Electrodynamics and Gravitation in The Model of 4D Matter

I. The electromagnetic field

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Abstract

Hydrodynamical model of four-dimensional medium as the extension of the ideal fluid is presented in the first four sections. As the medium is supposed to be incondensable and located in a limited volume, the expansion of the Euler equation to four dimensions are applied to describe its behaviour. Electromagnetic field is derived as the consequence of the velocity field of the medium. The analogue of the Helmholtz equation for vorticity of the velocity field is obtained that states that electromagnetic field is frozen into the medium. The Maxwell's equations are obtained as the result of the basic properties of the velocity field.

I. Introduction

It is the common knowledge that now the contemporary physics consists from many different areas, slightly interconnected or almost disconnected from each other. Despite the essential successes made in every area one can hardly name this state in physics by other word then that of a crisis. In our opinion, this state that has been widely debated already for a long time is bound up with the scarce "ground" on which trials to understand the whole set of phenomena of nature has been undertaken. Most of the scientists are endeavouring to "jam" all physical events into three-dimensional space. It is justifiable while the objects of classical physics are considered. However, such handling failed when applied to micro and macro objects, to particles and to galaxies. That is why multidimensional spaces and united space and time are used in the string theory of the fundamental particles and in the theory of relativity. That is why the problem of the creation of the Grand Unification Theory and Theory of Everything is arisen and one direction to solve it is the model proposed here.

We assume that there is only one extra spatial dimension having the same properties as the usual three dimensions needs to be introduced. Of course, it is not a novel idea. A.Poincare was the first who made it with the time as the extra dimension and then was A.Einstein who developed this idea in his theory of relativity. However there it was used not spatial dimension as the extra one. There was the 5D theory of Kaluza [1] as the extension of the general theory of relativity in which the spatial dimension was added, and now there are many other theories used the same approach, see as the example [2], but as one can see below our handling differs from them in some essential moments. One of them consists in the meaning of the time. We think of it as a simple parameter which is not bound up with the space anyhow. In this point we diverge with the theory of relativity.

However, space is not the thing we intend to study. Our aim is to understand what matter, the substance, may be and what kinds of motion it may have. We are using space and time only for the description of the place of the substance and its movements in this model. Therefore to describe matter in this model of the reality by the simplest means, the simplest space among all others is chosen, the four-dimensional Euclidean space with positively defined metric.

Of course, no one does know what matter is in essence. In the attempt to clarify the nature of matter our consideration comes here from only one hypothesis – there is additional space for matter. In addition to it we assume that such 4D matter does not fill all space but is concentrated in the separate regions.

As it's known, the creator of classical electrodynamics, J. Maxwell, had been already trying to describe electric and magnetic phenomena as the motions of some fluid but he failed. By our opinion it happened so because he was restricted by three dimensions. Now we break this restriction and will look what is following from assumptions aforementioned. So we will be considering 4D fluid.

We will use some terms hereafter that will be employed through the whole paper because the introduction of the additional dimension demands it. As we suppose that all matter is consist of a 4D homogeneous medium and think of it as it is all only in four-dimensional closed regions with a border, we may call each such border as *the world*. Obviously, it has three dimension. The particles which the medium consists of are supposed to be very tiny and their structure is not considered here. So matter being discrete in their most low level may be treated as a continuous medium beginning from some scale. While the whole region is supposed to be situated in the four-dimensional Euclidean space with positively defined metric, the world has the induced metric that is non-Euclidean. If this region is supposed to be boundedly compact, the world is also to consider as the space with the Riemannian metric.

It must be mentioned that the term 4D medium is used now in other theories, i.g. see works P. Belov [14] and Monera [??] but in different meaning. They called by this term a "medium" composed from space and time.

As we will see at the next paper the properties of the boundary of the 4D medium is able to propagate the light and other electromagnetic waves. Some model of photon that is compatible with this conclusion was presented in paper [3] and will be given in details later. That is why only the world is observable and therefore it is named so. In that sense the world as the border hypersurface of 4D medium can be considered as the traditional 3D luminiferous aether which so long and unsuccessfully was being sought out since the famous experiment with interferometer made by Mickelson and Morly in 1887 [4]. In this model it really fills all "space" keeping in mind that this space originated by the border of the 4D material medium.

The elementary particles such as electrons, protons and so on are not thought of as the point-like objects but as *4D vortices* in the medium. In some rough approximation they can be treated as vortex lines like one-dimensional threads or strings. The place of the particle in the visible world is determined by the vent-hole of the vortex, by the position where it is risen on the border out of the medium. The aggregations of the vortices form the compound particles, atoms, molecules and so on up to all visible material objects of the world, the usual *3D matter*.

Due to the world exerts the surface tension, the region of 4D medium must have a form close to 4D sphere in the global scale. Therefore we name the entire region as *the universe* to distinguish it from the world. So we have 3D world as the (hyper-)surface of 4D universe. Of course, we can't exclude the possibility of the existence of the other external universes, supposedly spherical in shape as well, and distributed from each other on some distances in the infinite space. But we never can see them or adopt any information from them because the light and any kind of information can't spread among them through the empty space of *4D vacuum* where there is no any matter. Thus the interactions between universes can be only by direct contacts. The formation of the objects of the visual world has been described by this manner [5]. Here we will make an attempt to study the behaviour of the medium only in one of the universes. If the radius of the universe is big (as in the case of our *Universe*), at the rather small range the world may be described as 3D Euclidean space too. At the same time when there are no any 3D matter it has the name of usual *3D vacuum* through which the light can penetrate. However the world is not flat in general even if the perturbations in the universe such as waves, particles, stars and galaxies are not taken into account. So there are various scales where the picture proposed can apply on, from micro-world to macro-world.

The mutual interaction of the two adjacent vortices was studied [4] and the law of the their interaction close to the Newton's Universal law of gravitation was obtained as the effect of the curvature of the world. As it was said, in this paper the internal behavior of the medium is in our aim.

II. The Basic Equations

Let us consider any such universe that we have been determined in previous partition. In general we can describe the world of it as a border hypersurface of the 4D region occupied by matter with the help of equation

$$f(x,t)=0 \tag{2.1}$$

where $x = \{x_1, x_2, x_3, x_4\}$ are the coordinates of the space points. We take the Descartes coordinate system in Euclidean space with positively defined metrix. The centre of the system can be arbitrary. We can take it biased with the universe and call it as conditionally *absolute reference frame,* of course only within this chosen universe. The medium supposed to be situated inside of the boundary hypersurface. As it was told, the time t is an ordinary parameter independent from the space, but the position of any point of the medium is dependent from time, $x=x(t)$.

