

Article

Not peer-reviewed version

---

# Has the Electron's Electrostatic Charge $q_e$ Unknowingly Been Used as a Proxy for the Magnetic Moment $m_e$ ?

---

[Charles Mendler](#) \*

Posted Date: 8 October 2025

doi: 10.20944/preprints202510.0639.v1

Keywords: magnetic moment; electrostatic charge; Gauss's law; Maxwell equations



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a Creative Commons CC BY 4.0 license, which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Article

# Has the Electron’s Electrostatic Charge $q_e$ Unknowingly Been Used as a Proxy for the Magnetic Moment $\mu_e$ ?

Charles Mendler

ENVERA EV; cmendler@vcengine.com; Tel.: 415-887-8204

Abstract

This paper explores if the electron’s electrostatic charge  $q_e$  has unknowingly been used as a proxy for the electron’s magnetic moment  $\mu_e$ . Because both the electrostatic charge and the magnetic moment are intrinsic properties of the electron, the ratio between the two is also an intrinsic and constant property. The two properties are different, but if we know the value of one, we know the value of the other because of their fixed ratio. Because the ratio of  $q_e/\mu_e$  is constant, we can always express the traditional magnetic and electromagnetic equations in terms of  $q_e$ , as is currently done, or in terms of  $\mu_e$ . The existing magnetic and electromagnetic equations remain mathematically correct if we substitute  $\mu_e$  for  $q_e$  because of the fixed relationship between the two constants. The electron also has an electrostatic force field  $E$  that is caused by the electrostatic charge  $q_e$ , and a magnetic force field  $B$  that is said to also be caused by the electrostatic charge  $q_e$ . Logically, however, one would think that the electrostatic force field  $E$  would be caused by the electrostatic charge  $q_e$ , and the magnetic force field  $B$  would be caused by the magnetic moment  $\mu_e$ . This paper considers that the magnetic force field  $B$  is in fact caused by the magnetic moment  $\mu_e$ , and not the electrostatic charge  $q_e$ . It is proposed that  $q_e$  has unknowingly been used as a proxy for  $\mu_e$  in earlier mathematics.

**Keywords:** magnetic moment; electrostatic charge; Gauss’s law; Maxwell equations

## 1. Introduction

This paper explores if the electron’s electrostatic charge ( $q_e$ ) has unknowingly been used as a proxy for the electron’s magnetic moment ( $\mu_e$ ).

Because both the electrostatic charge and the magnetic moment are intrinsic properties of the electron, the ratio between the two is also an intrinsic and constant property [1]. The two properties are different, but if we know the value of one, we know the value of the other because of their fixed ratio.

Because the ratio of  $q_e/\mu_e$  is constant, we can always express the traditional magnetic and electromagnetic equations in terms of  $q_e$  (as is currently done) or in terms of  $\mu_e$ . The existing magnetic and electromagnetic equations remain mathematically correct if we substitute  $\mu_e$  for  $q_e$  because of the fixed relationship between the two constants.

## 2. Electrons

Electrons have intrinsic properties of electrostatic charge  $q_e$ , magnetic moment  $\mu_e$  and mass ( $m_e$ ). These intrinsic properties have the following constant values (National Institute of Standards and Technology) [2]:

Electrostatic charge  $q_e$  = -1.602,176,634 x 10<sup>-19</sup> Units: C

(1)

Magnetic moment  $\mu_e$  = -9.284,764,692 x 10<sup>-24</sup> Units: Nm/T

(2)

Mass  $m_e = 9.109,383,714 \times 10^{-31}$  Units: kg (3)

Because the intrinsic values of electrostatic charge and magnetic moment are constant, there is a fixed ratio of  $q_e/\mu_e$ , where,

$q_e/\mu_e = -1.602,176,634 \times 10^{-19}/-9.284,764,692 \times 10^{-24}$

$q_e/\mu_e = 17,255.974,569$  Units: (Cs/m<sup>2</sup>C) = s/m<sup>2</sup> (4)

The reciprocal of Equation 4 is,

$\mu_e/q_e = 0.000,057,950,943$  Units: (m<sup>2</sup>C/sC) = m<sup>2</sup>/s (5)

From Equation 4 we find that  $q_e$  equals,

$q_e = \mu_e(17,255.974,569)$  Units: (m<sup>2</sup>C/s)(s/m<sup>2</sup>) = C (6)

The two properties  $q_e$  and  $\mu_e$  are different, but if we know the value of one, we know the value of the other because of their fixed ratio. Therefore, the electrostatic charge  $q_e$  can be a proxy for the magnetic moment  $\mu_e$ . This paper considers that  $q_e$  has been used unknowingly as a proxy for the cause of magnetism, and that the magnetic moment, instead, is the source of the magnetic field around electrical conductors.

