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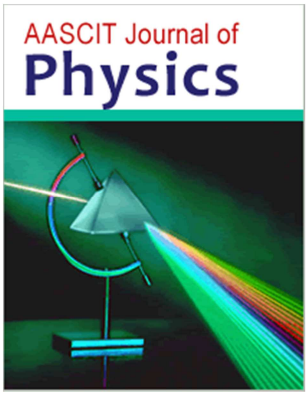

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Vlasov's Equations in the Concept of the Scalar-Vector Potential

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Abstract
At present Vlasov's equations are the fundamental equations of the electrodynamics of the plasma, in which the electromagnetic fields are self-consistent with the fields of the charges, which present plasma. Into these equations enters the Lorentz force, which in the concept of scalar- vector potential can be expressed through the properties of the charged particles, which surround observation point. This approach, realized in this article, entirely realizes the idea of the long-range interaction of Coulomb pour on, which is the basis of Vlasov's equations.

1. Introduction

Vlasov's idea for the introduction of self-congruent field, consisted in the fact that the electromagnetic fields in the plasma and the fields, created by the charged particles must be self-consistent [1-3]. This principle easily understanding based on the example of cavity resonator. Its resonance frequency determines the variable electromagnetic fields, which are subordinated to Maxwell's equations, to which are superimposed boundary conditions. And if inside the resonator appears any object, including free charges, then its resonance frequency changes in such a way that its electromagnetic fields would be coordinated with the fields by those induced by outside object. Being guided by this principle, Vlasov originally examined the system of the general equations of plasma, which include three components (electrons, ions and neutral atoms), and wrote Boltzmann's equation for s - oh the component of plasma in the form [1-3]:

$$\frac{\partial f_s}{\partial t} + div_r \vec{v} f_s + \frac{e_s}{m_s}\left(\vec{E} + \left[\vec{v} \times \vec{B}\right]\right) grad_v f_s = \left[\frac{\partial f_s}{\partial t}\right]_{s\,1}^{st} + \left[\frac{\partial f_s}{\partial t}\right]_{s2}^{st} + \left[\frac{\partial f_s}{\partial t}\right]_{s3}^{st} \qquad (1.1)$$

where $f_s(\vec{r}, \vec{p}, t)$ - the distribution function.

The right side of the equation (1.1) represents the integrals of collisions. This system of equations included also Maxwell's equations, and equation for the charge and the current, the expressed through the functions distributions. Since Vlasov was interested only in wave solutions, thus he disregarded the contributions of the integrals of collisions, since according to his estimations it left, that the frequencies of plasma waves are much more than the frequencies of the paired collisions of particles in the plasma. I.e., instead of the description of interaction of the charged particles in the plasma by means of the collisions, he proposed to use the self-congruent field, created with the charged particles of plasma for describing the long-range potential. Instead of Boltzmann's equation Vlasov proposed to use the following system of equations for describing the charged components of plasma (electrons with the function of distributions $f_e(\vec{r}, \vec{p}, t)$ and positive ions with the distribution function $f_i(\vec{r}, \vec{p}, t)$):

$$\frac{\partial f_e}{\partial t}+\vec{v}\frac{\partial f_e}{\partial \vec{x}}-\left(e\vec{E}+e\left[\vec{v}\times\vec{B}\right]\right)\frac{\partial f_e}{\partial \vec{p}}=0$$
$$\frac{\partial f_i}{\partial t}+\vec{v}\frac{\partial f_i}{\partial \vec{x}}+\left(e\vec{E}+e\left[\vec{v}\times\vec{B}\right]\right)\frac{\partial f_i}{\partial \vec{p}}=0$$
$$rot\vec{H}=\vec{j}+\varepsilon\frac{\partial \vec{E}}{\partial t},\quad rot\vec{E}=-\frac{\partial \vec{B}}{dt} \tag{1.2}$$
$$div\vec{E}=\rho,\quad div\vec{B}=0$$
$$\rho=e\int(f_i-f_e)d^3\vec{p},\quad \vec{j}=e\int(f_i-f_e)\vec{v}d^3\vec{p}$$

In the relationship (1.2) in the first two equations in the brackets stands the force acting on the moving particle in the electrical and magnetic field, created by the surrounding charged particles. The fixed moving particles create electric field, and those moving – create magnetic field. But for writing of Vlasov's equations it is possible to use the concept of scalar-vector potential [1-13], which assumes the dependence of the scalar potential of charge on the speed.