The dimensionality of the hypersurface is three and the knowledge the function f is a final task in our interpretation because the positions and the behaviour of all objects in the world can be found from the form of the function f. It is so because any object in the universe is "made" of from the 4D medium with its, conditionally said, visual part in the world, on the common 3D border hypersurface.

While the world is not flat it is supposed to undergo the pressure due to (hyper-) surface tension lineally depending from curvature of the border hypersurface:

$$p = \sigma K \tag{2.2}$$

where σ is a coefficient of the (hyper-)surface tension and K is the mean curvature of the hypersurface. Here we refer to p as a pressure density, *the hyperpressure density*, the force effecting on the unit of the hypersurface. In the case of four dimensions p and σ has the dimensionalities $[M^1 L^{-2} T^{-2}]$ and $[M^1 L^{-1} T^{-2}]$, respectively. If under this *hyperpressure* the universe takes the form of a sphere of radius R, the pressure reacts on the border in the direction of its gradient inwards the medium to the centre of sphere and its value can be rather small for big radius

$$p_0 = \frac{3\sigma}{R} \tag{2.3}$$

Nevertheless it might be big enough to hold the entire universe together. It can be if σ reaches a rather big value. In more complicated cases then sphere the mean curvature must be considered as the function of form of the hypersurface determined through the function f in Eq.(2.1). The tangent space to the sphere in any its point is Euclidean space R^3. This space can be taken as the simplest approximation of the world for the flat universe with zero curvature.

The state of the smooth world without 4D vortices on it we called *3D vacuum*. It can penetrate only the waves. But in general any piece of the medium can participate in any complicated movements with the velocity $u(x,t)=\frac{dx}{dt}\equiv\dot{x}$ in such a manner that their average density (in rather small region of the space) is not changed. This means that the medium can be treated as incondensable, homogeneous liquid where the divergence of u vanishes

$$\partial\cdot u = 0 \tag{2.4}$$

where symbol ∂ stands for partial derivatives with respect to four coordinates x. This property is taken for simplicity and makes the medium to be alike to the ideal fluid with no viscosity. As a result, the total flow through the closed hypersurface f, or the whole world, is vanished too and the 4D volume of the medium is constant. It can be treated as the consequence of Gauss-Ostrigradsky theorem for 4D case $\int d^4x\, \partial\cdot u = \oint d^3x\cdot u$

While the condition of incondensability is accepted we can take the equation of the motion for the small piece of the medium in the form similar to Euler equation for ideal fluid or fluid without viscosity extended to four dimensions:

$$\dot{u} + (u \cdot \partial) u + \frac{1}{\rho_4} \partial p = 0 \tag{2.5}$$

where ρ_4 is the density of the medium with dimensionality $[M^1 L^{-4} T^0]$. Because the latter is supposed to be constant in all its volume of the universe, the pressure is endowed with the sense of potential.

It is easy to consider the static case when the velocity field is constant for all universe. It means the whole universe is moving with that velocity. As it ensues from Eq.(2.5), pressure p will be constant inside the medium. This statement is known as the Pascal's law. For the spherical universe the constant pressure is determined by its external value in Eq.(2.3). Moreover, only spherical universe can have constant velocity for all its pieces. It is the inertial movement of the universe and the reference frame connected with such universe is the inertial reference frame in 4D space. Of course, the universe can also accomplish the inertial movement as whole with many various motion of its elements with its shape far different from spherical form.

The last member in Eq.(2.5) is suffered the jump on the hypersurface where the hyperpressure p is vanished meeting the 4D vacuum. It is sufficient while calculation the gradient p to use the surface gradient equalized to 4D vector of normal to the hypersurface multiplied on the value of hyperpressure.

In some approximation the hypersurface of the universe for the rather small area can be considered as the tangent space of the simplest case of the flat hypersurface when Eq.(2.1) looks like that in conveniently chosen system of coordinates

$$f = x_4 = 0 \tag{2.6}$$

In this case the pressure is vanished as it follows from Eq.(2.3) at $R \to \infty$ and the medium accepted to be occupied the half space, e.g. where $x_4 > 0$. The world in this case is the "usual" three-dimensional Euclidean space that we are usually associated in our single Universe with our single *World*. The World seems for us as we live in really seems as a flat space but it is not so both in the global macro scale for whole Universe and in the local micro scale when the particles of 3D substance is considered.

For chose local system of coordinates as pointed above we have the first three axes belonged or complanar to the 3D world and the fourth axis x_4 is normal to them keeping in mind that there are two possible orientations for this axis. So there are right and left systems of coordinates in 4D case along with the right and left systems in 3D case. Then the Eq.(2.5) dissevers to as follows:

$$\begin{gathered} \dot{\mathbf{u}} + (\mathbf{u} \cdot \nabla) \mathbf{u} + u_4 \partial_4 \mathbf{u} + 1/\rho_4 \nabla p = 0 \\ \dot{u}_4 + \mathbf{u} \cdot \nabla u_4 + u_4 \partial_4 u_4 + 1/\rho_4 \, \partial_4 p = 0 \end{gathered} \tag{2.7}$$

where ∇ is the usual partial derivative with respect to three coordinates $\boldsymbol{r} = \{x_1, x_2, x_3\}$. We took the same notation for velocity u in Eqs. (2.7) as in Eq. (2.5) because the various form of derivative (∇ instead of ∂) is using so they can't mix up. In addition to it 3D vectors are emphasized. Thus $\boldsymbol{u}$ is the velocity field that is complanar to the hypersurface at the some point of the 4D medium. It is not unique essence but only part of the full 4D velocity u, the first three components of it. Moreover, such record is fit for any hypersurface that can be defined in the universe, not only for border one.

From the form of the Eqs.(2.7) it is clear that they are invariant in the sense of the left or right frames.

Eq. (2.5) can be rewrote at such choice as

$$\nabla \cdot \mathbf{u} + \partial_4 u_4 = 0 \tag{2.9}$$

The hypersurface f is supposed to be free. It means that there are not any external constraints and that the equation

$$\dot{f} + u^f \cdot \partial f = 0 \tag{2.10}$$

is true under condition (2.1). The upper index f stands for the value which must be given on the border. If the hypersurface can be presented in the form of graph, e.g. $x_4 = x_4(\boldsymbol{r}, t)$, Eq.(2.10) will look like

$$u_4 + \mathbf{u}^{\mathbf{f}} \cdot \nabla x_4 = 0 \tag{2.11}$$

Hence to know the behaviour of hypersurface f one needs to know the border velocity field u^f for which Eq.(2.5) is satisfied under condition (2.4). But to know velocity one must know the form of the border hypersurface to calculate the hyperpressure. So the task seems to be unsolvable. However further we consider the possible motions of the medium inside the universe and how it may be perceived in the world.

