UNIFIED 'NO FIELD' THEORY AND THE BOHR ATOM

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ABSTRACT

Writing in a recent issue of Galilean Electrodynamics, Osborne and Pope [1] proposed, and to some extent demonstrated, that all forces are due to the conservation of angular momentum, and not due to gravity, electrostatic, inertia, or other forces. The central idea is that material objects, neutral mass, and charged mass, when moving in a 'natural' orbit about another body, experience no forces. Also presented was the idea that orbits, and not rectilinear motions, are the natural motions of particles. While Pope and Osborne developed this idea somewhat at the macro and micro levels, the author of the present paper re-examines these ideas at the micro level in a slightly different manner, using the Bohr Atom. What is demonstrated is that the electrical forces associated with Coulomb's Law can be attributed to angular momentum or kinetic energy moments, instead of electric charges.

DEFINITIONS AND VALUES

Symbols and subscripts are employed to precisely define what is referred to. Also values of constants are given so further referral is not necessary. All calculations are done for circular orbits, instead of elliptical orbits, to emphasis the important points without undue mathematical complexity.

Symbols:

- m mass
- $\mathbf{v}, v$ velocity and speed with respect to center-of-mass (CM)
- r radius of orbit from CM
- K kinetic energy
- n energy level ($n = 1, 2, 3,\ etc.$)
- L angular momentum
- r_t total distance between electron and proton orbiting each other
- k $1/4\pi\varepsilon_0$, where ε_0 is the permittivity of free space
- e charge of electron or proton

Subscripts:

- e electron
- p proton
- o orbital
- s spin
- t total
- n energy level ($n = 1, 2, 3,\ etc.$)

Constants:

- $E_k \equiv 2m_ec^2 = 1.6374529\text{x}10^{-13}$ J
- $R_k \equiv ke^2/2m_ec^2 = 1.4089695\times10^{-15}$ m
- $c = 2.9979250\times10^8$ m/s = speed of light
- $\hbar =$ Planck's constant $/2\pi = 1.05459\times10^{-34}$ J-s
- $m_e = 9.109558\times10^{-31}$ kg = mass of electron
- $m_p = 1.672614\times10^{-27}$ kg = mass of proton
- $a = 1 + m_e/m_p = 1.00054463$ = constant much like reduced mass constant
- $\alpha = 1/137.0361$ = fine structure constant

THE ANGULAR MOMENTUM APPROACH AND THE BOHR ATOM

In the following analysis of the Bohr Atom, the integrity of Coulomb's Law is maintained on both sides of the force-balance equations. This is done without cross canceling over the equal sign. A formula used in the Bohr atom is:

$$m_p v_{pon} r_{pon} + m_e v_{eon} r_{eon} = n\hbar \tag{1}$$

This is Bohr's assumption that the *total* orbital angular momentum of the hydrogen atom is an integral constant n times Planck's constant $\hbar$. For this discussion (1) is simplified by solving for the orbital angular momentum of the electron in Bohr's orbit:

$$L_{ton} = L_{eon} a = m_e v_{eon} r_{eon} a = n\hbar \tag{2}$$

The author demonstrated in an article[2] the equivalence of the following for Coulomb's Law for charges of value e:

$$\frac{ke^2}{r_t^2} = \frac{E_k R_k}{r_t^2} \tag{3}$$

where

$$r_t = a r_{eo}. \tag{4}$$

One should be wary of products such as is on the right side of (3). The constants can be anything, so long as their product equals the left side. One may postulate certain values for the constants and see where they lead. This was what was done in [2]. One of the meanings of R_k is the distance between *unlike* charges where the potential energy between them goes to zero. For distances less than R_k the potential energy is zero. Therefore, the force for *unlike* charges is presumed to zero throughout this distance.

The next formula Bohr used is for force balance. From (3) and the formula for E_k:

$$\frac{2m_e c^2 R_k}{a^2 r_{eo}^2} = \frac{m_e v_{eo}^2}{r_{eo}} \tag{5}$$

Rearranging (5), including (2) and (4), and inserting α, the fine structure constant:

$$\left(\frac{2R_k m_e c}{\alpha}\right)(\alpha c)\left(\frac{1}{r_{tn}^2}\right) = \left(L_{eon} a\right)\left(v_{eon} a\right)\left(\frac{1}{r_{tn}^2}\right) \tag{6}$$

If numerical values are substituted into the constants enclosed in the first parenthesis on the left side of (6), we find it is exactly equal to $\hbar$:

$$\frac{2R_k m_e c}{\alpha} = \hbar \tag{7}$$

Since $L_{eo1} \text{x} a = \hbar$ ($n = 1$) then:

$$v_{eo1} = \frac{\alpha c}{a} = 2.1864991 \times 10^6 \text{ m / s}$$

Substituting this value of v_{eo1} in (2) and solving for r_{eo1}:

$$r_{eo1} = 5.291765 \times 10^{-11} \text{ m}$$

This value of r_{eo1} compares favorably with the value of Bohr's first radius, given by $A = 5.2917715 \times 10^{-11}$ m.