2. Vlasov's Equations in the Concept of the Scalar-Vector Potential

The Maxwell equations do not give the possibility to write down fields in the moving coordinate systems, if fields in the fixed system are known. This problem is solved with the aid of the conversions of Lorenz, however, these conversions from the classical electrodynamics they do not follow. Question does arise, is it possible with the aid of the classical electrodynamics to obtain conversions fields on upon transfer of one inertial system to another, and if yes, then, as must appear the equations of such conversions. Indications of this are located already in the law of the Faraday induction. Let us write down Faraday law:

$$\oint \vec{E}'d\,\vec{l}'=-\frac{d\,\Phi_B}{d\,t}. \tag{2.1}$$

As is evident in contrast to Maxwell equations in it not particular and substantive (complete) time derivative is used.

The substantional derivative in relationship (2.1) indicates the independence of the eventual result of appearance emf in the outline from the method of changing the flow, i.e. flow can change both due to the local time derivative of the induction of and because the system, in which is measured , it moves in the three-dimensional changing field . The value of magnetic flux inrelationship (2.1) is determined from the relationship

$$\Phi_B=\int \vec{B}\,d\,\vec{S}', \tag{2.2}$$

where the magnetic induction $\vec{B}=\mu\,\vec{H}$ is determined in the fixed coordinate system, and the element $d\,\vec{S}'$ is determined in the moving system. Taking into account (2.2), we obtain from (2.1)

$$\oint \vec{E}'d\,\vec{l}'=-\frac{d}{d\,t}\int \vec{B}\,d\,\vec{S}', \tag{2.3}$$

and further, since $\frac{d}{d\,t}=\frac{\partial}{\partial\,t}+\vec{v}\,grad$, let us write down

$$\oint \vec{E}'d\,\vec{l}'=-\int\frac{\partial\,\vec{B}}{\partial\,t}\,d\,\vec{S}-\int\left[\vec{B}\times\vec{v}\right]\,d\,\vec{l}'-\int\vec{v}\,div\,\vec{B}\,d\,\vec{S}'. \tag{2.4}$$

In this case contour integral is taken on the outline $d\,\vec{l}'$, which covers the area $d\,\vec{S}'$. Let us immediately note that entire following presentation will be conducted under the assumption the validity of the Galileo conversions, i.e., $d\,\vec{l}'=d\,\vec{l}$ and $d\,\vec{S}'=d\,\vec{S}$. From relationship (2.6) follows

$$\vec{E}'=\vec{E}+\left[\vec{v}\times\vec{B}\right]. \tag{2.5}$$

If both parts of equation (2.6) are multiplied by the charge, then we will obtain relationship for the Lorentz force

$$\vec{F}_L'=e\,\vec{E}+e\,\left[\vec{v}\times\vec{B}\right]. \tag{2.6}$$

Thus, Lorentz force is the direct consequence of the law of magnetoelectric induction.

For explaining physical nature of the appearance of last term in relationship (2.5) let us write down $\vec{B}$ and $\vec{E}$ through the magnetic vector potential $\vec{A}_B$:

$$\vec{B}=rot\,\vec{A}_B,\qquad \vec{E}=-\frac{\partial\,\vec{A}_B}{\partial\,t}. \tag{2.7}$$

Then relationship (2.5) can be rewritten

$$\vec{E}'=-\frac{\partial\,\vec{A}_B}{\partial\,t}+\left[\vec{v}\times rot\,\vec{A}_B\right] \tag{2.8}$$

and further

$$\vec{E}'=-\frac{\partial\,\vec{A}_B}{\partial\,t}-\left(\vec{v}\,\nabla\right)\vec{A}_B+grad\,\left(\vec{v}\,\vec{A}_B\right) \tag{2.9}$$

The first two members of the right side of equality (2.9) can be gathered into the total derivative of vector potential on the time, namely:

$$\vec{E}'=-\frac{d\,\vec{A}_B}{d\,t}+grad\,\left(\vec{v}\,\vec{A}_B\right). \tag{2.10}$$

From relationship (2.9) it is evident that the field strength, and consequently also the force, which acts on the charge, consists of three parts.