3. Electrical Current

Let’s refer to electrical current as *electron current* for the remainder of this paper. Electron current is the physical flow of electrons through a conductor. Electron current (I) is equal to,

$I = Q/t = n_e q_e$  C(e/s) Units: C/s (7)

where Q is electrostatic charge in units of Coulombs, t is time and Q/t is the electrostatic charge flowing through the conductor per second. On the right side of Equation 7,  $n_e$  is the number of electrons flowing through the conductor per second, and  $q_e$  is the electrostatic charge of a single electron.

4. Magnetic Field Surrounding an Electrical Conductor

The existence of circular magnetic fields surrounding electrical conductors was discovered by Hans Christian Oersted in 1820 [3,4]. According to Ampere’s Law, the magnetic flux density (B) around an electrical conductor is equal to [1,5],

$B = \mu_o I / 2\pi R$  Units: kg/sC = T (8)

$\mu_o = 4\pi \times 10^{-7}$  Units: kgm/C<sup>2</sup> = Tm/A (9)

where  $\mu_o$  is the permeability of free space, I is the electron current, and R is the radial distance from the electrical conductor.

The term  $2\pi R$  is the length a circular Amperian loop around a conductor, and may be denoted  $L_c$ . Dividing both sides of Equation 8 by circular length  $2\pi R$  we have,

$L_c = 2\pi R$  Units: m (10)

$$BL_C = \mu_o I = \mu_o I_{enc} \qquad \text{Units: } \text{kgm/sC} = \text{Tm} \qquad (11)$$

The term  $I_{enc}$  is often used to underscore that only the electron current inside of the Amperian loop is considered in Ampere’s Law.

**5. Relationship Between the Magnetic Moment  $\mu_e$  and Magnetic Flux Density B**

Let’s revisit Equation 7. The electron current for a single electron ( $i_e$ ) is equal to,

$$i_e = n_1 q_e \qquad \text{Units: } \text{C/s} \qquad (12)$$

where  $n_1$  denotes a single electron flowing through the conductor per second. Let’s now revisit Equation 8 for the magnetic flux density B surrounding an electrical conductor. The magnetic flux density attributable to the single electron (b) is then equal to,

$$b = \mu_o i_e / 2\pi R \qquad \text{Units: } \text{T} \qquad (13)$$

$$b = \mu_o n_1 q_e / 2\pi R \qquad \text{Units: } \text{T} \qquad (14)$$

Let’s now express Equation 14 in terms of the magnetic moment  $\mu_e$ . Substitute Equation 6 into Equation 14 we have,

$$b = \mu_o n_1 \mu_e (17,255.974,569) / 2\pi R \qquad \text{Units: } \text{T} \qquad (15)$$

Multiplying both sides by  $2\pi R$  we have,

$$b 2\pi R = \mu_o n_1 \mu_e (17,255.974,569) \qquad \text{Units: } \text{Tm} \qquad (16a)$$

And replacing  $2\pi R$  with  $L_c$  we have,

$$b L_C = n_1 \mu_o \mu_e (17,255.974,569) \qquad \text{Units: } \text{Tm} \qquad (16b)$$

To solve for the total magnetic field B around the electrical conductor, let’s now replace our single electron  $n_1$  by term  $n_f$  for the total number of free electrons making up the electron current:

$$BL_C = n_f \mu_o \mu_e (17,255.974,569) \qquad \text{Units: } \text{kgm/sC} = \text{Tm} \qquad (17)$$

An imbalance of static electric charge from one location to another in a conductor can cause a “rebalancing” electron current ( $n_d$ ), even when the wire has a disconnected end preventing the conduction of electron current  $n_f$ . The rebalancing electron current  $n_d$  is known as *displacement current*, a term coined by James Clerk Maxwell [1]. Considering displacement current  $n_d$ , Equation 17 then becomes,

$$BL_C = (n_f + n_d) \mu_o \mu_e (17,255.974,569) \qquad \text{Units: } \text{kgm/sC} = \text{Tm} \qquad (18)$$

Let’s now consider a non-circular Amperian loop. We solve for a non-circular closed Amperian loop with integration and the dot product of vectors  $\vec{B}$  and  $d\vec{L}$ , where,

$$\oint \vec{B} \cdot d\vec{L} = (n_f + n_d) \mu_o \mu_e (17,255.974,569) \qquad \text{Units: } \text{kgm/sC} = \text{Tm} \qquad (19)$$

Equation 19 is the proposed Ampere-Maxwell-Mendler circuit Law, where the magnetic flux around an electrical conductor is solved for in terms of the magnetic moment of the electrons contributing to the electron current.