III. The Field Invariants

There are additional relations that can be useful while solving the task. For the purpose to find one of them we multiply Eq.(2.5) represented by components

$$\dot{u}_i + u_k \partial_k u_i + \frac{1}{\rho_4} \partial_i p = 0 \tag{3.1}$$

to u_i and summarize. Hereafter the latin indices takes values from 1 to 4 and the usual rule of summation for repeating indices is presumed. Then it is easy to get the following equation

$$\dot{w} + u \cdot \partial w = 0 \tag{3.2}$$

where w is the constant in Bernoulli-like equation and, if we recall that density ρ_4 is constant, can be treated as the energy of the unit of mass with kinetic and potential parts:

$$w = \frac{1}{2} u^2 + \frac{1}{\rho_4} p \tag{3.3}$$

The last term is supposed to be independent from the time explicitly. Also the other form of this equation can be presented by expression $p_{tot} = \rho_4 w = p_{dyn} + p$ telling that *total hyperpressure* p_{tot} as the sum of the static hyperpressure p and the *dynamic hyperpressure* $p_{dyn} = 1/2 \rho_4 u^2$ conserves. It means that the density of energy in 4D case $\rho_4 w$ and total hyperpressure are the same. Knowing the energy density, one can obtain the Euler equation (2.5) from the Lagrangian density $\mathrm{L} = 1/2 \rho_4 \mathrm{u}^2 - \mathrm{p}$, keeping in mind that u is patently time and space dependent.

We may determine usual 3D energy density W referred to the 3D volume of the border hypersurface as follows

$$W = \frac{dU}{dV} = \rho_4 \int dx_4 w = \int dx_4 p_{tot} \tag{3.4}$$

where U is the energy, V is 3D volume given on the border and the integration is taken over x_4 axis from the border where velocity field is undergone the jump to some value L where the this field is vanished in the depth of the universe. So we can express the last equation as $W = L \rho_4 w^m$, where $w^m = \frac{1}{L} \int dx_4 w$ is w averaged over fourth dimension.

One can notice that the dimensionalities of W and σ are coincided. So the coefficient of the hypersurface tension may have the same sense as the density of energy in the classical physics. It is possible if σ has a big value for 4D medium. Really it was estimated as $2.65 \cdot 10^{13} J/L$ [6] and this value very much exceeds to energy density of nuclear fission for uranium, $1.54 \cdot 10^9 J/L$ [7]. Supposedly, it provides the survival of the big universes, such like our Universe, for those hyperpressure lessens with size in accordance with Eq. (2.3).

The law of energy conservation (3.2) also can be put down in a short form as

$$d_t w = 0 \tag{3.5}$$

if use the notation d_t instead of $\partial_t + (u \cdot \partial)$ as the full or the material derivative in 4D space. It means that the Bernulli constant w and p_{tot} keeps constant value not in the fixed point of the space but along the streamline belonging to so-called Bernoulli surface (which can be both 2D and 3D surfaces here).

The form of the streamline can be determined by the equations

$$\frac{dx_1}{u_1} = \frac{dx_2}{u_2} = \frac{dx_3}{u_3} = \frac{dx_4}{u_4} \tag{3.6}$$

As in 3D fluids, it coincides with the trajectory of the selected element of the medium unless the velocity field is time dependent. The set of the conjugate streamlines can form the Bernoulli surface where the value of energy density is the same. It means that the 3D Bernulli surface can be treated as the free hypersurfaces in the bulk of the 4D medium determined by the Eq.(2.1). The time independence of energy density on the Bernulli surface f means that $\dot{f}=0$. Then at any point of Bernulli surface f $u\cdot\partial f=0$ that signifies that the velocity field is tangent to this surface.

But the external surface is differed from the internal surfaces in one essential aspect. The pressure acting on the former is not in equilibrium as on the latter. The medium points of the inner streamline has the same values of the pressure from the both sides of the Bernoulli surface but with opposite signs. That is why the existence of the pressure inside of the border cannot be implied for the incondensable medium.

The sum of the energy (3.4) over all Bernulli surfaces localized in some 4D volume forms the full energy U of some "material object", e.g. the elementary particle, being in the world like a projection on the border from this volume. In the next paper we will give the detailed model of such construction.

The property of the additivity of the energy means that the streamlines belonging to different Bernulli surfaces can mix up under their juxtaposition. Really, if two conjugated Bernoulli surfaces f_1 and f_2 satisfy equations $d_t f_1=0$ and $d_t f_2=0$, the common Bernoulli surface $f=f_1+f_2$ will also satisfy Eq.(2.10) $d_t f=0$. That is why this property of the superposition of the hypersurfaces is used in [4] to derive the law of gravitation.

From Eq.(2.5) the law of 4D momentum density conservation $P=\rho_4 u$, also along the streamline, can be represented in a similar way if $-\partial p$, the force density, or acceleration of he medium particle $-\partial p/\rho_4$ caused by the curvature of the border hypersurface , is vanished

$$d_t P = 0 \tag{3.7}$$

Of course, this is the reflection of the fact that the velocity field belongs to the streamline. By other words, the streamline forms by the velocity field.

By multiplying Eq.(3.1) on $\rho_4 x_j$, changing indexes i and j and making subtraction we can easily get the conservation law of impulse-momentum density

$$\rho_4 d_t m = 0 \tag{3.8}$$

where m stands for the tensor of impulse-momentum density for the unit of mass

$$m_{ij} = x_i u_j - x_j u_i \tag{3.9}$$

The relation (3.8) will be true only if discard the last member in Eq.(3.1). Otherwise the right part of (3.8) will be equal to the torque density tensor $\rho_4(x_i\partial_j p - x_j\partial_i p)$. Obviously, it may not vanish only on the curved border and under violation of the symmetry of the pressure distribution in the 2D plane constructed from the axes marked by i and j. When we separate the coordinate x_4 from three others $\mathbf{r} = \{x_1, x_2, x_3\}$, we get two 3D vectors

$$\begin{aligned} \mathbf{m} &= \mathbf{r}\times\mathbf{u} \\ \mathbf{l} &= x_4\mathbf{u} - \mathbf{r}u_4 \end{aligned} \tag{3.10}$$