First term is obliged by local time derivative. The sense of second term of the right side of relationship (2.9) is also intelligible. It is connected with a change in the vector potential, but already because charge moves in the three-dimensional changing field of this potential. Other nature of last term of the right side of relationship (2.9). It is connected with the presence of potential forces, since. potential energy of the charge, which moves in the potential field $\vec{A}_B$ with the speed $\vec{v}$, is equal $e\left(\vec{v}\ \vec{A}_B\right)$. The value $e\ grad\left(\vec{v}\ \vec{A}_B\right)$ gives force, exactly as gives force the gradient of scalar potential. Taking rotor from both parts of equality (2.10) and taking into account that $rot\ grad\ \equiv 0$, we obtain

$$rot\ \vec{E}' = -\frac{d\ \vec{B}}{d\ t}\ . \tag{2.11}$$

If there is no motion, then relationship (2.11) is converted into the Maxwell first equation. Relationship (2.11) is more informative than Maxwell equation

$$rot\ \vec{E} = -\frac{\partial\ \vec{B}}{\partial\ t}.$$

Since in connection with the fact that $rot\ grad\ \equiv 0$, in Maxwell equation there is no information about the potential forces, designated through $e\ grad\left(\vec{v}\ \vec{A}_B\right)$.

Let us write down the amount of Lorentz force in the terms of the magnetic vector potential:

$$\vec{F}_L{}' = e\ \vec{E} + e\ [\vec{v}\times rot\ \vec{A}_B] = e\ \vec{E} - e(\vec{v}\ \nabla)\vec{A}_B + egrad\ (\vec{v}\ \vec{A}_B)\,. \tag{2.12}$$

Is more preferable, since the possibility to understand the complete structure of this force gives.

Faraday law (2.2) is called the law of electromagnetic induction, however this is terminological error. This law should be called the law of magnetoelectric induction, since the appearance of electrical fields on by a change in the magnetic caused fields on.

However, in the classical electrodynamics there is no law of magnetoelectric induction, which would show, how a change in the electrical fields on, or motion in them, it leads to the appearance of magnetic fields on. The development of classical electrodynamics followed along another way. Ampere law was first introduced:

$$\oint \vec{H}\ d\ \vec{l} = I\,, \tag{2.13}$$

where I is current, which crosses the area, included by the outline of integration. In the differential form relationship (2.13) takes the form:

$$rot\ \vec{H} = \vec{j}_\sigma\,, \tag{2.14}$$

where $\vec{j}_\sigma$ is current density of conductivity.

Maxwell supplemented relationship (2.14) with bias current

$$rot\ \vec{H} = \vec{j}_\sigma + \frac{\partial\ \vec{D}}{\partial\ t}. \tag{2.15}$$

If we from relationship (2.15) exclude conduction current, then the integral law follows from it

$$\oint \vec{H} d\ \vec{l} = \frac{\partial\ \Phi_D}{\partial\ t}\,, \tag{2.16}$$

where $\Phi_D = \int \vec{D}\ d\vec{S}$ the flow of electrical induction.

If we in relationship (2.16) use the substantional derivative, as we made during the writing of the Faraday law, then we will obtain [3-13]:

$$\oint \vec{H}' d\ \vec{l}' = \int \frac{\partial\ \vec{D}}{\partial\ t} d\ \vec{S} + \oint [\vec{D}\times\vec{v}] d\ \vec{l}' + \int \vec{v}\ div\ \vec{D}\ d\ \vec{S}'. \tag{2.17}$$

In contrast to the magnetic fields, when $div\vec{B} = 0$, for the electrical fields on $div\vec{D} = \rho$ and last term in the right side of relationship (2.8) it gives the conduction current of and from relationship (2.7) the Ampere law immediately follows. In the case of the absence of conduction current from relationship (2.17) the equality follows:

$$\vec{H}' = \vec{H} - [\vec{v}\times\vec{D}]\,. \tag{2.18}$$

As shown in the work [11], from relationship (2.18) follows and Bio-Savara law, if for enumerating the magnetic fields on to take the electric fields of the moving charges. In this case the last member of the right side of relationship (2.17) can be simply omitted, and the laws of induction acquire the completely symmetrical form [10-16]

