EMERGENCE OF CHARGE FROM SPIN

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ABSTRACT

This paper proposes that charge is an emergent property of a spinning body. Specifically, an atomic particle or celestial body spinning about its axis develops a charge $Q = km\omega\sqrt{(\frac{\varepsilon_0}{\rho})}$, where k is a dimensionless constant, m is the mass of the sphere, ω is the angular velocity of its surface, ρ its density, and ε_0 the permittivity of free space. We argue that the charge so developed is an important contributory factor to geomagnetism and propose a calculation for the component of a planet's magnetic field strength that arises from its orbital motion. We also reframe Coulomb's law to express the electrostatic force between two charged particles in terms of their masses, densities, and angular velocities. We further show that our proposed equation for charge leads to the well-known relationship $e = \sqrt{(2\alpha hc\varepsilon_0)}$ (where α is the fine-structure constant) if we make the assumption that the electron is a spherical particle and that every point on its surface revolves about its centre at velocity c – effectively suggesting that the electron does not have a solid surface nor is it a point particle. The paper ends with a conclusion and recommendation for further study.

***Key words**: electric charge, spin, coulomb's law, geomagnetism, planetary charge*

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1. INTRODUCTION

References to the charge of the earth in the literature generally attribute it to the accumulation of ions, electrons, and protons – for example, [1]. This paper proposes that charge is an emergent effect of spin, so celestial bodies must all possess charge in consequence of their spins just like atomic particles and separate from the charge acquired through the accumulation of such particles. This hypothesis of the development of charge relies on a paradigm that stipulates the routine capability of matter to exist alternately as a particle and a wave and to travel at the velocity of light. We shall therefore treat electrons, protons, and like entities as particles when considering the origin of their charges.

2. METHODS

This paper is founded on two postulates whose consequences we then proceed to investigate.

i. Postulate 1

A spinning body develops charge by its spinning motion.

ii. Postulate 2

The surfaces of charged atomic particles rotate about their centres at the velocity of light.

The second postulate is inspired by the observation that if fundamental charge is a consequence of the rotatory motion of the surface of an atomic particle about its centre or axis, the velocity of rotation must itself be a fundamental velocity if such charge is to prove constant across space, time, and events. The only fundamental velocity in nature is the velocity of light, hence the postulate. I recognize the longstanding objection to the notion of a spinning electron on account of its magnetic moment but having weighed it against the recognition that stipulation of spin in the manner described apparently accounts for the origin of charge, I consider this postulate reasonable.

3. RESULTS

i. Derivation of the general equation of charge

Using dimensions, we propose that when a spherical particle of mass m and density ρ spins with angular velocity ω in free space, it develops a charge Q given by

$$Q = km\omega\sqrt{\left(\frac{\varepsilon_0}{\rho}\right)} \qquad \text{.....(i)}$$

where k is a dimensionless constant to be determined and ε_0 is the permittivity of free space. To determine the value of k, let us suppose that r = radius of spherical charged atomic particle.

Then $Q = k\omega\sqrt{\left(\frac{4\pi r^3 m\varepsilon_0}{3}\right)}$

According to *Postulate 2*, $c = r\omega$ where c is the velocity of light. If we substitute for ω above, then

$$Q = k\sqrt{\left(\frac{4\pi r m c^2 \varepsilon_0}{3}\right)} \qquad \text{.....(ii)}$$

Now $mc^2 = hf$, where h is Planck's constant and f is the frequency of the atomic particle, say an electron.

We interpret f to be equal to the reciprocal of the period of revolution of the particle surface.

Therefore, $f = \frac{c}{2\pi r}$ .....(iii)

Giving $r = \frac{h}{2\pi mc}$ .....(iv)

Substituting for r in *equation (ii)* above gives $Q = k\sqrt{\left(\frac{2hc\varepsilon_0}{3}\right)}$ ..... (v)

Since Q is the electron charge e, our constant $k = 0.1479 = \sqrt{(3\alpha)}$, where α is the fine-structure constant.

ii. Reframing Coulomb's law in terms of mass, length, & time

If we substitute *equation (i)* into Coulomb's law, it assumes the following form for point particles separated by a distance a:

$$F = \left(\frac{k^2}{4\pi}\right)\left(\frac{m_1 m_2}{a^2}\right)\left(\frac{\omega_1 \omega_2}{\sqrt{(\rho_1 \rho_2)}}\right) \qquad \text{.....(vi)}$$

iii. Planetary magnetic field strength due to orbital motion

We shall assume that *equation (i)* also expresses the charge developed by a planet spinning about its axis. The orbital rotation of such a planet must then generate a magnetic field.