The magnetic flux density around an electrical conductor is solved for by multiplying the scalar value of the number of free electrons making up the electrical current  $(n_f + n_d)/n_1$  by the magnetic flux density  $b$  of an individual electron, where,

$$B = b(n_f + n_d)/n_1$$

Units: T

(20)

6. Free Electron Alignment

Let’s consider first a copper electrical conductor. Copper atoms have an equal number of electrons and protons, leaving the copper atoms with a net static electric charge of zero. The protons are secured in place in the atom’s nucleus, and not free to leave the copper atom. By contrast, one of the outer valance electrons is free to leave the atom, provided that a second electron is added to the atom to take its place. This free motion of the outer electrons enables the flow of electron current through copper wire. So long as the departing electron is replaced by an arriving electron, the static electric charge of the copper remains equal to zero. The electrons are said to be in “free space” when they are in motion between copper atoms.

According to Equation 20, the magnetic flux density  $B$  around an electrical conductor is due to the sum of the magnetic moments  $b$  of the individual electrons making up the electron current. The derivation of Equation 20 implies that the magnetic moments of the free electrons making up the electron current are aligned, and thereby provide an additive net magnetic force field. Alignment is assumed to occur only in the special case when the electrons are between (copper) atoms and in “free space”. Electrons are currently known to align in free space in certain situations. Of note, the emerging field of spintronics considers generation of spin-polarized electrons [6]. Alignment of the magnetic moments of the electrons in free space within electrical conductors is the subject of further research.

7. Stationary Force Fields

The electrostatic and magnetic force fields have directionality, but not intrinsic motion. For example, a magnet placed far away from other objects has a stationary magnetic force field. The force field has directionality without physical motion. The electrostatic charge  $q_e$  produces a static force field having radial flux. The magnetic moment  $\mu_e$  produces a static force field having rotational flux (as first observed by Oersted). The force fields are stationary in their static ground state, while at the same time having directional orientation.

8. Gauss’s Law of Radiating Flux

Gauss’s Law relates to **radiating flux**. Gauss’s Law states that the net flux radiating through a closed surface surrounding a source charge is proportional in magnitude to the radial flux from the source charge.

Gauss’s Law for electrostatic and magnetic charges are as follows [1,5,7,8]:

$$\phi_{E-enc} = \oint (\vec{E} \cdot \hat{n}_A) dA = Q_{enc} / \epsilon_0$$

Gauss’s Law of Static Electricity

(21)

Units:

$$kg\ m^3/s^2C = Nm^2/C$$

$$\phi_{B-enc} = \oint (\vec{B} \cdot \hat{n}_A) dA = 0$$

Gauss’ Law of Magnetism

(22)

Units:

$$kg\ m^2/sC = Tm^2$$

Equations 21 and 22 solve for the net flux radiating through a closed surface. Terms  $\phi_{E-enc}$  and  $\phi_{B-enc}$  provide the total radiating flux normal to a closed surface surrounding a source charge.

In the case of electrostatics, Gauss’s Law states that the net flux radiating through a closed surface surrounding a source charge is equal in magnitude to the source charge ( $Q_{enc}$ ) divided by the permittivity of free space ( $\epsilon_0$ ). The source charge for a single electron is denoted  $q_e$ , and for multiple charges  $Q$ .

Let’s now consider Equation 22. Magnetic field lines form closed loops. Accordingly, the magnetic flux leaving a closed surface is equal to the magnetic flux entering the closed surface, resulting in a net radial flux equal to zero.

9. Mendler’s Law of Rotational Flux

Mendler’s Law relates to **rotational flux**, and is being first proposed in this paper. Gauss’s Law relates to radiating flux through a closed surface, and Mendler’s Law relates to the rotational moment force or torque on the closed surface.

