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Lagrange Function of Charge in the Concept of the Scalar-Vector Potential

By F. F. Mende

Abstract- One of the methods for solving problems in mechanics is the use of Lagrangian formalism.By function of Lagrange or Lagrangian in the mechanics is understood the difference between the kinetic and potential energy of the system ofin question.If we integrate the Lagrangian with respect to time, we obtain the first main Hamilton function, called the action.In the general case kinetic energy of system depends on speed, and potential energy depends on coordinates. In the case of the conservatism of system during its motion she selects the way, with which the action is minimum. However, the record of Lagrangian, accepted in the electrodynamics does not entirely satisfy the condition of the conservatism of system. The vector potential, in which moves the charge, create the strange moving charges, and the moving charge interacts not with the field of vector potential, but with the moving charges, influencing their motion. But this circumstance does not consider the existing model, since. vector potential comes out as the independent substance, with which interacts the moving charge. Moreover, into the generalized momentum of the moving charge is introduced the scalar product of its speed and vector potential, in which the charge moves.

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I. Introduction

One of the methods for solving problems in mechanics is the use of Lagrangian formalism.By function of Lagrange or Lagrangian in the mechanics is understood the difference between the kinetic and potential energy of the system ofin question

$$L = W_k(t) - W_p(t).$$

If we integrate Lagrangian with respect to the time, then we will obtain the first main function Hamilton function, called action. Since in the general case kinetic energy depends on speeds, and potential - from the coordinates, action can be recorded as

$$S = \int_{t_1}^{t_2} L(x_i, v_i)dt$$

With the condition of the conservatism of this system Lagrange formalism assumes least-action principle, when system during its motion selects the way, with which the action is minimum.

In the electrodynamics Lagrangian of the charged particle, which is moved with the relativistic speed, is written as follows [1]:

$$L = -mc^2\sqrt{1-\frac{v^2}{c^2}} - q\left(\varphi + \mu_0(\vec{v}\vec{A}_H)\right). \quad (1.1)$$

For non-relativistic speeds this expression will be written:

$$L = \frac{mv^2}{2} - q\left(\varphi + \mu_0(\vec{v}\vec{A}_H)\right)$$

where q, m, $\vec{v}$ - charge mass and the velocity of particle, c - the speed of light, μ_0 - magnetic permeability of vacuum, the scalar potential of electric field, $\vec{A}_H$ - the vector potential of magnetic field, in which it moves with particle. This expression and further all relations are written in the SI system of units. However, the record of Lagrangian, accepted in the electrodynamics does not entirely satisfy the condition of the conservatism of system. The vector potential, in which moves the charge, create the strange moving charges, and the moving charge interacts not with the field of vector potential, but with the moving charges, influencing their motion. But this circumstance does not consider the existing model, since. vector potential comes out as the independent substance, with which interacts the moving charge.

There are misunderstandings in [2], on p. 279 we read: "Therefore, even in the relativistic approximation, the Lagrange function in an electromagnetic field cannot be represented as the difference of kinetic and potential energy" (end of quote).

In relation (1.1), the author is confused by the term containing the scalar product of the charge velocity and the vector potential, and he does not know what kind of energy it belongs to.

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Among other things, this uncertainty is not over, and Landau works [3]. The introduction of the Lagrange function and moving charge in this work on paragraphs 16 and 17. With the introduction of these concepts in paragraph 16 is done the following observation: "The following below assertions it is necessary to examine to a considerable degree as the result of experimental data. The form of action for the particle in the electromagnetic field cannot be established on the basis only of general considerations, such as the requirement of relativistic invariance. (latter it would allow in action also the member of form integral of Ads, where A scalar function)" (end of quote).

But with the further consideration of this question of any experimental data the author does not give and it is not completely understandable, on what bases [Lagranzha]'s function introduces in the form (1.1). It is further - it is still worse. Without understanding the physical essence of Lagrangian, and in fact [ugadav] its (see relationship (17.4) into [3]), the author immediately includes the potential part (the scalar product of speed and vector potential) in generalized momentum, and then for finding the force is differentiated on the coordinate of Lagrangian, calculating gradient from this value (see relationship after equality (18.1) of [3]). But, finding gradient from the work indicated, the author thus recognizes his potential status.

