Check for updates

Theoretical physics.
Theory of magnetic properties of solids

UDC 537.611.2

EDN WCYYUP
https://www.doi.org/10.33910/2687-153X-2025-6-2-110-115

Theoretical and experimental discovery of the magnetic monopole and magnetic charge

I. P. Popov [✉1]

[1] Kurgan State University, 63/4 Sovetskaya Str., Kurgan 640020, Russia

Author
Igor P. Popov, ORCID: 0000-0001-8683-0387, e-mail: ip.popow@yandex.ru

For citation: Popov, I. P. (2025) Theoretical and experimental discovery of the magnetic monopole and magnetic charge. *Physics of Complex Systems*, 6 (2), 110–115. https://www.doi.org/10.33910/2687-153X-2025-6-2-110-115 EDN WCYYUP

Received 9 March 2025; reviewed 19 March 2025; accepted 19 March 2025.

Funding: The study did not receive any external funding.

Abstract. This paper shows that magnetic monopoles and charges exist, inter alia, in solids and cosmic rays, which include electric charges. The magnetic charge, like the electric and the gravitational one, is located in the numerator of the formula for the force of magnetic interaction. Thus, the magnetic charge is equal to $I d\mathbf{l}$. It is this value that creates the force (magnetic) field, interacts with other similar values and, therefore, in accordance with the definition given above, is the magnetic charge. Universal representation is $q\mathbf{v}$. Its universality lies in the fact that it is suitable for individual particles, including cosmic rays, which include electric charges.

Keywords: magnetic monopole, magnetic charge, electric charge, gravitational charge, electron

Introduction

Attempts to obtain a magnetic monopole by cutting a magnet into two parts have failed so far. Magnetic monopoles have not been found in space, ores, meteorites, lunar soil, experiments at the Large Hadron Collider, or anywhere at all.

Abstract models of the magnetic monopole of Dirac, Hooft — Polyakov, Urutskoev, and others have remained such and have not been found in nature.

At the same time, magnetic monopoles and charges exist, among other things, in solid bodies and cosmic rays, which include electric charges.

The purpose of this work is to detect them.

To do this, we just need to take a look at other charges.

Preliminary remarks on relationship between the magnetic charge and the electric charge

Theorem. The magnetic charge is proportional to the electric charge and the speed of its movement.

Proof.

1). The electric charge q is INSEPARABLY connected with the electric field.

2). The electric field strength $\mathbf{E}$ is proportional to the magnitude of the electric charge q, i. e. $E = k_1 q$.

3). The magnetic charge μ is INSEPARABLY connected with the magnetic field.

4). The magnetic field strength $\mathbf{H}$ is proportional to the magnitude of the magnetic charge μ, i. e. $H = k_2 \mu$.

When an electric charge moves at a speed **v**, a magnetic field arises, the strength of which is equal to

$$\mathbf{H} = \varepsilon_0[\mathbf{v}, \mathbf{E}] ,$$

where ε_0 is the electric constant.

In accordance with 2) and 4),

$$\frac{\mathbf{H}}{H} k_2 \mu = \varepsilon_0 \left[\mathbf{v}, \frac{\mathbf{E}}{E} k_1 q \right] .$$

The theorem is proved.

Corollary 1. The velocity **v** depends on the choice of the reference frame. Therefore, both the magnetic field and the magnetic charge also depend on the choice of the reference frame (they are not invariant).

Corollary 2. At **v** = 0, the magnetic field cannot exist. Therefore, in accordance with 3), the magnetic charge cannot exist either.

Remark 1. The idea that the magnetic charge is a fundamental characteristic of a particle and does not depend on the choice of the reference frame in accordance with 3) is equivalent to the idea that the magnetic field does not depend on the choice of the reference frame (unreliable idea).

Remark 2. The common view of a permanent magnet (magnetic dipole) as a static object ignores the motion of electrons in it. If these motions, including spin ones, are hypothetically stopped, the magnetic dipole will cease to exist.

Remark 3. A magnetic monopole is not the only physical object that cannot exist at zero velocity. Another one is the photon, the existence of which is unquestioned.