One can notice that vector $\mathbf{m}$ is nothing else then the usual angular velocity. Vector $\boldsymbol{l}$ also can be reckoned as angular velocity involving the fourth direction. It is easy to see that the scalar product vectors $\boldsymbol{m}$ and $\boldsymbol{l}$ is zero and that the value of $m^2 = \boldsymbol{m}^2 + \boldsymbol{l}^2$ conserves. It follows from the circular equation

$$det\ |m - \lambda\ E| = 0 \tag{3.11}$$

where E is the unit matrix, or wrote with a help of 3D vectors

$$\lambda^4 - \lambda^2\,(\boldsymbol{m}^2 + \boldsymbol{l}^2) + \boldsymbol{m}\cdot\boldsymbol{l} = 0 \tag{3.12}$$

eigen values of which are $\lambda_{1,2} = \pm\sqrt{\boldsymbol{m}^2 + \boldsymbol{l}^2}$

IV. The Electromagnetic Field

Let us again consider Eq.(2.5) and transform it as follows

$$\dot{\mathrm{u}} + \mathrm{F\,u} + \partial\,\mathrm{w} = 0 \tag{4.1}$$

where F is antisymmetric tensor of rank two composed from the partial derivatives of u:

$$\mathrm{F}_{i\,j} = \partial_i \mathrm{u}_j - \partial_j \mathrm{u}_i \tag{4.2}$$

It is easy to check that the gradient of F vanishes as it follows from definition of gradient:

$$(\mathrm{dF})_{ijk} \equiv \partial_i \mathrm{F}_{jk} - \partial_j \mathrm{F}_{ik} + \partial_k \mathrm{F}_{ij} = 0 \tag{4.3}$$

We may denote $F_{4\alpha}$ as e_α and $F_{\alpha\beta}$ as h_γ where Greek indices accept their values cyclically from 1 to 3. Then the sets $\mathbf{e} = \{e_\alpha\}$ and $\mathbf{h} = \{h_\alpha\}$ can be considered as they form the 3D-vectors. The vector $\mathbf{h} = \nabla\times\mathbf{u}$ is the usual vorticity of the field **u**, so the tensor F is its 4D extension. The vector $\boldsymbol{e} = \partial_4 \boldsymbol{u} - \nabla\, u_4$ can be also considered as the vorticity involving the extra dimension. Thus the record of Eq.(4.1) is the 4D extension of the Euler equation in the Gromeka-Lamb form.

Here it is needed to note that the orientation of the coordinate axes may be chosen fully arbitrary and may not be compatible with the border hypersurface. This means that the vectors $\boldsymbol{e}$ and $\boldsymbol{h}$ are interchangeable. But it is not so in vicinity of the border where we want to have usual three-dimensional axes marked as $\mathbf{r} = \{x_1, x_2, x_3\}$. Therefore we can choose orientation of the axis x_4 to be normal to the border which will suppose hereafter to be flat as in Eq. (2.6).

Using vectors **e** and **h** in Eq.(4.3), one can get two equations

$$\begin{aligned} &\nabla\cdot\mathbf{h} = 0 \\ &\nabla\times\mathbf{e} - \partial_4 \mathbf{h} = 0 \end{aligned} \tag{4.4}$$

Calculating the divergence of F with respect to the one of the indices. we get the following expression

$$(\partial\cdot\mathrm{F})_i \equiv \partial_k \mathrm{F}_{ik} = 4\,\pi\,\mathrm{J}_i \tag{4.5}$$

where it is used the denotation given with the help of (2.4)

$$4\,\pi\,\mathrm{J} = -\partial^2 \mathrm{u} \tag{4.6}$$

It doesn't matter what index is used because of antisymmetric type of F.

The Eq.(4.5) resolves into two with the help of vectors **e** and **h**

$$\begin{aligned} &\nabla\cdot\mathbf{e} = 4\,\pi\,\rho \\ &\nabla\times\mathbf{h} - \partial_4 \mathbf{e} = 4\,\pi\,\mathbf{j}/\mathrm{c} \end{aligned} \tag{4.7}$$

where c is some constant with dimensionality of velocity that, as will be shown later, is equal to the light speed, **j** and ρ are components of 4D vector $\mathrm{J} = (\mathbf{j}/\mathrm{c}, \rho)$ or explicitly

$$\begin{aligned} &4\,\pi\,\rho = -\partial^2 \mathrm{u}_4 = -(\nabla^2 \mathrm{u}_4 + \partial_4^2 \mathrm{u}_4) \\ &4\,\pi\,\mathbf{j}/\mathrm{c} = -\partial^2 \mathbf{u} = -(\nabla^2 \mathbf{u} + \partial_4^2 \mathbf{u}) \end{aligned} \tag{4.8}$$

Taking into account Eq.(2.4) one can get from Eq.(4.6)

$$\partial \cdot \mathrm{J} = \nabla \cdot \mathbf{j}/\mathrm{c} + \partial_4 \rho = 0 \tag{4.9}$$

It is easy to notice the similarity of Eqs. (4.4, 4.7) with those of Maxwell for electromagnetic fields **E** and **H** and Eq.(4.9) with equation of continuity. The components of 4D velocity field of medium would play in that collation the role of electromagnetic potentials **A** and φ . Then the quantities ρ and j ought be considered as ones having relation to the 4D charge density and current density, respectively.

In addition, the Eq.(4.1) being expressed through vectors **e** and **h** is taken the similar form as in the Lorentz equation for the charge particle

$$\dot{\mathbf{u}} - \mathbf{u} \times \mathbf{h} + \mathrm{u}_4 \mathbf{e} + \nabla \mathrm{w} = 0 \tag{4.10}$$

and as the change of its kinetic energy [10] but not by time but by the fourth dimension under condition $u_4 = const$

$$\dot{\mathrm{u}}_4 - \mathbf{u} \cdot \mathbf{e} + \partial_4 \mathrm{w} = 0 \tag{4.11}$$

There is no explicit place for the charge in these two equations. But as it follows from the Eq.(4.8) the sign of the charge can be associated with the direction of the velocity field along the fourth dimension that is presented in these equations. However the analog of Lorentz equation contains additional term with the force density ∇w which can not be implied if the motion of the streamline is considered where w takes constant value.