$$\begin{aligned} \oint \vec{E}' dl' &= -\int \frac{\partial \vec{B}}{\partial t} d\vec{s} + \oint \left[\vec{v}\times\vec{B}\right] dl'\vec{H} \\ \oint \vec{H}' dl' &= \int \frac{\partial \vec{D}}{\partial t} d\vec{s} - \oint \left[\vec{v}\times\vec{D}\right] dl'\vec{H}' \end{aligned}\ , \tag{2.19}$$

or

$$\begin{aligned} rot\vec{E}' &= -\frac{\partial \vec{B}}{\partial t} + rot\left[\vec{v}\times\vec{B}\right] \\ rot\vec{H}' &= \frac{\partial \vec{D}}{dt} - rot\left[\vec{v}\times\vec{D}\right] \end{aligned} \tag{2.20}$$

For dc fields on these relationships they take the form:

$$\begin{aligned} \vec{E}' &= \left[\vec{v}\times\vec{B}\right] \\ \vec{H}' &= -\left[\vec{v}\times\vec{D}\right] \end{aligned}. \tag{2.21}$$

In relationships (2.19-2.21), which assume the validity of the Galileo conversions, prime and not prime values present fields and elements in moving and fixed inertial reference system (IS) respectively. It must be noted, that conversions (2.21) earlier could be obtained only from the Lorenz conversions.

The relationships (2.19-2.21), which present the laws of induction, do not give information about how arose fields in initial fixed IS. They describe only laws governing the propagation and conversion fields on in the case of motion with respect to the already existing fields.

The relationship (2.21) 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 on $\vec{E}$ and vice versa. From these relationships escape the additional consequences, which were for the first time examined in the work [13].

The electric field $E = \frac{g}{2\pi\varepsilon r}$ outside the charged long rod with a linear density g decreases as $\frac{1}{r}$, where r is 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 IS, then in it will appear the additional magnetic field $\Delta H = \varepsilon E \Delta v$. If we now with respect to already moving IS 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 $\Delta E = \mu\varepsilon E(\Delta v)^2$. 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 $E'_v(r)$ in moving IS with reaching of the speed $v = n\Delta v$, when $\Delta v \to 0$, and $n \to \infty$. In the final analysis in moving IS the value of dynamic electric field will prove to be more than in the initial and to be determined by the relationship:

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

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

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

where $v_\perp$ is normal component of charge rate to the vector, which connects the moving charge and observation point.

Expression for the scalar potential, created by the moving charge, for this case will be written down as follows:

$$\varphi'(r,v_\perp) = \frac{ech\frac{v_\perp}{c}}{4\pi\varepsilon r} = \varphi(r)ch\frac{v_\perp}{c}, \qquad (2.22)$$

where $\varphi(r)$ is scalar potential of fixed charge. The potential $\varphi'(r,v_\perp)$ 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. Moreover, if charge rate changes, which is connected with its acceleration, then can be calculated the electric fields, induced by the accelerated charge.

During the motion in the magnetic field, using the already examined method, we obtain:

$$H'(v_\perp) = Hch\frac{v_\perp}{c}.$$

where $v_\perp$ is speed normal to the direction of the magnetic field.

If we apply the obtained results to the electromagnetic wave and to designate components fields on parallel speeds IS as $E_\uparrow$, $H_\uparrow$, and $E_\perp$, $H_\perp$ as components normal to it, then with the conversion fields on components, parallel to speed will not change, but components, normal to the direction of speed are converted according to the rule

$$\begin{aligned}\vec{E}'_\perp &= \vec{E}_\perp ch\ \frac{v}{c} + \frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},\\ \vec{B}'_\perp &= \vec{B}_\perp ch\ \frac{v}{c} - \frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c},\end{aligned} \qquad (2.23)$$

where c is speed of light.

Conversions fields (2.23) they were for the first time obtained in the work [10].

However, the iteration technique, utilized for obtaining the given relationships, it is not possible to consider strict, since its convergence is not explained

Let us give a stricter conclusion in the matrix form [17,18].