In the mechanics by pulse is understood the work of the mass of particle to its speed. Multiplying pulse on the speed, mechanical energy is derived. In the electrodynamics, in connection with the fact that the charge has a mass; also is introduced the concept of angular impulse. But this not all. Is introduced also the concept of the generalized momentum

$$\vec{P} = m\vec{v} + q\vec{A},$$

when to the angular impulse is added the work of charge to the vector potential of magnetic field, in which moves the charge. Moreover even with the insignificant magnetic fields this additive considerably exceeds angular impulse. If generalized momentum scalar was multiplied by the speed

$$\vec{v}\vec{P} = m(\vec{v})^2 + q\vec{v}\vec{A}, \qquad (1.2)$$

that angular impulse will give kinetic energy. Scalar product of speed and vector potential will also give energy, here only this energy proves to be not kinetic, but potential. Here and is obtained composite solyanka, when it enters into the composition of energy of the moving charge and kinetic, and potential energy. With this is connected the incomprehension of physical nature of last term in the relationship (1.2), the having place in the work [2].

We already said that the record of Lagrangian (1.1) does not in the form satisfy the condition of the conservatism of system. This is connected with the fact that the vector potential, entering this relationship, it is connected with the motion of the strange charges, with which interacts the moving charge. A change in the charge rate, for which is located Lagrangian, will involve a change in the speed of these charges, and energy of the moving charge will be spent to this. In order to ensure the conservatism of system, it is necessary to know interaction energy of the moving charge with all strange charges, including with those, on which depends vector potential. This can be made a way of using the scalar-vector potential [4-7].

a) Concept of scalar- vector potential

The laws of induction have symmetrical nature [2-5]:

$$\oint \vec{E}'dl' = -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v} \times \vec{B}\right] dl'$$
$$\oint \vec{H}'dl' = \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v} \times \vec{D}\right] dl' \qquad (2.1)$$

or

$$rot\vec{E}' = -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v} \times \vec{B}\right]$$
$$rot\vec{H}' = \frac{\partial \vec{D}}{dt} - rot\left[\vec{v} \times \vec{D}\right] \qquad (2.2)$$

In these relationships: $\vec{E}$ and $\vec{H}$ - electrical and magnetic field, $\vec{D}$ and $\vec{B}$- electrical and magnetic induction, $\vec{v}$ -relative speed between the shtrikhovannoy and reference system of counting (IRS).

For the constants pour on these relationships they take the form:

$$\vec{E}' = \left[\vec{v} \times \vec{B}\right]$$
$$\vec{H}' = -\left[\vec{v} \times \vec{D}\right] \qquad (2.3)$$

In the relations (2.1-2.3), assuming the validity of the Galileo transforms, the hatched and the not-hatched quantities represent the fields and elements in the moving and fixed IRS, respectively. It should be noted that transformations (2.3) previously could be obtained only from Lorentz transformations.

The relationship (2.3) attest to the fact that in the case of relative motion of frame of references, between the fields $\vec{E}$ and $\vec{H}$ there is a cross coupling, i.e., motion in the fields $\vec{H}$ leads to the appearance fields

$\vec{E}$ on and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [2]. The electric field $E = \frac{g}{2\pi\varepsilon r}$ outside the charged long rod, per unit length of which the charge falls g, decreases according to the law $\frac{1}{r}$, where r is the distance from the central axis of the rod to the observation point.