The similarity with the Maxwell's equations and with the equation of continuity will be closer if we could be possible to replace the spatial derivative ∂_4 in Eqs.(4.4, 4.7) by the temporal one $-1/c\,\partial_t$, where c is the constant speed of light. This could be done if Eq.(2.5) simplify in such a way that it takes a form

$$\begin{aligned} &\dot{\mathbf{u}} + \mathrm{c}\,\partial_4 \mathbf{u} = 0 \\ &\dot{\mathrm{u}}_4 + \mathrm{c}\,\partial_4 \mathrm{u}_4 = 0 \end{aligned} \tag{4.12}$$

It has an obvious plain wave solution $u_i(x,t) = u_i(k x_4 - \omega t)$ with condition $\omega = kc$.

Then the similar relations would be true for every partial derivative from u and its combinations and therefore the changing demanded above seems to be quite legitimate under assumption

$$(\mathbf{u} \cdot \nabla)\mathrm{u}_i + \mathrm{u}_4 \partial_4 \mathrm{u}_i = \mathrm{c}\,\partial_4 \mathrm{u}_i \tag{4.13}$$

The aforementioned wave solution leads to more stronger condition

$$\begin{aligned} &\mathrm{u}_4 = \mathrm{c} \\ &(\mathbf{u} \cdot \nabla)\mathbf{u} = 0 \end{aligned} \tag{4.14}$$

and gives $\partial_4 u_4 = 0$ that leads in view of (2.9) to an analogue of the Coulomb gauge $\operatorname{div} \boldsymbol{A} = 0$

$$\nabla \cdot \boldsymbol{u} = 0 \tag{4.15}$$

However, then Eq.(4.15) for the fourth component of velocity field becomes the identity with the light speed and the condition (4.13) would mean that the convective derivative $(\boldsymbol{u} \cdot \nabla)\boldsymbol{u}$ is neglected. If these conditions will be adopted to be valid, there should be no sense in the considering of the 4D matter as a liquid-like medium and no sense in the introduction of the fourth component of the velocity field. Then the intrinsic field F_{ij} should be postulated as in the classical electrodynamics but not be introduced from the equation of motion as it was made above. Therefore it would erode whole purport of the theory. And of course, the fourth component of the velocity field u_4 couldn't take there the enormous value of the speed of light at the border. So such assumption can be used as some approximation only far away from the border or in the model with infinite, boundless universe.

It is left only one formal difference between Maxwell's equations and those were been obtaining here. The sign at the second member in Eq.(4.7), the analogue of the Maxiwell's displacement current, don't correspond to that usually figured. The problem lies on the indeterminacy of the orientation of the embedded 3D-hypersurface into the 4D-manifold. Indeed in 3D space the vector **h** is an axial vector, or pseudo-vector, and its direction in 4D space can be freely referred to the 4th axis too because the latter is normal to **h** as any other vector in 3D subspace. Therefore the direction of **h** may be chose arbitrary in the 2D plane composed by its direction in 3D space and the 4th axis and so it may be by the arbitrary way inverted in 3D space. But when we map the **h** vector onto the border 3D space, onto the world, its orientation can not be arbitrary and must be taken in concordance with the orientation of the border. The problem also can be stem from the uncertainty of the sign of gradient of F that is vanished by Eq.(4.3) and from the sign dependence of divergence of F by Eq.(4.5).

Moreover, the sign in the equation of continuity after replacement $\partial_4 \to -1/c\,\partial_t$ also would not be that that stands in classical equation. It tells us that the problem doesn't solve by such operation.

The distinction of the forth direction and the time that would be disappeared under condition of Eq.(4.12) becomes obvious while the considering the transformational property of the fields $\boldsymbol{e}$ and $\boldsymbol{h}$. The first of them changed its sign while the second is left unchanged under inversion $x_4 \to -x_4$ but the time inversion $t \to -t$ changes the both of them. In classical electrodynamics the transformational properties of the electromagnetic fields are different and the magnetic field expresses through matrix F by different way then it was proposed here. There used rather artificial method with the help of the Levi-Civita symbol ϵ_{ijkl} (proved in the special theory of relativity) to make the right sign in Maxwell's equations.

Otherwise it seems one can easily overcome the sign misconception by the redetermine the current density as

$$4\pi\,\mathbf{j}/c = \nabla^2 \mathbf{u} + \partial_4^2 \mathbf{u} + 2\,\nabla\times\mathbf{h} \tag{4.16}$$

instead of Eq.(4.8) to get the needed signs at second Eq.(4.7). However the sign in the equation of continuity (4.9) will change after this operation.

But even then there is a main distinction between the classical electromagnetic potentials and the velocity field u. The former are defined in 3D space, in the flat world, and the latter is in 4D space of the "round" universe. Therefore they will never be fully in comparison and their dimensionalities are therefore different. We may call the fields **e** and **h** the *intrinsic electric and magnetic fields* to distinguish its from "extrinsic" fields **E** and **H**, respectively, that are using in the classical physics.

We can calculate time derivative of F by the straightforward way with substituting $\dot{u}$ from Eq.(3.1) into the determination of F (4.2). Then we get

$$\begin{aligned} &\dot{F}_{ij} + \partial_i\left((u_k\partial_k)u_j + 1/\rho_4\,\partial_j p\right) - \partial_j\left((u_k\partial_k)u_i + 1/\rho_4\,\partial_i p\right) = \\ &\quad = \dot{F}_{ij} + u_k\partial_k F_{ij} + \partial_i u_k \partial_k u_j - \partial_j u_k \partial_k u_i \end{aligned} \tag{4.17}$$

After adding $\pm\partial_i u_k \partial_j u_k$ and making some simple arrangements the next relation that express the extension of the Helmholtz equation for 4D vorticity appears

$$\dot{\mathrm{F}} + \mathrm{L_u F} = 0 \tag{4.18}$$

where $\mathrm{L_u}$ is the Lie derivative with respect of 4D field u

$$L_u F_{ij} \equiv u_k \partial_k F_{ij} + \partial_i u_k F_{kj} + \partial_j u_k F_{ik} \tag{4.19}$$

Relation (4.18) shows that the intrinsic electromagnetic field is "frozen" into the velocity field. It is carrying along by the field u because it is generated by this field. In the case of extrinsic fields it is not so. This fact can be shown if Eq.(4.18) will be presented with the help of vectors **e** and **h**

$$\begin{aligned} &\dot{\mathbf{e}} + (\mathbf{u}\cdot\nabla)\mathbf{e} + \mathrm{u}_4\partial_4\mathbf{e} + (\mathbf{e}\cdot\nabla)\mathbf{u} + \mathbf{e}\,\partial_4\mathrm{u}_4 + \mathbf{h}\times\nabla\mathrm{u}_4 = 0 \\ &\dot{\mathbf{h}} + (\mathbf{u}\cdot\nabla)\mathbf{h} + \mathrm{u}_4\partial_4\mathbf{h} - (\mathbf{h}\cdot\nabla)\mathbf{u} - \mathbf{h}\,\partial_4\mathrm{u}_4 + \mathbf{e}\times\nabla\mathrm{u}_4 = 0 \end{aligned} \tag{4.20}$$