The spin angular momentum of the electron and proton as projected onto a vector perpendicular to the plane of the electron's orbit around the proton is given to be:

$$L_{se} = L_{sp} = \tfrac{1}{2}\hbar \tag{8}$$

Since (7) is a formula related to Coulomb's Law, it is postulated by the author to be the sum of the spin angular momenta of the electron and the proton:

$$\frac{2R_k m_e c}{\alpha} = L_{se} + L_{sp} = \frac{1}{2}\hbar + \frac{1}{2}\hbar = \hbar \tag{9}$$

Since L_{se} and L_{sp} values are magnitudes of angular momentum vectors projected in the same direction and at right angles to the plane of the orbiting electron, then the over-all magnitudes of the angular momentums of these particles may be greater. The magnitude of the electron angular momentum may be as high as $\hbar$. Since (9) is embedded in Coulomb's Law, it can be interpreted as part of the parameters that produce the 'electrostatic' force.

Continuing the development for the Bohr orbit ($n = 1$) including (9) in (6):

$$\left(L_{sp} + L_{se}\right)\left(v_{eo1}a\right)\left(1 / r_{t1}^2\right) = \left(L_{to1}\right)\left(v_{eo1}a\right)\left(1 / r_{t1}^2\right) \tag{10}$$

We see from (10) that:

$$L_{sp} + L_{se} - L_{to1} = 0 \tag{11}$$

So for the Bohr orbit, a 'natural' orbit, we may surmise that 'forces' are contrived to conserve angular momentum. Also this may indicate inertial force is local and not particularly related to the mach principle. However, for the cases where $n = 2, 3, 4,$ *etc*., we have:

$$\left(L_{sp} + L_{se}\right)\left(v_{eo1}a\right)\left(1 / r_{tn}^2\right) = \left(nL_{to1}\right)\left(v_{eo1}a / n\right)\left(1 / r_{tn}^2\right) \tag{12}$$

We observe in (12), an equation for other 'natural orbits', that the electron orbital velocity v_{eon} plays a role in balancing the equation as the atom absorbs photons (with angular momentum $\hbar$) and increases the energy level to $n =$ 2, 3, 4, *etc*. The atom's total orbital angular momentum is increased with increased n as shown in (12) and (2). Total angular momentum is conserved when one considers that that the angular momentum of the absorbed photon is added to the angular momentums of the atom. To complete the development, we find that $v_{eon} = v_{eo1} / n$ and $r_{eon} = r_{eo1}n^2$.

RADIUS AND KINETIC ENERGY OF THE ELECTRON

Diverting form the central objective of this article for a moment, we observe that (9) has more to offer. A workable assumption is that the spin angular momentum of the electron is:

$$L_{se} = m_e v_e r_e \tag{13}$$

where r_e is the radius of the electron and v_e is the velocity with which the electron spins. From (9):

$$L_{se} = m_e v_e r_e = m_e c\left(R_k / \alpha\right) = \tfrac{1}{2}\hbar$$

Thus it appears $v_e = c$ and $r_e \geq R_k / \alpha = 1.93079685 \times 10^{-13}$ m for the electron. The de Broglie wavelength of the electron mass traveling at speed c is given by:

$$\lambda = \hbar 2\pi / m_e c = 2.426305 \times 10^{-12}\,\mathrm{m}$$

The circumference of the electron for this situation is $c_e = 2\pi r_e = 1.21315544 \times 10^{-12}$ m. If the spin angular momentum vector of the electron in orbit were tilted 60° from the normal of its orbital plane, then the angular momentum of the electron would be $\hbar$. Its r_e would double, and its circumference would equal one de Broglie wavelength. So this author postulates the angular momentum of the electron is $\hbar$. This has a unifying appeal in that the photon has angular momentum $\hbar$. Also the Bohr orbit has one wavelength with the electron traveling at speed v_{eo1}. This wavelength is calculated to be 3.3267×10^{-10} m and the circumference of the Bohr radius A is calculated to be 3.3249×10^{-10} m, the difference associated with the factor α.
It is also observed from these calculations that:

$$r_e = (2/\alpha) \times R_k, \quad \mathrm{A} = (1/\alpha) \times r_e, \text{ and } \alpha^2 = 2R_k / A \tag{14}$$

The kinetic energy of the electron is deduced from (5). Since the mass m_e is rotating at speed c, its kinetic energy is [3]:

$$K_{se} = m_e c^2$$

Thus the energy of the electron is most likely to be kinetic. It appears that the potential energy of the electron with respect to the proton is stored as kinetic energy. Its rest mass is essentially zero, traveling at speed c. Thus the electron is composed of relativistic mass.

Other authors have proposed other models of the electron. This model, however, seems reasonable to this author. It illustrates an important connection between waves and particles. Also, it suggests the electron is a large photon, and that other matter may be composed of a large photon as a photon particle: $mcr = \hbar$ or some similar formula. This idea has been put forth by other authors [4], [5], [6].

A similar argument can be made for the kinetic energy of the proton and its own radius. Since its angular momentum contributes the same amount in (9) as does the electron, we can hypothesis that its radius is much smaller by the same proportion as its mass with the electron:

$$r_p = (m_e / m_p) r_e$$

Also, its kinetic energy is $K_{sp} = m_p c^2$.