If we in parallel to the axis of rod in the field E begin to move with the speed Δv another IRS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IRS begin to move third frame of reference with the speed Δv, then already due to the motion in the field ΔH will appear additive to the electric field $\Delta E = \mu\varepsilon E\left(\Delta v\right)^2$. This process can be continued and further, as a result of which can be obtained the number, which gives the value of the electric field $E_v'\left(r\right)$ in moving IRS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$. In the final analysis in moving IRS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship:

$$E'\left(r, v_\perp\right) = \frac{gch\frac{v_\perp}{c}}{2\pi\varepsilon r} = Ech\frac{v_\perp}{c}.$$

If speech goes about the electric field of the single charge e, then its electric field will be determined by the relationship:

$$E'\left(r, v_\perp\right) = \frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r^2}, \qquad (2.4)$$

where $v_\perp$ - normal component of charge rate to the vector, which connects the moving charge and observation point.The potential can be called scalar-vector, because it depends not only on the absolute value of the charge, but also on the speed and direction of its movement with respect to the observation point. This potential has maximum value in the direction normal to the movement of the charge itself [8-11].

$$\varphi'(r, v_\perp) = \frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r} = \varphi(r)ch\frac{v_\perp}{c}, \qquad (2.5)$$

where $\varphi(r)$ - scalar potential of fixed charge. The potential of $\varphi'(r, v_\perp)$ can be named scalar- vector, since. it depends not only on the absolute value of charge, but also on speed and direction of its motion with respect to the observation point. Maximum value this potential has in the direction normal to the motion of charge itself.

b) Lagrange formalism in the concept of scalar- vector potential

The scalar potential $\varphi(r)$ at the point of the presence of charge is determined by all surrounding charges g_j and is determined by the relationship:

$$\varphi(r) = \sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j}$$

Each moving charge creates a potential at the observation point, defined by relation (2.5).

If some quantity of moving and fixed charges surrounds this point of space, then for finding the scalar potential in the given one to point it is necessary to produce the summing up of their potentials:

$$\varphi'(r) = \sum_j \varphi(r_j)ch\frac{v_{j\perp}}{c} = \sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j}ch\frac{v_{j\perp}}{c}.$$

Taking into account this circumstance Lagrangian of the charge e, which is found in the environment of the fixed and moving strange charges can be written down as follows:

$$L = -e\sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j}ch\frac{v_{j\perp}}{c}.$$

If the charge e is moving relative to the selected IRS speed then its Lagrangian is determined by the ratio (2.1) except that as speeds are relative velocities $v_{j\perp}$ the relative velocities of the charges with respect to the charge e are taken and a term is added that determines the kinetic energy of the charge itself. The Lagrangian for low speeds in this case takes the form:

$$L = \frac{mv^2}{2} - e\sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j}ch\frac{v_{j\perp}}{c}$$

This approach is deprived already of the deficiency indicated, since. it satisfies the complete conservatism of system, since in Lagrangian are taken into account all interactions charge with its surrounding charges.

II. Conclusion

One of the methods for solving problems in mechanics is the use of Lagrangian formalism.By function of Lagrange or Lagrangian in the mechanics is understood the difference between the kinetic and potential energy of the system ofin question.If we integrate the Lagrangian with respect to time, we obtain the first main Hamilton function, called the action.In the general case kinetic energy of system depends on speed, and potential energy depends on coordinates. In the case of the conservatism of system during its motion she selects the way, with which the action is minimum. However, the record of Lagrangian, accepted in the electrodynamics does not entirely satisfy the condition of the conservatism of system. The vector potential, in which moves the charge, create the strange moving charges, and the moving charge interacts not with the field of vector potential, but with the moving charges, influencing their motion. But this circumstance does not consider the existing model, since. vector potential comes out as the independent substance, with which interacts the moving charge. Moreover, into the generalized momentum of the moving charge is introduced the scalar product of its speed and vector potential, in which the charge moves. But this term presents not kinetic, but potential energy, which contradicts the determination of pulse in the mechanics. With these circumstances are connected those errors, which occur in the works on electrodynamics. In the work it is shown that use of a concept of scalar- vector potential for enumerating the Lagrangian of the moving charge gives the possibility to exclude the errors, existing in the contemporary electrodynamics.

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