We see that there are additional terms along with the Lie derivatives in 3D space with respect to 3D component of the velocity $\boldsymbol{u}$ $L_u \boldsymbol{e} = (\boldsymbol{u}\cdot\nabla)\boldsymbol{e} - (\boldsymbol{e}\cdot\nabla)\boldsymbol{u}$ and $L_u \boldsymbol{h} = (\boldsymbol{u}\cdot\nabla)\boldsymbol{h} - (\boldsymbol{h}\cdot\nabla)\boldsymbol{u}$. If it would be not so, the expressions in (4.20) would be seemed as the usual Helmholtz equation for 3D vorticities $\boldsymbol{h}$ and $\boldsymbol{e}$ and it would be meant that the intrinsic fields $\boldsymbol{h}$ and $\boldsymbol{e}$ are frozen 3D velocity field too. It tells us that there isn't any of both fields $\boldsymbol{e}$ and $\boldsymbol{h}$ being frozen separately but only their aggregation in the tensor field F.

However, the terms with Lie derivatives in Eqs.(4.20) may be included in the *total time derivatives* with respect to some 3D-hypersurface parallel to the border $D_t = \partial_t + L_{\mathbf{u}}$. It differs from the full derivative $\partial_t + \boldsymbol{u}\cdot\nabla$ and means that the time derivatives is measured with respect to the points of the medium belonging to this hypersurface but not with respect to the point of 4D space. The third terms in Eqs.(4.20) can be changed with the help of Eqs.(4.4, 4.7) to be closer to the form of the Maxwell's equations. But the two last terms in Eqs.(4.20) are redundant from the point of view of the classical electrodynamics. They are vanishing if the condition of the constant fourth component of velocity is implied. Really there isn't any derivatives of this component of velocity in 3D physics. So if we take this condition, these pair of equations together with Eqs.(4.4, 4.7 and 4.16) will be an analogue of the set of main equations in electrodynamics:

$$\begin{aligned} &\nabla\times\mathbf{h} - \frac{1}{c} D_t \mathbf{e} = \frac{4\pi}{c}\left(\mathbf{j} + \mathbf{j}^{\mathbf{add}}\right) \\ &\nabla\times\mathbf{e} + \frac{1}{c} D_t \mathbf{h} = 0 \end{aligned} \tag{4.21}$$

where $\boldsymbol{j}^{add} = 1/2\pi(\boldsymbol{e}\cdot\nabla)\boldsymbol{u}$ is the *additional intrinsic current density*. The signs in the first equation are corresponded to the right signs of the analogue of the Ampere's equation by using new determination of current density.

It is not hard to get the integral forms of the Maxwell's-like equations by integrating Eqs. (4.4) and (4.7) over some flat 3D hypersurface normal to the x_4 -axis or by integrating over some closed 2D surface situated on this hypersurface.

$$\begin{aligned} &\oiint \boldsymbol{h}\, d^2\boldsymbol{r} = 0 \\ &\oint \boldsymbol{e}\cdot d\boldsymbol{r} = \partial_4 \int \boldsymbol{h}\cdot d^2\boldsymbol{r} \\ &\oiint \boldsymbol{e}\, d^2\boldsymbol{r} = 4\pi \int \rho\, d^3\boldsymbol{r} \\ &\oint \boldsymbol{h}\cdot d\boldsymbol{r} = \partial_4 \int \boldsymbol{e}\cdot d^2\boldsymbol{r} + \frac{4\pi}{c}\int \boldsymbol{j}\cdot d^2\boldsymbol{r} \end{aligned} \tag{4.22}$$

There were used the Stock's and Gauss-Ostrogradsky theorems in the left sides of these equations given the closed path and surface integrals, respectively. So e.g. the second of them, the analogue of the Faraday's law of induction for the intrinsic fields, can be formulated as so:

The *intrinsic electromotive force* in any closed path belonging to the 3D hypersurface normal to the fourth direction into the 4D medium is equal to the derivative over fourth coordinate of the *intrinsic magnetic flux* through 2D surface covering by this path. Note that the dimensionality of the intrinsic electromotive force is the same as of velocity. Because operations of the fourth derivative and integrating over surface normal to the fourth direction are commuted we can put the left side of this equation as $\partial_4 \oint \boldsymbol{u}\cdot d\boldsymbol{r}$ taking into account the determination of field $\boldsymbol{e}$ and that the closed path integral from the gradient function in it is vanished. Thus the intrinsic magnetic flux through some 2D surface is the velocity circulation over the path restricted this surface and the intrinsic electromotive force can be determined as the forth derivative from the circulation of the 3D velocity field normal to the fourth direction:

$$\int \boldsymbol{h}\cdot d^2\boldsymbol{r} = \oint \boldsymbol{u}\cdot d\boldsymbol{r} \tag{4.23}$$

Of course, it also can be obtained as the consequence of the Stock's theorem for $\boldsymbol{h} = \nabla\times\boldsymbol{u}$.

The next relation follows from the equation of continuity (4.12)

$$\frac{1}{c}\oiint \boldsymbol{j}\cdot d^2\boldsymbol{r} = -\partial_4 \int \rho d^3\boldsymbol{r} \qquad (4.24)$$

We see that if the right side is null for the constant (in the fourth dimension) *intrinsic charge* $q=\int \rho d^3\boldsymbol{r}$ for some 3D volume for some hypersurface the *intrinsic current flux* through the 2D surface of this volume is absent too.