Mendler’s Law states that the net moment force of flux on a closed surface surrounding a source charge is proportional in magnitude to the rotational moment force of the source charge. Mendler’s Law for electrostatic and magnetic charges are as follows:

$$\varphi_{E-enc} = \oint (\vec{E} \times \vec{R}) dA = 0$$

Mendler’s Law of Static Electricity

(23)

Units:

$$\text{kg m}^4/\text{s}^2\text{C} = \text{Nm}^3/\text{C}$$

$$\varphi_{B-enc} = \oint (\vec{b} \times \vec{R}) dA = \mu_e \mu_o$$

Mendler’ Law of Magnetism

(24)

Single electron equation

Units:

$$\text{kg m}^3/\text{sC} = \text{Tm}^3$$

Term  $\varphi_{B-enc}$  of Equation 24 provides the net magnetic moment force or torque acting on a closed surface surrounding an electron. Magnetic moment  $\mu_e$  is considered the source charge for magnetism. Term  $\varphi_{E-enc}$  from Equation 23 has a value of zero because the electrostatic force acts only in the radial direction, and does not have a rotationally acting component.

In Table 1 the Maxwell Equations are extended to include Mendler’s Law of rotational force fields, and the proposed Ampere-Maxwell-Mendler circuit Law. Table 2 compares electrostatic and magnetic force fields relative to the Gauss and Mendler laws.

Table 1. Maxwell Equations Extended [1,8,9].

|                                        |                                                                                                                                                                                                                     |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gauss’ Law for static Electricity      | $\varphi_{E-enc} = \oint (\vec{E} \cdot \hat{n}_A) dA = Q_{enc} / \epsilon_o$<br>$\nabla \cdot E = \rho / \epsilon_o$                                                                                               |
| Gauss’ Law for Magnetism               | $\varphi_{B-enc} = \oint (\vec{B} \cdot \hat{n}_A) dA = 0$<br>$\nabla \cdot B = 0$                                                                                                                                  |
| Mendler’s Law for Static Electricity   | $\varphi_{E-enc} = \oint (\vec{E} \times \vec{R}) dA = 0$                                                                                                                                                           |
| Mendler’s Law for Magnetism            |                                                                                                                                                                                                                     |
| Single electron                        | $\varphi_{B-enc} = \oint (\vec{b} \times \vec{R}) dA = \mu_o \mu_e$                                                                                                                                                 |
| Faraday’s Law of Induction             | $BEMF = \int \vec{E} \cdot d\vec{L} = -d\varphi_B/dt$<br>$\nabla \times E = dB/dt$                                                                                                                                  |
| Ampere - Maxwell Circuit Law           | $\oint \vec{B} \cdot d\vec{L} = \mu_o (i_{enc} + i_d)$<br>$\oint \vec{B} \cdot d\vec{L} = \mu_o (i_{enc} + \epsilon_o d\varphi_E/dt)$<br>$\nabla \times B = \mu_o ( \vec{J} + \epsilon_o \partial E / \partial t )$ |
| Ampere - Maxwell - Mendler Circuit Law | $\oint \vec{B} \cdot d\vec{L} = (n_i + n_d) \mu_o \mu_e \text{ 17,256}$                                                                                                                                             |

Table 2. Electron radiating and rotational flux values compared.

| Flux density   |               | E                 | B                 |
|----------------|---------------|-------------------|-------------------|
| Gauss’s Law:   | Flux          | $\varphi_{E-enc}$ | 0                 |
| Mendler’s Law: | Flux x meters | 0                 | $\varphi_{B-enc}$ |



## 10. Prior Theory of Magnetism

According to prior theory magnetism is a variance in the electrostatic force field that is found by applying Special Relativity [10]. Attributing magnetism to Special Relativity effects has two drawbacks. In the first case, the field around an electrical conductor has a rotational direction. According to Special Relativity, the conductor would experience radial not rotational flux. In the second case, the effect of Special Relativity has been shown to produce only a negligibly small effect in common electrical conductors [11]. This is due to the slow electron drift velocities relative to the speed of light. Accordingly, Special Relativity does not account for the observed magnetic force field. A new or revised explanation for the rotational magnetic field is needed. This paper proposes that the magnetic field  $B$  is due to the electron's magnetic moment  $\mu_e$ , and not  $q_e$ .

## 11. Conclusions

This paper explores if the electron's electrostatic charge  $q_e$  has unknowingly been used as a proxy for the electron's magnetic moment  $\mu_e$ .

Because both the electrostatic charge and the magnetic moment are intrinsic properties of the electron, the ratio between the two is also an intrinsic and constant property. The two properties are different, but if we know the value of one, we know the value of the other because of their fixed ratio.

Because the ratio of  $q_e/\mu_e$  is constant, we can always express the traditional magnetic and electromagnetic equations in terms of  $q_e$  (as is currently done) or in terms of  $\mu_e$ . The existing magnetic and electromagnetic equations remain mathematically correct if we substitute  $\mu_e$  for  $q_e$  because of the fixed relationship between the two constants.

