$Y = \cos\left(\frac{2\pi}{K_f}x\right)\sin\left(n\sqrt{\frac{2K_e}{M_n}}t\right) \tag{21}$$

A solution of (21), the angular frequency over the wave number is (22). It expresses the velocity of a longitudinal mechanical wave within the nucleus. Longitudinal mechanical waves are commonly called sound waves. The longitudinal nature of the wave is expressed by the absence of an additional factor of 2π. The elastic constant K_e was expanded and set to the length of a captured nucleon $(K_f/2)$. The displacement of the elastic constant was set to the Fermi wave number K_f. This author suggests that the kinetic isotope effect may emerge, in (21), through the small difference between the proton's and neutron's mass. The speed of a longitudinal mechanical wave, in the nucleus, S_n was found to be an integer multiple of 1,094,386 meters per second (22). These independent classical speeds establish the quantum condition.

$$S_n = \frac{nK_f}{2\pi}\sqrt{\frac{2F_m / K_f}{M_n}} \tag{22}$$

6. THE SPEED OF LIGHT EQUALS THE SPEED OF SOUND

An electronic standing wave was associated with the atom's stationary quantum states. Harmonics n, of this standing wave, emerged with the natural frequency (23). A wave number was extracted as a term from a reformulation of Coulomb's equation. The wave number was increased by one half to account of the half wavelength fundamental of a standing wave.

$$Y = \cos\left[\left(\frac{4\pi}{R_c}x\right)\left(n\sqrt{\frac{K_e}{M_e}}t\right)\right] \tag{23}$$

Speeds were extracted from (23) as the ratio of natural frequency over the wave number. Standing waves do not propagate. Equation (23) expresses the speed at which energy propagates between the electronic harmonic levels. Equation (23) was multiplied by 2π in order to obtain the transverse speed of an electrical wave. These speeds were placed in the right side of (24). The elastic constant K_e was expanded as the ratio of F_m over r_a. The electron interacts with the nucleus through channels of matching impedance. These channels are quantified by a match in the speed of the interacting partners. The speed of a of transverse electrical wave s_a was set equal to the speed of a longitudinal nuclear wave S_n in (24) [10]. The equality (24) matched the impedance of the system.

$$S_n = \frac{nR_c}{2}\sqrt{\frac{F_m / r_a}{M_e}} \tag{24}$$

The solution of (24) produced the radii of the hydrogen atom as squares of its ground state radius (25).

$$r_a = n^2 R_h \tag{25}$$

The electron attempts to take all paths into the nucleus. The electric field is inelastic and the electron does not bounce. The electron must interact promptly during transition. The flash and the bang of a quantum transition must progress simultaneously. This prompt interaction proceeds through a channels of matching impedance. This channel is characterized by a match in the longitudinal nuclear speed S_n and the transverse atomic speed s_a. The energy levels of the hydrogen atom emerged, as an effect, of this equality in speeds in (24). The energy, of a quantum transition, flows promptly, without bounce, and a single photon is emitted. The condition has been traditionally described by Fermi statistics [11]. The new, impedance matched, quantification of this motion employed the classical properties of mass, elasticity, and elastic limit. The argument is not ad-hoc. Planck's constant emerges as a consequence of the classical condition [12].

Equation (24) was extended in (26). The elastic constant of the electric field was increased directly with the nuclear charge Z. A harmonic of the nuclear velocity Z was selected as a condition were the orbital frequency of the electron matched its elastic harmonic motion.

$$ZS_n = \frac{nR_c}{2}\sqrt{\frac{ZF_m / r_a}{M_e}} \tag{26}$$

A solution of (26) produced the atomic radii, of the single electron ions of the heavier elements, in (27).

$$r_a = \frac{n^2 R_h}{Z} \tag{27}$$

The atomic structure of the heavy elements emerged from and extension of the analysis.

7. THE FINE STRUCTURE CONSTANT

The origin of the fine structure constant has been a long standing mystery. Maxwell's interpretation of Coulomb's equation produced the speed of light. The terms of a refactored of Coulomb's equation produced the speed of sound in the nucleus S_n. Half the ratio of these two speeds equals the fine structure constant. The inspection of (10 & 12) reveals the emergence of the elastic discontinuity R_c. The electrical field is pined into a superconductor at defects (discontinuities). This author suggests that the fields of matter are also pinned into to the structure of matter at the discontinuity R_c. Atomic vibrations shake the electric field from the grip of the elastic discontinuity [13,14]. The fine structure constant emerges as the ratio of the velocity a restrained field over the velocity of an unrestrained field.

8. THE PHOTO-ELECTRIC EFFECT

A vibrating source induces a wave of motion. The frequency of the emitted wave matches the frequency of its source. Maxwell's equations described the wave like properties of a classical continuum. Wavelike properties were observed in the dispersion of a wave as it passed through a single slit. The wavelike properties were also observed through the interference of waves as they passed through two slits. Thomas Young demonstrated these effects, within light, during the early 19^{th} century [15]. It appeared that light was a wave. The intensity of the light was reduced, in the double slit experiment, and single points of impact appeared. Einstein interpreted this result as an effect of a particle like photon [16]. It appeared that light was both a particle and a wave. The frequency of the particle of light was not coupled to any atomic vibration. It was assumed that the bias of the observer determines the effect (wave like or a particle like) that emerges. The classically wired human mind could not reconcile the dispersant effects. The concept of the path of the quantum transition was abandoned [17].

