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RADIAL COMPONENT OF VORTEX ELECTRIC FIELD FORCE

Vasil Tchaban

Lviv Polytechnic National University, Lviv, Ukraine

vasyl.y.chaban@lpnu.ua

Abstract. The differential equations of motion of electrically charged bodies in an uneven vortex electric field at all possible range of velocities are obtained in the article. In the force interaction, in addition to the two components – the Coulomb and Lorentz forces – the third component of a hitherto unknown force is involved. This component turned out to play a crucial role in the dynamics of movement. The equations are written in the usual 3D Euclidean space and physical time. This takes into account the finite speed of electric field propagation and the law of electric charge conservation. On this basis, the trajectory of the electron in an uneven electric field generated by a positively charged spherical body is simulated. The equations of motion are written in vector and coordinate forms. A physical interpretation of the obtained mathematical results is given. Examples of simulations are given.

Key words: the third component of the force of electric interaction, the finite speed of electric field propagation, the equation of motion, 3D Euclidean space.

1. Introduction

This work is a direct continuation of the previous work [1], published in the last issue of this journal, and turned out not to have been completed from a new angle view.

There are many scientific publications devoted to the dynamics of motion of electrically charged bodies in an electric field, for example [2], but most of them cover the range of prerelativistic velocities. There is still a misconception that in such a range sufficient accuracy is provided by Coulomb’s law of electric interaction and magnetic interaction of the so-called Lorentz force. But this, as we will show below, is far from reality, because the third component of the electrical force interaction – radial – is not taken into account. It is this component that will be discussed in our study, its influence on the dynamics of the motion of charged bodies in an electric field. We draw your attention to the fact that in our interpretation the concept of electric field is broader than the generally accepted one because the magnetic field is interpreted as a tangential component of the force interaction of the electric field as a side effect of the motion of charged bodies

As for the relativistic velocities of charged bodies, things here are much worse because this range of velocities was occupied by two theories of relativity and practically they failed this important field of physical research. Moreover, in an unauthorized way, they both outlawed the Galilean transformations, and then declared our usual Euclidean world cramped and went into a distorted one. And they still cannot get out of this Minotaur maze.

Our immediate goal is to return to the time of Charles Auguste Coulomb with his law of force interaction of charged bodies and to start moving in another direction. The question is, why so far back? The answer is, because another component of this force, i.e. the magnetic interaction, the so-called Lorentz force, later became a cognitive obstacle. As shown in our previous study [1], this force is quite fair. But it was the force that overshadowed the third component of electrical interaction. This article is devoted to this component and its significance. This does not mean that we were the first to set such a goal. Work [3] is interesting from this perspective, but it also does not go beyond the Lorentz force.

Our belief in the successful adaptation of Coulomb's law in the case of moving charged bodies was the warning, made to relativists over a hundred years ago by Henry Poincaré about the truth of Galileo's transformations [1, 4], as well as much more radical statements by Karavashkin [5].

2. Coulomb's law of moving charges

The law of electric interaction of point charged bodies was experimentally established by Charles Coulomb in 1785. Coulomb's theory laid the foundations of electrostatics. The law describes the electric force interaction of stationary charged bodies

$$\mathbf{F}_C = k\frac{q_1 q_2}{r^2}\mathbf{r}_0, \tag{1}$$

where $\mathbf{F}_C$ is the force vector of stationary interacting bodies with charges q_1 and q_2; r is the distance between the electrical centers of these bodies; $\mathbf{r}_0$ is the unit vector; k is the electrical constant

$$k = \frac{1}{4\pi\varepsilon_0} = 8.987742\times10^9\ \text{Nm}^2\text{C}^{-2}.$$

Restriction on the immobility of interacting charges can be interpreted as the propagation of an electric field with infinite velocity, or the so-called. instantaneous electric interaction. In fact, according to modern notions, both electric and gravitational fields propagate with the maximum possible physical velocity $c = 3.108$ m / s. Therefore, in order to adapt law (1) to real conditions, it is suffecient to consider the fact of time electric wave delay! Otherwise, at the frozen moment of time t, the distance will not be taken to the actual location of the interacting bodies, but to the point of the trajectory taking into account the time delay.