V. The Maxwell's Equations

We saw that the time dependence of intrinsic fields $\boldsymbol{e}$ and $\boldsymbol{h}$ can not be came down to the form of classical equations of electrodynamics by direct way. To obtain the form of the Maxwell's equations from the velocity field one can made the procedure to conform its dimentionalities. Then in order to get the "usual" electromagnetic fields from the intrinsic ones it is sufficient to use square root of 3D energy density given by Eq.(3.4) instead velocity u. So to come over to extrinsic field from intrinsic one one can take constant $k=\sqrt{\rho_4 L/2}$ as a factor in all determinations. So we will have the following expressions:

$$\begin{aligned} \mathbf{E} &= k\int dx_4 \mathbf{e} = k\mathbf{u^f} - \nabla k\int dx_4 u_4 \\ \mathbf{H} &= k\int dx_4 \mathbf{h} = \nabla\times k\int dx_4 \mathbf{u} \end{aligned} \qquad (5.1)$$

Here $\boldsymbol{u}^f$ is the value of the 3D velocity $\boldsymbol{u}$ on the border. We can determine the electromagnetic potentials as follows

$$\begin{aligned} \mathbf{A} &= k\int dx_4 \mathbf{u} = kL\mathbf{u^m} \\ \varphi &= k\int dx_4 u_4 = kL u_4^m \end{aligned} \qquad (5.2)$$

As we can see they are really, as it was pointed out above, the components of the mean 4D velocity, marked by upper index m, with accuracy of the factor kL. Therefore the averaged value over the fourth direction of the dynamical part of hyperpressure, defined in the section III, can be wrote as $p_{dyn}^m = \frac{1}{L^3}(\boldsymbol{A}^2+\varphi^2)$. So with the help of the potentials the electric and magnetic fields the latter will look close to those in the classical theory

$$\begin{aligned} \mathbf{E} &= k\mathbf{u} - \nabla\varphi \\ \mathbf{H} &= \nabla\times\mathbf{A} \end{aligned} \qquad (5.3)$$

To meet the determination of $\boldsymbol{E}$ given in Eq.(5.1) with the classical one in Eq.(5.3) we are compelled to admit that

$$k\boldsymbol{u}^f = -\frac{1}{c}\dot{\boldsymbol{A}} \qquad (5.4)$$

Of course, this relation will be true only under condition (4.12), given for $\boldsymbol{u}$ because we can get it while integrating the former along the fourth dimension.

To obtain the first pair of Maxwll's equations we can take divergence of the second Eq.(5.1) and integrate the second Eq.(4.23) taking into account that the integration over x_4 and the total derivative commutes. So we have the next expressions

$$\begin{aligned} &\nabla\cdot\boldsymbol{H} = 0 \\ &\nabla\times\boldsymbol{E} + \frac{1}{c}D_t\boldsymbol{H} = 0 \end{aligned} \qquad (5.5)$$

The difference between (5.7) and (5.8) by our opinion consists in the following. The observer which is connected with medium can perceive with the help of his receptors and instruments only such alteration of the electromagnetic fields which is not "frozen" into medium. He perceives only 3D part of the medium and feels the temporal change of $\boldsymbol{H}$ only if there is the whirl of $\boldsymbol{E}$. It must be noted that it was used Coulomn's gauge while the Faraday's law by Eq.(5.8) is derived.

Giving the divergence of the first equation in (5.1) or integrating (4.8) we get the next

Maxwell's equation

$$\nabla\cdot\boldsymbol{E}=4\pi\rho^{cl} \tag{5.6}$$

where ρ^{cl} stands for the classical charge density which is referred to the three-dimensional case and can be defined by that expression

$$\begin{aligned}4\pi\rho^{cl}&=4\pi k\int dx_4\rho=-\nabla^2\varphi+k(\partial_4 u_4)^f=\\&=-\nabla^2\varphi-k\nabla\cdot\boldsymbol{u}^f=-\nabla^2\varphi-\frac{1}{u_4^2}D_t^2\varphi,\end{aligned} \tag{5.7}$$

where we used Eqs.(5.6). We see that the charge can be generated by the surface divergence of the $\boldsymbol{u}$ as well as by the scalar potential φ .

The last equation with the right sign at the Maxwell's displacement current can be obtained when integrate the first Eq.(4.21)

$$\nabla\times\boldsymbol{H}-\frac{1}{c}D_t\boldsymbol{E}=\frac{4\pi}{c}\left(\boldsymbol{j}^{cl}+\boldsymbol{j}'\right) \tag{5.8}$$

where we denote external density of current of conductivity with tilde that differs from that used above

$$\boldsymbol{j}^{cl}=k\int dx_4\boldsymbol{j}=-\nabla^2\boldsymbol{A}+k\partial_4\boldsymbol{u}^f=-\nabla^2\boldsymbol{A}-\frac{1}{u_4^2}D_t^2\boldsymbol{A} \tag{5.9}$$

and *supplementary external current density* that is absent in classical theory

$$\boldsymbol{j}'=k\int dx_4\boldsymbol{j}^{add}=2k\int dx_4(\boldsymbol{e}\cdot\nabla)\boldsymbol{u} \tag{5.10}$$

The presence of supplementary current is predicted by I.Dini [???]. Because the displacement current still didn't observed in any experiment, the additional current presence assures the existence of the whirl of the magnetic field in the case of absence of any source of the electric conductivity current.

Taking the operation of divergence of Eq.(5.8) and using Eq.(5.6) we get the continuity equation in the following form

$$D_t\rho^{cl}+\nabla\cdot(\boldsymbol{j}^{cl}+\boldsymbol{j}')=0 \tag{5.13}$$

where $D_t\rho^{cl}=\dot\rho^{cl}+\boldsymbol{u}\cdot\nabla\rho^{cl}$ is the total derivative for scalar ρ^{cl} .

To be this form of equation of continuity compatible with that figured in the classical textbooks the divergence of $\boldsymbol{j}'$ must be vanished. It is not hard to show that it must be fulfilled the following expression for that

$$\nabla^2(\boldsymbol{u}\cdot\boldsymbol{e})=0 \tag{5.14}$$

It is true taking in view of Eq.(4.11) for $u_4=const$.

Such presentation of the current density follows straightforwardly from the basic equations of the theory and meets the problem with the proper sign at the second term in Eq.(5.8), the Maxwell's displacement current, and that is why they lead to the proper form of the equation of continuity as it used in the classical electrodynamics.

Thus we get the Maxwell's equations from the intrinsic velocity field u making only one alteration in the changing time derivatives by the total ones. However it seems rather logical if take into account that we and all our devices are in the same field u too. Also it was used the condition of constancy of u_4 or the Coulonm gauge. Below we consider this moment in details. So the classical Maxwell's equations ought not be considered as the final equations for the behavior of the electric and magnetic fields. The actual equations for the fields $\boldsymbol{E}$ and $\boldsymbol{H}$ in this theory can be obtained by the integration of Eqs.(4.22) without of setting $u_4=c$.