Remark 4: Opponents may point out that the dependence of the magnetic charge on velocity may indicate that it is not a conserved quantity. However, this argument does not discredit the idea of the magnetic charge, since the electric charge is not always conserved either — for example, in the annihilation of an electron and a positron.

A note on Dirac's magnetic charge

It is equal to the following:

$$g = \frac{n\hbar c}{2e} .$$

The fine structure constant is

$$\alpha = \frac{e^2}{4\pi\hbar}\sqrt{\frac{\mu_0}{\varepsilon_0}} .$$

$$\hbar = \frac{e^2}{4\pi\alpha}\sqrt{\frac{\mu_0}{\varepsilon_0}} .$$

$$g = \frac{n\hbar c}{2e} = \frac{nc}{2e}\frac{e^2}{4\pi\alpha}\sqrt{\frac{\mu_0}{\varepsilon_0}} = \frac{nce}{8\pi\alpha} Z_0 .$$

Z_0 is the impedance of free space.

The dimension of the Dirac magnetic charge includes the electric charge and velocity, which does not contradict the theorem proved above.

Finding a magnetic charge

A charge is a physical object that creates a force field and interacts with other charges of the same physical nature (Demidov 2022; Gorokhovatsky et al. 2022; Kononov et al. 2020).

The electric charge (q_1, q_2) (Aslyamova, Gavrilov 2020; Pronin, Khinich 2020) is located in the numerator of the formula for the force of interaction of electric charges

$$\mathbf{F}_{12} = \pm \frac{1}{4\pi\varepsilon_0\varepsilon} \frac{q_1 q_2}{r_{12}^3} \mathbf{r}_{12} ,$$

where e is relative permittivity and $\mathbf{r}_{12}$ is the radius vector.

The gravitational charge (m_1, m_2) (Vertogradov 2023) is located in the numerator of the formula for the force of gravitational interaction

$$\mathbf{F}_{12} = -G \frac{m_1 m_2}{r_{12}^3} \mathbf{r}_{12} ,$$

where G is the gravitational constant.

The magnetic charge, like the electric and the gravitational one, is located in the numerator of the formula for the force of magnetic interaction (Popov 2024)

$$d\mathbf{F}_{12} = -\frac{\mu_0\mu}{4\pi} \frac{\left(I_1 d\mathbf{l}_1, I_2 d\mathbf{l}_2\right)}{r_{12}^3} \mathbf{r}_{12} , \quad (1)$$

where μ_0 is the magnetic constant, μ is relative magnetic permeability, I_1, I_2 are the electric currents in the conductors, and $d\mathbf{l}_1$, $d\mathbf{l}_2$ are the elements of the interacting conductors with the currents.

A similar formula was obtained by Ampere (Ampere 1954).

Thus, the magnetic charge is equal to

$$d\boldsymbol{\mu} = I d\mathbf{l} . \quad (2)$$

It is this quantity that creates a force (magnetic) field, interacts with other similar quantities, and, therefore, is a magnetic charge according to the definition given above.

Universal representation is

$$d\boldsymbol{\mu} = I d\mathbf{l} = \frac{dq}{dt} d\mathbf{l} = \frac{d\mathbf{l}}{dt} dq = \mathbf{v} dq .$$

$$\boldsymbol{\mu} = q\mathbf{v} , \quad (3)$$

where $\mathbf{v}$ is the velocity of the electric charge.

Its versatility lies in the fact that it is suitable for individual particles (Pavlov 2024; Pavlov 2025), including cosmic rays, which include electric charges.

For an electron:

$$\boldsymbol{\mu}_e = -e\mathbf{v} , \quad (4)$$

where e is the charge of the electron.

As a consequence, the Lorentz force is equal to

$$\mathbf{F}_L = [\boldsymbol{\mu}, \mathbf{B}] ,$$

where $\mathbf{B}$ is magnetic induction.

 https://www.doi.org/10.33910/2687-153X-2025-6-2-110-115

Qualitative representation of the magnetic interaction force

A rigorous derivation of formula (1) is beyond the scope of this discussion, but its fundamental structure can be verified by the following reasoning.