The energy of a light wave attempts to take all paths as it interacts with matter. This energy is confined within channels of matching impedance. The state of matching impedance is characterized by a match in speed. The photo electric effect was described, in (27), as a condition where the speed of sound in the nucleus S_n matches the speed of the collapsing light wave. The speed of a collapsing transverse light wave was expressed a function of an atomic frequency f_a and an atomic wavelength λ_a, (28). A factor of 2π accounts for the transverse nature of the electromagnetic wave.

$$S_n = 2\pi f_a \lambda_a \tag{28}$$

The frequency f_a is that of the emitted photon. The wavelength λ_a, in interaction with an electric charge, produces the energy of the photon. In combination these effects reconcile the particle like and wave like duality of light.

The geometry of the collapsing light wave, in this simple example, was assumed to be that of the S atomic state. This geometry was quantified in units of capacitance c_p. The capacitive of the interacting light wave was represented by the isotropic capacitance of an isolated sphere (29).

$$c_p = 4\pi e_0 \lambda_a \tag{29}$$

The energy level of the hydrogen atom emerged in (27) as a condition of an impedance match. This impedance match was described in terms of the velocity of the interacting partners. The radius of the atomic state λ_a, like the length of an antenna, couples the photon's frequency f_a to the nuclear velocity S_n (1,094,386 m/s). The simultaneous solution of (28) and (29) expressed this geometry in units of capacitance (30). The voltage of an electric field varies inversely with the capacitance of the system. Equation (30) reveals that the energy of light is a function of the amplitude of its voltage. Bohr's principal of quantum correspondence emerges a consequence of this amplitude.

$$c_p = \frac{2e_o S_n}{f_a} \tag{30}$$

The energy of an electric charge was presented, in (31), as a function of capacitance c_p.

$$Energy = \frac{Q^2}{2c_p} \tag{31}$$

The simultaneous solution of (30) and (31) produced (32).

$$Energy = \left(\frac{Q^2}{4e_0 S_n}\right) f_a \tag{32}$$

The reduction of the terms within the bracket in (32) produced (33). The result (33) is Einstein's famous photo electric equation [16].

$$Energy = hf_a \tag{33}$$

The energy of a propagating light appears as a wave. Points of matching impedance appear within this continuum. These points are characterized by a match in the velocity of the interacting partners. Light promptly interacts with matter at these points. Light behaves, at these points, as a particle. Planck's constant emerged naturally from the analysis. Einstein's photo electric effect was produced as effect of a prompt, impedance matched condition.

CONCLUSION

Coulomb's equation has been used to quantify the force and the energy of the electric interaction. Maxwell extended Coulomb's formations and produced the speed of light. These accomplishments were a crowning achievement of classical physics. The philosophy of classical physics could not explain the discrete quantum properties of matter and energy. Planck's constant was injected, into a set of classical constructs, in an effort to qualify the lumpiness of the quantum realm.

This author refactored Coulomb's equation into terms of an elastic constant and a wave number. The elastic constant quantified the wave like properties of stuff and the wave number quantified the particle like properties of things. The analysis, in this paper, was used to describe a small, but important, portion of the quantum condition. This author suggests that this extension analysis may demonstrate that the entirety of the quantum condition exists within a subset of Newtonian mechanics.

NOMENCLATURE

c	=	3×10^8 meters/second, The speed of light
c_p	=	Capacitance in Farads
e_0	=	8.854×10^{-12} coulombs^2/newton-m^2, The permittivity of free space
F_c	=	1.236×10^{20} Hertz, The Compton frequency of the electron
f_a	=	The atomic frequency in Hertz
F_m	=	29.05 Newtons, The maximum force of the electrical field of a single charge
h	=	6.625×10^{-34} joules-sec, Planck's constant
K_c	=	8.987×10^9 N m^2 /C, Coulomb's constant
K_f	=	1.36×10^{-15} meters, The length of the nuclear Fermi wave number
K_e	=	29.05 / r Newtons/meter, The elastic constant of the electron
λ_a	=	The atomic wavelength in meters
M_e	=	9.109×10^{-31} kg, The mass of the electron in Kg
M_n	=	1.67×10^{-27} kg, The mass of a nucleon in Kg
n	=	1,2,3..., An integer
p	=	The pressure in Newtons/square meter
Q	=	1.602×10^{-19} Coulombs, The electric charge
r	=	The radius of displacement in meters
r_a	=	The atomic radius in meters
R_c	=	2.818×10^{-15} meters, The classical radius of the electron
R_h	=	0.5292×10^{-10} meters, The Bohr radius

s_a = 2.186 x 10^6 meters/second/n^2, The speed of an atom's electron

S_n = 1,093,486 meters/second, The speed of "sound" within the nucleus

u_0 = 8.854x10^{-12} webbers/amper-m, The permeability of free space

ω = The angular velocity in radians per second

x = The displacement in meters

Z = The atomic number

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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ADDITIONAL READING

Znidarsic, Frank; *Energy, Cold Fusion and Antigravity,* Amazon.com, **2012**.

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