In [1, 6–8], the mathematical dependences of the time delay of an electric field wave are obtained from purely geometric representations.

$$\mathbf{F} = k\frac{q_1 q_2}{r^2}\left(1 + \frac{v^2}{c^2} + 2\frac{v}{c}\mathbf{r}_0 \cdot \mathbf{v}_0\right)\mathbf{r}_0, \qquad (2)$$

where $\mathbf{F}$ is the total vector of electric interaction; v is the instantaneous mutual velocity; c is the velocity of light in vacuum; $\mathbf{v}_0$ is the unit vector of the velocity vector $\mathbf{v}$.

It is clear that when $v \to 0$, expression (2) degenerates in (1).

Force (2) is described as the sum of three components. The first component coincides with (1). It actually presents the Coulomb force of static electric interaction. The other two take the form of

$$\mathbf{F}_L = k\frac{q_1 q_2}{r^2}\frac{v^2}{c^2}\mathbf{r}_0, \qquad (3)$$

$$\mathbf{F}_T = 2k\frac{q_1 q_2}{r^2}\left(\frac{v}{c}\mathbf{r}_0 \cdot \mathbf{v}_0\right)\mathbf{r}_0, \qquad (4)$$

where $\mathbf{F}_L, \mathbf{F}_T$ are the Lorentz force vectors and the force vector of the new component, respectively.

The marginal share in the force interaction of components (3) and (4), based on the velocity and orienttation characteristics, is obvious

$$\mathbf{F}_L = (0 \div 1)\mathbf{F}_C; \quad \mathbf{F}_T = ((-2) \div (+2))\mathbf{F}_C. \qquad (5)$$

In [1, 6], it is convincingly shown that the component of force (3) completely coincides with the Lorentz force, which in classical electrodynamics presents the force action of a magnetic field, or the so-called relativistic effect in an electric field,

$$\mathbf{F}_L = q\left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right), \qquad (5)$$

where $\mathbf{E}$ is the vector of electric field intensity in the instantaneous electric interaction; $\mathbf{B}$ is the vector of magnetic induction; $\mathbf{v}$ is the velocity vector; q is the charge of a moving body.

It is clear that our immediate subject of interest will be radial component of force (4).

The dependence of $\mathbf{F}_T$ (4) on the velocity of motion is higher than $\mathbf{F}_C$ (3), because at $v \le c$, the multiplier v/c in (3) is squared, and in (4) it is raised to the first power.

Some cases. 1. *The direct trajectory of motion passes through the interacting point bodies.* Then $\mathbf{r}_0 \cdot \mathbf{v}_0 = 1$ when the masses move away and $\mathbf{r}_0 \cdot \mathbf{v}_0 = -1$ when they approach. Therefore (4) is simplified

$$\mathbf{F} = k\frac{q_1 q_2}{R^2}\left(1 \pm \frac{v}{c}\right)^2 \mathbf{r}_0, \qquad (6)$$

and the sign "+" indicates the distancing of bodies, and the sign "-", on the contrary – their approach.

When approaching in the natural direction with the limiting velocity ($v = c$), the electric interaction disappears by itself ($F \to 0$). However, when braking (against an electric action) ($v = -v$), the relativistic coefficient increases fourfold ($F \to 4F$). This explains the effects such as electrical signal delay.

2. *A moving body travels across the force*. In this case $\mathbf{r}_0 \cdot \mathbf{v}_0 = 0$. Then (4) takes a slightly different form

$$\mathbf{F} = k\frac{q_1 q_2}{R^2}\left(1 + \frac{v^2}{c^2}\right)\mathbf{r}_0, \qquad (7)$$

3. *Fixed bodies*. When $v = 0$, expressions (4), (6), (7) degenerate to the original law (1).

It is clear that to determine the force as a vector of values of electric field intensity and velocity is not enough. This requires a spatial orientation of the quantities involved. It is for this orientation that the second and third terms are responsible, which depends on the spatial angle between them.

3. Differential equations of motion

If we consider an electrically charged body as a material one with a mass m, then differential equations of its motion can be written in the form of Newton's law

$$m\frac{d\mathbf{v}}{dt} = \mathbf{F}; \quad \frac{d\mathbf{r}}{dt} = \mathbf{v}. \qquad (8)$$

where $\mathbf{r}$ is the radius-vector directed from the charge generating the field to the charge of the moving body.

Expressions (2) and (8) form a complete system of vector differential equations of mechanical motion of a charged body in a vortex electric field generated by another charged body (bodies). We will show the possibilities of these equations in practice.

Example. We will solve a practical important problem of capturing by a sphere body with charge Q a moving body with charge q into its own orbit.