The electron also has an electrostatic force field  $E$  that is caused by the electrostatic charge  $q_e$ , and a magnetic force field  $B$  that is said to also be caused by the electrostatic charge  $q_e$ . Logically, however, one would think that the electrostatic force field  $E$  would be caused by the electrostatic charge  $q_e$ , and the magnetic force field  $B$  would be caused by the magnetic moment  $\mu_e$ . This paper considers that the magnetic force field  $B$  is in fact caused by the magnetic moment  $\mu_e$ , and not the electrostatic charge  $q_e$ .

The rotational magnetic field around electrical conductors was first observed by Oersted in 1820. Shortly after Biot and Savart working together, and then Ampere working separately derived "Ampere's" circuit law. The electron had not yet been discovered.

The electron was discovered by J. J. Thomson in 1897, and the electrostatic charge of the electron was determined by Robert A. Millikan in 1909 [3,5]. We can now solve for the number of electrons  $n_e$  making up an electron current. We are then left with the choice of multiplying the number of electrons making up the electron current  $n_e$  by the electron's electrostatic charge  $q_e$  or the magnetic moment  $\mu_e$ . Either approach may be used to solve the Ampere circuit law because of the fixed ratio of  $q_e/\mu_e$ . It seems logical to solve for the magnetic flux density  $B$  in terms of the magnetic moment  $\mu_e$ . This paper considers that the magnetic flux density  $B$  is caused by the magnetic moment  $\mu_e$  and not  $q_e$ . It is proposed that  $q_e$  has been used as a proxy for  $\mu_e$  in the Amperian Circuit Law.

Mendler's Law of rotational force fields is proposed. Gauss's Law relates to radiating flux, and Mendler's Law relates to the moment force or torque of rotational flux. The Maxwell Equations are extended in this paper to include Mendler's Law.

The magnetic field around electrical conductors has previously been considered to be due to Special Relativity effects. That explanation has two shortcomings. In the first instance, Special Relativity effects would produce a radial force field, however the observed magnetic field is rotational. In the second instance, Special Relativity produces a negligibly small force field due to the slow electron drift velocity relative to the speed of light. The proposed new explanation for the magnetic field is based directly on the magnetic moment  $\mu_e$ , and provides both a rotational magnetic force field and a force field of the correct strength.

The proposed new explanation for the magnetic field around electrical conductors assumes that the magnetic moment's of the free electrons align in the direction of the electron current. Alignment

is assumed to occur only in the special case when the electrons are between (copper) atoms and in “free space”. Electrons are currently known to align in free space in certain situations. Alignment of the magnetic moments of the electrons in free space within electrical conductors is the subject of further research.

## References

1. Walker, J. (2011) *Fundamental of Physics* (9th Ed.). Wiley pub, p. 605, 765, 866, 869, 871.
2. National Institute of Standards and Technology (NIST). [https://Physics.nist.gov/cgi-bin/cuu/Value?me|search\\_for=electron+mass](https://Physics.nist.gov/cgi-bin/cuu/Value?me|search_for=electron+mass)
3. Fitzpatrick, Richard (2008) *Maxwell's Equations and the Principles of Electromagnetism*. Infinity Science Press, p. 68, 73
4. Schultz, Mitchel E. (2021). *Grob's Basic Electronics* (13<sup>th</sup> ed.). McGraw Hill pub. p. 427.
5. Giancoli, Douglas C. (2005). *Physics* (6<sup>th</sup> ed.). Pearson Prentice Hall pub. p. 457, 568, 754, 756.
6. Hirohata, Atsufumi (2020). Review of spintronics: Principles and device applications. *Journal of Magnetism and Magnetic Materials* 509 (2020) 166711, p. 3
7. Larson, Ron (2006). *Calculus* (8<sup>th</sup> ed.). Houghton Mifflin pub. p. 1120.
8. Lucid, Nick (2023). *Advanced Theoretical Physics*. Science Asylum pub. p. 108, 117.
9. Zangwill, Andrew (2022). *Modern Electrodynamics*. Cambridge University Press pub. p. rear inner cover.
10. Purcell, E., & Morin, D. (2013). *Electricity and Magnetism* (3<sup>rd</sup> ed.). Cambridge University Press, p. 259.
11. Mendler, C. (2025, April 24). Simplified Calculation of Magnetic Fields Induced by Special Relativity Effects Shows Magnetism Due Largely to Other Causes. (*Applied Physics Research*; Vol. 17, No. 1) pub. Canadian Center of Science and Education

**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.