There are two parallel elements of conductors with currents (magnetic monopoles with charges $I_1 d\mathbf{l}_1$ and $I_2 d\mathbf{l}_2$) (Fig. 1).

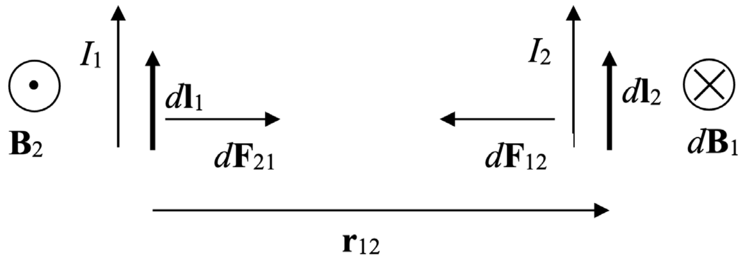

Fig. 1. Interaction of magnetic monopoles

The magnetic charge $I_1 d\mathbf{l}_1$ creates a magnetic field with induction at the location of the magnetic charge $I_2 d\mathbf{l}_2$

$$d\mathbf{B}_1 = \frac{\mu_0\mu}{4\pi r_{12}^3} I_1 [d\mathbf{l}_1, \mathbf{r}_{12}] .$$

The force acting on the second charge from the magnetic field is equal to

$$d\mathbf{F}_{12} = I_2 [d\mathbf{l}_2, d\mathbf{B}_1] =$$

$$= \frac{\mu_0\mu I_1 I_2}{4\pi r_{12}^3} \left[d\mathbf{l}_2, [d\mathbf{l}_1, \mathbf{r}_{12}]\right] = -\frac{\mu_0\mu}{4\pi} \frac{(I_1 d\mathbf{l}_1, I_2 d\mathbf{l}_2)}{r_{12}^3} \mathbf{r}_{12} . \quad (5)$$

On Newton's third law and Ampere's law

Theoretical magnetostatics does not satisfy Newton's third law (Fig. 2).

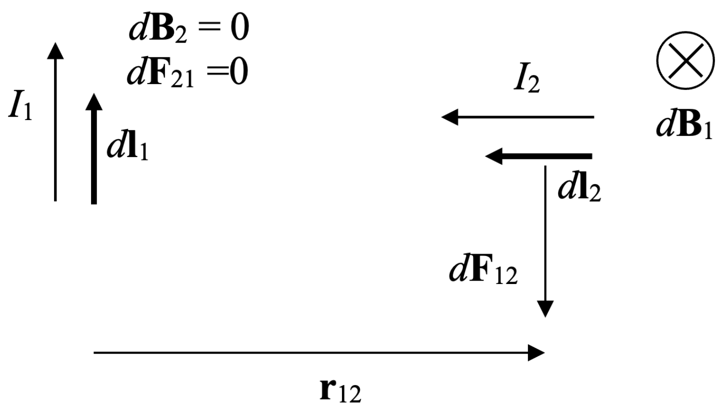

Fig. 2. Violation of Newton's third law

Indeed,

$$d\mathbf{F}_{12} = I_2\left[d\mathbf{l}_2, d\mathbf{B}_1\right] = \frac{\mu_0\mu I_1 I_2}{4\pi r_{12}^3}\left[d\mathbf{l}_2,\left[d\mathbf{l}_1,\mathbf{r}_{12}\right]\right] \neq 0 \ ,$$

$$d\mathbf{F}_{21} = I_1\left[d\mathbf{l}_1, d\mathbf{B}_2\right] = \frac{\mu_0\mu I_1 I_2}{4\pi r_{12}^3}\left[d\mathbf{l}_1,\left[d\mathbf{l}_2,\mathbf{r}_{12}\right]\right] = 0 \ .$$

Here

$$\left[d\mathbf{l}_2,\mathbf{r}_{12}\right] = 0 \ ,$$

since the vectors are collinear.

The contradiction with Newton's third law has the following justification: current elements are not independent objects, while Newton's third law is observed for closed electric circuits.