KINETIC ENERGY APPROACH

Performing a similar development as the angular momentum approach, the development yields for the Bohr atom:

$$\left(\tfrac{1}{2} K_{sp} r_p + \tfrac{1}{2} K_{se} r_e\right)(\alpha)\left(1 / r_{tn}^2\right) = \left(2aK_{eo1} / n^2\right)\left(ar_{eo1} n^2\right)\left(1 / r_{tn}^2\right) \tag{15}$$

The author defines the product Kr as '**kinetic energy moment**'. We observe that the kinetic energy moments remain constant on both sides of Eq. (15). This equation strongly suggests that the spin of the particles is the real cause for Coulomb force attraction, not the electrostatic charge e.

Eq. (15) can be simplified for circular orbits of different n's:

$$\left(\tfrac{1}{2} K_{sp} r_p + \tfrac{1}{2} K_{se} r_e\right)(\alpha) = 2K_{ton} r_{ton} \tag{16}$$

THE DE BROGLIE WAVE EQUATION

From (9) and (14) we have:

$$m_e c r_e = \hbar = h / 2\pi \tag{17}$$

The wavelength of the electron is then:

$$\lambda_e = 2\pi r_e = h / m_e c = h / \rho_e \tag{18}$$

Generalizing for all single particles including photons, (18) becomes the de Broglie wave equation:

$$\lambda = h / \rho \tag{19}$$

From (17) and (18), the equation for energy of the electron is:

$$K_{se} = E_e = m_e c^2 = hc / \lambda_e \tag{20}$$

Generalizing for all single particles and photons, (20) becomes:

$$E = hc / \lambda \tag{21}$$

THE HEISENBERG UNCERTAINTY PRINCIPLE

If the time for one orbit of revolution is considered, $T = \lambda / c$, then (21) becomes:

$$ET = h \tag{22}$$

which resembles one form of the Heisenberg uncertainty principle.

BACK TO THE BOHR ATOM

From (6), (7), and (16):

$$\hbar c\alpha = 2K_{ton} r_{ton} = 2a^2 K_{eon} r_{eon} \tag{23}$$

It is easy to see from (23) that the kinetic energy moment of an electron orbiting about a proton in the Bohr atom is constant, $K_{eon} r_{eon} = \hbar c\alpha / 2a^2$. From (20), the spin kinetic energy moment of the electron is $K_{se} r_e = \hbar c$. So the ratio R_{so} of the spin kinetic energy moment to its orbital kinetic energy moment is:

$$R_{so} = K_{se} r_e / K_{eon} r_{eon} = 2a^2 / \alpha \tag{24}$$

Eq. (24) shows that the self spin ability of a electron to create force has $2a^2 / \alpha$ times the force ability of its orbital spin. This ratio may also apply to neutral massive bodies and their self spin and orbital spin, but this has not been demonstrated.

THE KINETIC ENERGY APPROACH APPLIED TO NEUTRAL MASSIVE BODIES

For neutral massive bodies, the following applies:

$$GM_1 m_2 \left(1 / r_t^2\right) = \left(2aK_{o2}\right)\left(ar_{o2}\right)\left(1 / r_t^2\right) = E_g R_g \left(1 / r_t^2\right) \tag{25}$$

Eq. (25) expresses the gravity force law for *natural* orbits in terms of orbital kinetic energy moment. The far right side of (25) is analogous to the right side of (3). If we set $R_g = ar_{o2}$ and $E_g = 2aK_{o2}$, then R_g becomes the distance at which a less distance would have no force (see the comments on (3) above), thus making the natural orbit one without force.

The force on a mass in a constrained orbit, such as a mass at the equator of our revolving Earth, is given by:

$$F_c = \left(1 / r_c^2\right)\left(GM_1 m_2 - 2K_{o2} r_c\right) = \left(1 / r_c^2\right) 2K_{o2}\left(r_{o2} - r_c\right) \tag{26}$$

where r_c is the radius of the constrained orbit. This equation is just the expression of conventional Newtonian mechanics.

Osborne and Pope has allowed for variation of the parameter G to account for weight changes due to a spinning mass such as a gyroscope. This author, however, has not carried the development of the theory beyond conventional physics formulae.

CONCLUSIONS

1. Angular momentum of the Bohr atom is conserved at all energy levels of the Bohr atom when it is considered that the angular momentum of an absorbed photon is added to the angular momentum of the atom. This supports Osborne and Pope's claim of 'holistic' angular momentum conservation at the micro level. Also, the energy moments (Kr) remains constant for all energy levels. It is necessary for orbital radii of the electron and proton to vary to keep its product with changing orbital kinetic energy constant.

2. This paper offers no new support to Osborne and Pope's theory at the macro level.

3. The model of the electron supported by analysis in this article is: the electron is a 'photon particle', its kinetic spin energy is $m_e c^2$, and its radius is $3.8615937 \times 10^{-13}$ m. Similar properties of the proton are also supported.

4. Relationships among the basic equations of modern physics are shown in this paper. This may be termed as a 'unification', but not necessarily a 'no-field' unification.

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