According to the Biot-Savart law, the magnetic field strength B at a distance r due to a current I in a tiny length Δl of conductor is given by

$$B = \frac{\mu_0 I \Delta l \sin\theta}{4\pi r^2}$$

For a planet with charge Q and orbital velocity v, $I\Delta l = Qv$. Therefore, the maximum magnetic field strength on its surface due to its orbital velocity is given by

$$B = \frac{\mu_0 Q v}{4\pi r^2} \qquad \text{.....(vii)}$$

where r is the radius of the planet.

4. DISCUSSION

i. Meaning of frequency of an elementary charged particle at rest

Equation (iii) describes what is meant by the frequency of an atomic particle at rest.

ii. Structure of an elementary charged particle

We may re-arrange *equation (iv)* to become $mcr = \frac{h}{2\pi}$

The left hand side of this equation gives the total magnitude of angular momenta over the entire surface of the particle. The equation suggests that the particle is a hollow sphere whose radius is inversely proportional to its mass. The electron, therefore, has a larger radius than the proton.

This counterintuitive size disparity is better appreciated if we express the radius of a charged atomic particle in terms of its energy content. Using *equation (iii),*

$E = mc^2 = hf = \frac{hc}{2\pi r}$

Therefore, energy content $E = \frac{hc}{2\pi r}$

This implies that the greater the energy content of the particle, the greater is the curvature of the circle that a point on its surface traces as it revolves about the particle's centre at the speed of light. Hence the greater the energy content of the particle, the smaller is the particle. It is therefore a mistake to call the electron a point particle – it does not possess the quantity of energy required to shrink itself to a veritable point particle.

This equation relating the energy content of a particle to its radius is important, for without it the force that constrains the particle's fluid-like surface to rotate about its centre would necessarily originate from another particle, most likely one hitherto unknown. This would tend to promote the Pandora's box model of the atom characterized by interminable postulation of new particles.

Equation (iv) gives us the following values for radius of the proton and electron:

Radius of proton $r_p = 0.21$ fm

And radius of electron $r_e = 386.2$ fm

The experimental value of the radius of the proton is not firmly established but is estimated to be 0.8409 fm (PDG group cited by [2, p. 1]). The difference between the predicted and experimental values is probably due to the proton being different in structure from the model of particle described here: a hollow sphere with every point on its surface rotating about its centre at velocity *c*. If protons were spherical, the charge and mass of a proton would be fully accounted for by the rotation and mass of its surface. Its constituent particles would therefore have neither mass nor charge.

Contemporary particle theory holds that the proton is a composite particle comprising two up-quarks and one down-quark whose fractional charges add up to the fundamental charge *e*. According to *equation (v)*, however, the charge *e* is always produced whole since the

equation has no variables. The occurrence of fractional charges, though, suggests that the surfaces of particles with such charges rotate at a velocity less than *c* about their centres. Suppose that the velocity of rotation is *v* and that $\frac{v}{c} = \gamma$. Then *equation (v)* becomes

$Q = k\sqrt{\left(\frac{2\gamma hc\varepsilon_0}{3}\right)}$ .....*(viii)*

Therefore, if *q* is the fractional charge, then $q = e\sqrt{(v/c)}$ .....*(ix)*

The accommodation of a subluminal velocity of rotation about the particle centre is obviously not compatible with *Postulate 2*, but we shall let the postulate stand because free particles with fractional charges have never been observed.

iii. Charge independence of mass

Equations (v) and *(viii)* show that the charge of an elementary particle should be independent of its mass – exactly as observed experimentally.

iv. Electrostatic force independence of ε_0

Equation (vi) shows that while the permittivity of free space influences the magnitude of charge developed by a particle, the electrostatic force between charged particles is independent of the medium.