However, such justification is not convincing, since not all electric currents are closed. Among the examples of such currents are cosmic rays, which include electric charges.

Based on expression (1), magnetostatics is completely consistent with Newton's third law, which it unconditionally satisfies. (Popov 2024).

Remark 1. Ampere constructed magnetostatics on the basis of an expression similar to (1) (his formula differed only in the dimensionless coefficient) and declared the necessity of fulfilling Newton's third law (Ampere 1954).

Remark 2. Expression (5) is not Ampere's law. He does not have a single expression resembling this formula (Ampere 1954).

Conclusion

The discovered magnetic monopoles (2)–(4) have nothing in common with the monopoles of Dirac, Hooft–Polyakov, Urutskoev, etc. At the same time, the monopoles of Dirac, Hooft–Polyakov, Urutskoev, etc. do not exist in nature. However, monopoles (2)–(4) exist wherever there are moving electric charges, i. e., practically everywhere. They particularly determine the magnetic properties of solids and are present in cosmic rays, which include electric charges.

The theoretical value of this work lies in that the discovery of magnetic monopoles and magnetic charges improves the formal symmetry of electrodynamics, the violation of which has often concerned many specialists.

The practical contribution of the study is that the overwhelming majority of processes in electrical systems are determined by magnetic charges.

Conflict of Interest

The author declares that there is no conflict of interest, either existing or potential.

References

Ampere, A. M. (1954) *Elektrodinamika [Electrodynamics]*. Moscow: USSR Academy of Sciences Publ., 492 p. (In Russian)

Aslyamova, I. N., Gavrilov, S. P. (2020) Characteristics of high-frequency emission of an electron in graphene in a constant electric field. *Physics of Complex Systems*, 1 (2), 78–84. https://doi.org/10.33910/2687-153X-2020-1-2-78-84 (In English)

Demidov, E. V. (2022) Extrema positions of charge carrier band spectrum in thin bismuth films. *Physics of Complex Systems*, 3 (4), 154–158. https://doi.org/10.33910/2687-153X-2022-3-4-154-158 (In English)

Gorokhovatsky, Yu. A., Sotova, Yu. I., Temnov, D. E. (2022) A study of charge relaxation in corona electrets based on P(VDF-TFE) copolymer. *Physics of Complex Systems*, 3 (3), 104–108. https://doi.org/10.33910/2687-153X-2022-3-3-104-108 (In English)

Kononov, A. A., Castro Arata, R. A., Nikonorova, N. N. (2020) Effect of quasi-stationary electric field on charge transfer in poly(phenylene oxide) based composites. *Physics of Complex Systems*, 1 (2), 52–55. https://doi.org/10.33910/2687-153X-2020-1-2-52-55 (In English)

Pavlov, V. D (2024) O momente impul'sa kuperovskoj pary elektronov i kvante magnitnogo potoka [On the angular momentum of a Cooper pair of electrons and a quantum of magnetic flux]. *Prikladnaya fizika i matematika — Applied Physics and Mathematics*, 4, 12–16. http://dx.doi.org/10.25791/pfim.04.2024.1301 (In Russian)

Pavlov, V. D. (2025) On the electronic quantum structures of conductors. *Physics of Complex Systems*, 6 (1), 49–53. https://www.doi.org/10.33910/2687-153X-2025-6-1-49-53 (In English)

Popov, I. P. (2024) Combined vectors and magnetic charge. *Technical Physics*, 69 (8), 2397–2405. https://doi.org/10.1134/S1063784224700415 (In English)

Pronin, V. P., Khinich, I. I. (2020) Characteristic energy loss of electrons in mg with angle resolution. *Physics of Complex Systems*, 1 (1), 4–9. https://doi.org/10.33910/2687-153X-2020-1-1-4-9 (In English)

Vertogradov, V. D. (2023) On particle collisions during gravitational collapse of vaidya spacetimes. *Physics of Complex Systems*, 4 (1), 17–23. https://doi.org/10.33910/2687-153X-2022-4-1-17-23 (In English)