The easiest way to solve this problem is in 2D space. In the Cartesian coordinates, the balance of forces (2) and (8) takes the obvious form

$$\frac{dv_x}{dt} = -\frac{kqQ\,r_x}{mr^3}\left(1 + \frac{v^2}{c^2} + 2\frac{r_x v_x + r_y v_y}{cr}\right);$$
$$\frac{dv_y}{dt} = -\frac{kqQ\,r_y}{mr^3}\left(1 + \frac{v^2}{c^2} + 2\frac{r_x v_x + r_y v_y}{cr}\right), \qquad (9)$$

and

$$r = \sqrt{r_x^2 + r_y^2}; \qquad v = \sqrt{v_x^2 + v_y^2}. \qquad (10)$$

They only need to be supplemented by coordinate equations (8)

$$\frac{dr_x}{dt} = v_x; \qquad \frac{dr_y}{dt} = v_y. \qquad (11)$$

Expressions (9)–(11) are the differential equations of motion of one electrically charged body in the field of another charged body. The equations are written in Euclidean space and physical time. The uniqueness of their solution is ensured by the initial conditions $v_x(0), v_y(0),\ r_x(0), r_y(0)$. We emphasize that the real course of the transition process is too sensitive to the initial conditions !!!

The initial data for the computer simulation are as follows:

$$Q = 3.163\times10^{-7};\ q = -1.602\times10^{-19};$$
$$k = 8.988\times10^{9};\ m = 9.109\times10^{-31}$$

under initial conditions:

$$r_x(0) = -0.2;\ r_y(0) = 0.2;\ v_x(0) = 0.1c;\ \ v_y(0) = 0.$$

Fig. 1 shows the results of simulating the trajectory of the capture of an electron by a charged sphere into one of its possible orbits:

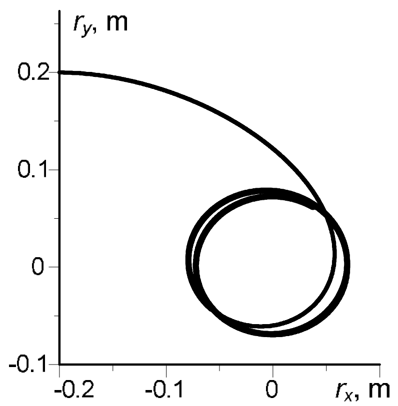

Fig. 1. Time dependence of the electron trajectory r = r(t).

According to the digital data of the transitional process, the electron is practically captured into a circular orbit with an average orbital radius r = 0.0654 m. Eccentricity of the orbit is: $e = 0.00004966$.

Fig. 2 shows the same transitional process as in Fig. 1, but with the absence of terms in equations of motion (9)–(11) corresponding to the orientational force F_T (4).

As we can see, the transitional curve in Fig. 2 differs from the corresponding curve in Fig. 1 not only quantitatively, but also strikingly qualitatively! And this suggests that practical analysis cannot do without the third component (4) of the resulting force (2)!

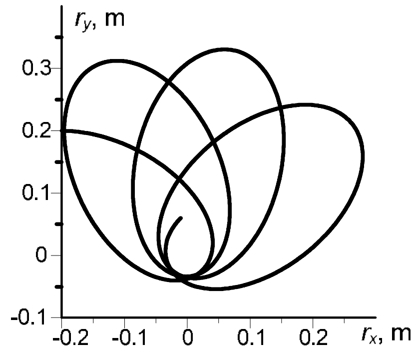

Fig. 2. The transitional process r = r(t) that corresponds to the transitional process in Fig. 1 provided the force component F_T (4) is neglected.

When the Lorentz force (3) is absent, this introduces an error, which is relatively smaller and does not exceed 9.45 %, into the computational process of the orbit trajectory (Fig. 1). The velocity characteristic of a moving electron is shown in Fig. 3.

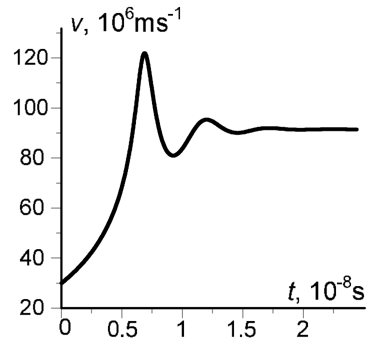

Fig. 3. The transitional linear velocity of an electron v = v(t), which corresponds to the transitional process in Fig. 1.