Let us examine the totality IS of such, that IS K_1 moves with the speed Δv relative to IS K, IS K_2 moves with the same speed Δv relative to K_1, etc. If the module of the speed Δv is small (in comparison with the speed of light c), then for the transverse components fields on in IS K_1, K_2,…. we have:

$$\begin{aligned}\vec{E}_{1\perp} &= \vec{E}_\perp + \Delta\vec{v}\times\vec{B}_\perp & \vec{B}_{1\perp} &= \vec{B}_\perp - \Delta\vec{v}\times\vec{E}_\perp / c^2\\ \vec{E}_{2\perp} &= \vec{E}_{1\perp} + \Delta\vec{v}\times\vec{B}_{1\perp} & \vec{B}_{2\perp} &= \vec{B}_{1\perp} - \Delta\vec{v}\times\vec{E}_{1\perp} / c^2\end{aligned}. \qquad (2.24)$$

Upon transfer to each following IS of field are obtained increases in $\Delta\vec{E}$ and $\Delta\vec{B}$

$$\Delta\vec{E} = \Delta\vec{v}\times\vec{B}_\perp, \qquad \Delta\vec{B} = -\Delta\vec{v}\times\vec{E}_\perp / c^2, \qquad (2.25)$$

where of the field $\vec{E}_\perp$ and $\vec{B}_\perp$ relate to current IS. Directing Cartesian axis x along $\Delta\vec{v}$, let us rewrite (4.7) in the components of the vector

$$\Delta E_y = -B_z\Delta v,\ \ \Delta E = B_y\Delta v,\ \ \Delta B_y = E_z\Delta v / c^2. \qquad (2.26)$$

Relationship (2.26) can be represented in the matrix form

$$\Delta U = AU\Delta v \qquad \begin{pmatrix} 0 & 0 & 0 & -1\\ 0 & 0 & 1 & 0\\ 0 & 1/c^2 & 0 & 0\\ -1/c^2 & 0 & 0 & 0\end{pmatrix} \qquad U = \begin{pmatrix}E_y\\ E_z\\ B_y\\ B_z\end{pmatrix}.$$

If one assumes that the speed of system is summarized for the classical law of addition of velocities, i.e. the speed of final IS $K' = K_N$ relative to the initial system K is $v = N\Delta v$, then we will obtain the matrix system of the differential equations of

$$\frac{dU(v)}{dv} = AU(v), \qquad (2.27)$$

with the matrix of the system v independent of the speed A. The solution of system is expressed as the matrix exponential curve $\exp(vA)$:

$$U' \equiv U(v) = \exp(vA)U, \quad U = U(0), \qquad (2.28)$$

here U is matrix column fields on in the system K, and U' is matrix column fields on in the system K'. Substituting (2.28) into system (2.27), we are convinced, that U' is actually the solution of system (2.27):

$$\frac{dU(v)}{dv} = \frac{d[\exp(vA)]}{dv}U = A\exp(vA)U = AU(v).$$

It remains to find this exponential curve by its expansion in the series:

$$\exp(va) = E + vA + \frac{1}{2!}v^2A^2 + \frac{1}{3!}v^3A^3 + \frac{1}{4!}v^4A^4 + ...$$

where E is unit matrix with the size 4×4. For this it is convenient to write down the matrix A in the unit type form

$$A = \begin{pmatrix} 0 & -\alpha \\ \alpha/c^2 & 0 \end{pmatrix}, \qquad \alpha = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}, \qquad 0 = \begin{pmatrix} 0 & 0 \\ 0 & 0 \end{pmatrix}.$$

then

$$A^2 = \begin{pmatrix} -\alpha^2/c^2 & 0 \\ 0 & -\alpha/c^2 \end{pmatrix}, \; A^3 = \begin{pmatrix} 0 & \alpha^3/c^2 \\ -\alpha^3/c^4 & 0 \end{pmatrix},$$

$$A^4 = \begin{pmatrix} \alpha^4/c^4 & 0 \\ 0 & \alpha^4/c^4 \end{pmatrix}, \; A^5 = \begin{pmatrix} 0 & -\alpha^5/c^4 \\ \alpha^5/c^6 & 0 \end{pmatrix}$$