The same equation shows that the ratio of electrostatic force to gravitational force is given by

$$\left(\frac{k^2}{4\pi G}\right)\left(\frac{\omega_1\omega_2}{\sqrt{(\rho_1\rho_2)}}\right)$$

where G is the gravitational constant. This indicates that electrostatic force far exceeds the magnitude of gravitational force largely because of the enormous angular velocities of atomic particles. In principle, therefore, it is possible for gravitational force to be greater than electrostatic force.

v. Magnetic field strengths of planets in the solar system due to planetary spin

Planet	**Planet Mass (Kg)**	**Period (s)**	**Density (Kg/cu. m)**	**Charge (C)**	**Predicted Maximum Magnetic Field Strength (tesla)**	**Observed Magnetic Field Strength (tesla)**
Earth	5.97×10^{24}	86400	5520	2.573×10^{12}	1.888×10^{-4}	3.8×10^{-5}
Mercury	3.285×10^{23}	5068800	5429	2.433×10^{9}	1.956×10^{-6}	3.0×10^{-7}
Venus	4.867×10^{24}	20995200	5243	8.857×10^{9}	8.476×10^{-7}	-
Mars	6.39×10^{23}	88642	3934	3.180×10^{11}	6.683×10^{-5}	$\leq 1 \times 10^{-7}$
Jupiter	1.898×10^{27}	35760	1326	4.033×10^{15}	1.078×10^{-3}	5.5×10^{-4}
Saturn	5.683×10^{26}	38040	687	1.577×10^{15}	4.473×10^{-4}	2.8×10^{-5}
Uranus	8.681×10^{25}	62040	1263	1.089×10^{14}	1.151×10^{-4}	3.2×10^{-5}
Neptune	1.024×10^{26}	57960	1638	1.208×10^{14}	1.082×10^{-4}	2.7×10^{-5}

Table 4.1 *Planetary Charges and Magnetic Field Strengths due to Orbital Motion (Observed magnetic field strengths sourced from Schubert and Soderlund* [3, p. 93]

The observed values of magnetic field strength differ significantly from the values predicted in the table above. This signifies the presence of other sources of geomagnetism. Interestingly, the charge of the earth is estimated by Dolezalek [4, p. 244] as 5 X 10^{12} C using a completely different approach from the one adopted here – an estimate about double the predicted value in Table 4.1 but of the same order.

5. CONCLUSION

.Based on the proposition that electric charge is not an intrinsic property of atomic particles but an emergent effect of spinning motion, we proposed an equation for the charge developed by a spinning orb, be it an atomic particle or a celestial body. With appropriate assumptions, we were able to derive from the aforesaid equation the well-known relationship between fundamental charge and other fundamental constants -- $e = \sqrt{(2\alpha hc\varepsilon_0)}$ (where α is the fine-structure constant). We applied our proposed charge equation to calculate the charge developed by each planet due to its rotation about its axis; the charge calculated was then used to work out the strength of the geomagnetic field that arises from the orbital motion of each planet. Lastly, we were able to frame Coulomb's law for the electrostatic force between two charged particles in terms of their masses, densities, and angular velocities.

I recommend for further study the mechanism by which the spin of charged particles creates attractive and repulsive forces between them.

6. DECLARATIONS

The author certifies that he has no affiliation with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

7. REFERENCES

[1] I. B. Bezrukov, V. P. Zavarzina, A. S. Kurlovich, B. K. Lubsandorzhiev, A. K. Mezhokh, V. P. Morgaluk and V. V. Sinev, "On the Negatively Charged Layer of the Earth's Electric Field," 11 January 2018. [Online]. Available: https://link.springer.com/article/10.1134/S1028335818050051. [Accessed 3 December 2022].

[2] S. Pacetti and E. Tomasi-Gustafsson, "The origin of the proton radius puzzle," 24 february 2021. [Online]. Available: https://doi.org/10.1140/epja/s10050-021-00398-8. [Accessed 3 December 2022].

[3] G. Schubert and K. M. Soderlund, "Planetary magnetic fields: Observations and models," *Physics of the Earth and Planetary Interiors,* vol. 187, no. 2011, pp. 92-108, 2011.

[4] H. Dolezalek, "Discussion on the Earth's Net Electric Charge," *Meteorology and Atmospheric Physics,* vol. 38, no. 4, pp. 240-245, 1988.