Thus, the linear velocity of the moving electron increased from 0.100 c to 0.306 c. The increase in the linear velocity of moving charged bodies when captured into the orbit by other charged bodies is a characteristic physical phenomenon, especially noticeable in the problems of electromechanical states in the microworld.

It would be inappropriate to ignore the limited possibilities of electromechanics involving only the Coulomb force (1). For this purpose, we simulated a transitional process, which corresponds to that in Fig. 1. The calculation results obtained for the same initial conditions are shown in Fig. 4.

The striking discrepancy of the electron flight trajectories shown in Figs. 1 and 4 could be forseen in advance, based only on physical considerations.

At the end of our study we say that the corresponding components of force (3) and (4) appear in the equations of the new celestial mechanics [6, 8, 9]

$$\mathbf{F}_{Lm} = \gamma \frac{m_1 m_2}{r^2} \frac{v^2}{c^2} \mathbf{r}_0, \qquad \mathbf{F}_{Tm} = 2k \frac{m_1 m_2}{r^2} \left(\frac{v}{c} \mathbf{r}_0 \cdot \mathbf{v}_0 \right) \mathbf{r}_0, \qquad (12)$$

where m_1, m_2 are the interacting masses; γ is the world constant.

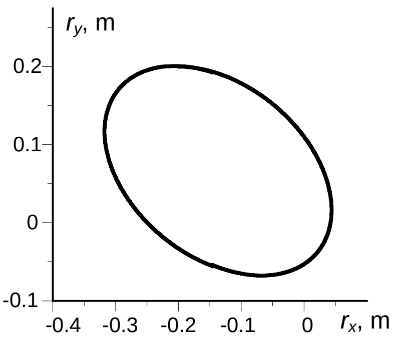

Fig. 4. The transitional process r = r(t) that corresponds to the transitional process in Fig. 1 provided only one component of the force is involved – Coulomb's F_C (1).

The first of these is the gravitomagnetic force, the other is the orientational force. It should be noted that both components (12) play a crucial role in combining the equations of electricity and gravity [6, 8, 9].

Radial components (4), (12) - initiate a new spiral round of progression of classical physics.

4. Conclusions

The electric interaction force of charged bodies is represented by three components. The first two of them are known – the forces of Coulomb and Lorentz. The third force – radial (tangential is the Lorentz force). It was detected when considering the finiteness of the propagation rate of electric field. The third component is much more velocity sensitive than Lorentz's force. In addition, it depends on the orientation of the trajectory. This makes it indispensable in the dynamics of charged bodies.

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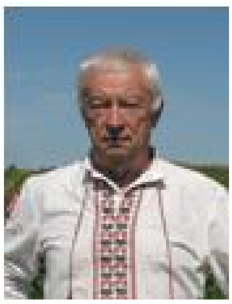
РАДІАЛЬНИЙ КОМПОНЕНТ СИЛИ ВИХРОВОГО ЕЛЕКТРИЧНОГО ПОЛЯ

Василь Чабан

У статті одержані диференціальні рівняння руху електрично наладованих тіл у нерівномірному вихровому електричному полі у всіх можливих діапазонах швидкостей. У силовій взаємодії на додачу до двох компонентів – кулонівської і лоренцової сил – задіяно третій компонент досі невідомої сили. Цей компонент, як виявилося, відіграє вирішальну роль у динаміці руху. Рівняння записано у звичному 3D евклідовому просторі і фізичному часі. При цьому враховано скінченну швидкість поширення електричного поля і закон збереження електричного ладунку. На цій підставі просимульовано траєкторію руху електрона в нерівномірному електричному полі, згенерованому позитивно наладованим сферичним тілом. Дано фізичну інтерпретацію одержаним математичним результатам, поданим у векторній і координатній формах. Приклади симуляції додано.



Vasil Tchaban: DSC, full professor at Lviv Polytechnic National University (Ukraine) as well as at Lviv Agrarian National University, Editor-in-Chief of Technical News journal. His Doctor-eng. habil degree in Electrical Engineering he obtained at Moscow Energetic University (Russia) in 1987. His research interests are in the areas of mathematical modelling of electromechanical processes and electromagnetic field theory, surrealistic short story writter. He is the autor of 540 scientific publications and 800 surrealistic short stories including 49 books (12 monographs, 17 didactic, 10 humanistic and 10 of the arts), 1500 aphorisms. The total number of publications is over 1500.

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