And the elements of matrix exponential curve take the form

$$[\exp(vA)]_{11} = [\exp(vA)]_{22} = I - \frac{v^2}{2!c^2} + \frac{v^4}{4!c^4} - ....,$$

$$[\exp(vA)]_{21} = -c^2[\exp(vA)]_{12} = \frac{\alpha}{c}\left(\frac{v}{c}I - \frac{v^3}{3!c^3} + \frac{v^5}{5!c^5} - .....\right),$$

where I is the unit matrix 2×2. It is not difficult to see that $-\alpha^2 = \alpha^4 = -\alpha^6 = \alpha^8 = ... = I$, therefore we finally obtain

$$\exp(vA) = \begin{pmatrix} Ich\ v/c & -c\alpha sh\ v/c \\ (\alpha sh\ v/c)/c & Ich\ v/c \end{pmatrix} =$$

$$\begin{pmatrix} ch\ v/c & 0 & 0 & -csh\ v/c \\ 0 & ch\ v/c & csh\ v/c & 0 \\ 0 & (ch\ v/c)/c & ch\ v/c & 0 \\ -(sh\ v/c)/c & 0 & 0 & ch\ v/c \end{pmatrix}.$$

Now we return to (4.10) and substituting there $\exp(vA)$, we find

$$E'_y = E_y ch\ v/c - cB_z sh\ v/c, \qquad E'_z = E_z ch\ v/c + cB_y sh\ v/c,$$
$$B'_y = B_y ch\ v/c + (E_z/c) sh\ v/c, \qquad B'_z = B_z ch\ v/c - (E_y/c) sh\ v/c,$$

or in the vector record

$$\vec{E}'_\perp = \vec{E}_\perp ch\frac{v}{c} + \frac{v}{c}\vec{v}\times\vec{B}_\perp sh\frac{v}{c},$$
$$\vec{B}'_\perp = \vec{B}_\perp ch\frac{v}{c} - \frac{1}{vc}\vec{v}\times\vec{E}_\perp sh\frac{v}{c}, \qquad (2.29)$$

This is conversions (2.23).

Consequently, if charged particle moves, then the fields of its surrounding particles that of field in the system of coordinates of the moving particle are converted in accordance with the relationships (2.23).

In Vlasov's equations (1.2) in the first two equations, the members concluded in the brackets, present the force, which acts on the moving charge. But the concept of scalar vector potential gives the possibility to calculate this force in the system of coordinates of the moving charge, taking into account long-range forces, the surrounding charges, after excluding magnetic field. This force is written as follows

$$\vec{F} = -e\sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j^2}ch\frac{v_{j\perp}}{c}, \qquad (2.30)$$

where g_j is one of the external charges, which is been located at a distance r_j from the charge e, $v_{j\perp}$ is normal component by relative charge rate g_j with respect to the charge e.

Substituting the expression of force (2.30) in the relationships (1.2), we obtain writing of Vlasov's equations in the concept of scalar- vector potential.

$$\frac{\partial f_e}{\partial t} + \vec{v}\frac{\partial f_e}{\partial \vec{x}} - \left(e\sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j^2}ch\frac{v_{j\perp}}{c}\right)\frac{\partial f_e}{\partial \vec{p}} = 0$$

$$\frac{\partial f_i}{\partial t} + \vec{v}\frac{\partial f_i}{\partial \vec{x}} + \left(e\sum_j \frac{1}{4\pi\varepsilon}\frac{g_j}{r_j^2}ch\frac{v_{j\perp}}{c}\right)\frac{\partial f_i}{\partial \vec{p}} = 0$$

$$rot\vec{H} = \vec{j} + \varepsilon \frac{\partial \vec{E}}{\partial t}, \quad rot\vec{E} = -\frac{\partial \vec{B}}{dt}$$
$$div\vec{E} = \rho, \quad div\vec{B} = 0$$
$$\rho = e\int (f_i - f_e) d^3\vec{p}, \quad \vec{j} = e\int (f_i - f_e)\vec{v} d^3\vec{p}$$

3. Conclusion

At present Vlasov's equations are the fundamental equations of the electrodynamics of the plasma, in which the electromagnetic fields are self-consistent with the fields of the charges, which present plasma. Into these equations enters the Lorentz force, which in the concept of scalar-vector potential can be expressed through the properties of the charged particles, which surround observation point. This approach, realized in this article, entirely realizes the idea of the long-range interaction of Coulomb pour on, which is the basis of Vlasov's equations.

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