VI. **The Gauge Potential**

As in the classic theory we can take the gauge potential $\psi(x,t)$ that doesn't change the intrinsic electromagnetic field F by adding any gradient of it to u

$$u \to u' = u + \partial\psi \qquad (6.1)$$

However, as it follows from the condition (2.4), the potential can not be fully arbitrary function as in classical electrodynamics and the Laplace equation for ψ should be valid

$$\partial^2 \psi = 0 \qquad (6.2)$$

As well it can be considered as the Poinson equation in 3D space being rewrote in the form $\nabla^2 \psi + \partial_4^2 \psi = 0$. There is a number of the well known solutions of these equations that will be considered at the next paper.

We can denote $\partial\psi$ as -V and, if V (and Ψ respectively) is not explicitly dependent from time, $V = V(x)$, after integration we get from Eq.(6.1) $x' = x - Vt + x_0$, where x_0 is constant of integration. One can choose $x_0 = 0$ so that the beginning of the new coordinate system x' will be such that at t=0 it coincides with the beginning of the old coordinate system x. It corresponds to the transition from reference frame with coordinate system x to the frame with coordinate system x'. Then we see that equation

$$x' = x - Vt \qquad (6.3)$$

together with equation u'=u-V is nothing else that the Galilean transformation for four-dimensional case. Thus the local form of the Galilean principal of relativity which is the special case of the gauge transformation (6.1) in the case of the stationary value of gauge potential is valid.

It is easy to consider the occasion of inertial reference frame for 4D space when vector V is constant in time and space for the universe considered, when gauge potential has a form $\psi = V \cdot x + \psi_0$, Ψ_0 is constant. It means that the movement of the universe with constant velocity does nothing with the behavior of velocity field inside the universe. The choice of any inertial reference frame doesn't change the form of the basic equations presented in the ch.II. It can be treated so that the Newton's-like first law of classical mechanics is true in 4D case too. It can be formulated as following. For inertial reference case the universe either remains at rest or continues the moving with constant velocity, unless acted by an other universe. Obviously for such object as the whole universe only the possible contact interaction with other universes must be considered. While the Galilean principle is valid in 4D space the case of inertial frame of reference for its subspace in three dimensions as the subject of the special theory of relativity will be considered later in the context of this model.

If there will be found such function Ψ that $u' = 0,$ the electromagnetic field F' in the reference frame x' is absent. Then the velocity field u will be the potential field for which intrinsic fields F is absent too. It means that if there is some reference frame where the electromagnetic field is vanished, it will be null in every other reference frame. We can not create electromagnetic field by choosing any special inertial reference frame. The intrinsic electromagnetic field and depended of which extrinsic one can appear only by the rotational movement of the medium. To the other hand. we can choose such local reference frame where the field F is vanished if it's velocity V will be equal to the velocity u. This case is correspond to the case of non-inertial reference frame in the classical theory where additional fictitious accelerations such as the centrifugal and Coriolis's ones are appearing instead.

It can be seen also after substitution (6.1) in Eq.(3.3) one can get the next form of the Bernulli integral

$$w' = w - u \cdot V + \frac{1}{2} V^2 \qquad (6.4)$$

We see that the additional part to the energy density dependent from the mutual direction of fields u and V is appeared beside the kinetic term $V^2/2$. Therefore the form of the streamlines under transformation (6.3) will change. Meanwhile, as we will show later, the law of energy conservation is true for some localized structures such as the fundamental particles if the mean value of scalar product of velocity fields u and V for some period of time is vanished.

The integration along the x_4 -axes gives from Eq.(6.1) in the form for three-dimensional part of the velocities the well-known gauge transformation for the vector potential

$$\boldsymbol{A}'=\boldsymbol{A}+\nabla\chi \tag{6.5}$$

where from the comparison with Eq.(5.2) one can get the classical gauge function χ which is the mean velocity potential ψ^m multiplied by the factor kL

$$\chi=k\int d\,x_4\,\psi=k\,L\,\psi^m \tag{6.6}$$

So χ is arbitrary function in 3D subspace transverse to x_4 -axes of the 4D medium due to the arbitrariness of ψ under the condition of Eq.(6.2).

For the scalar electrostatic potential φ the classical gauge transformation looks like $\varphi'=\varphi-\dot{\chi}/c$ that means keeping in view of Eqs.(6.1) and (6.6) that

$$\frac{1}{c}\dot{\chi}=\frac{k\,L}{c}\dot{\psi}^m=-k\,\psi^f \tag{6.7}$$

where ψ^f is the border value of ψ.

After the integration in the last equality over time from t=0 up to the some value T=L/c we obtain the time averaged value of ψ^f marked by the line and the following expression

$$\psi^m=-\,\overline{\psi^f} \tag{6.8}$$

Thus the averaged value of potential over some streamline in the fourth direction is equal with the opposite sign to the border potential over time if the length of the streamline L is equal to cT. The latter relation was in the close relation with the 4D string model of particle presented in [??].

From Eq.(6.8) one can see that under the gauge transformation the vector potential will change on the value in accordance with (??)

$$\nabla\chi=-\frac{\sqrt{\rho_4}}{L}c\,\boldsymbol{S} \tag{6.9}$$

where $\mathbf{S}=\mathbf{V}^{\mathbf{f}}t$ is the path gone by the some object of the universe, as it will be shown below, for example, the charge, with the velocity $\boldsymbol{V}^f$ on the border surface for time t. It can be understood if replace (6.1) into Eq.(2.10). We get the new value of function f at the point x' from (5.2) which must belong to the same hypersurface that was described by Eq. (2.1). We may choose the velocity V in (6.1) so that the time derivative of f(x') will vanish. It means that the form of the function f at the reference frame x' is not changing and the new velocity field u' is left tangent to the hypersurface. Really, from $\dot{f}(x')=0$ due to Eq. (2.10) and the apparent time independence it is following

$$u'\cdot\partial' f=0 \tag{6.11}$$

Hence new velocity u' is always tangent to the border, to the world, at any its point and to the any Bernulli surfaces in any point of the medium belonging to them. By the other words, any piece of the medium having such velocity can't change the form of the Bernulli surface f. That is why the charged particle conserves if it is stable one or undergoes a fission on the other particles otherwise. Nothing can disappear without a trace on the border hypersurface. Therefore we can treat velocity V as a velocity of the elementary particle's hypersurface in the reference frame given by the coordinate system x'. The first three components of it taken on the border hypersurface composes the visual velocity $\boldsymbol{V}$ of the particle so that this particle can be chose as the reference body for the coordinate system x'.

Although the Maxwell's equations, both for the intrinsic and extrinsic fields, are not changed under the gauge transformation, the equation of motion will contain additional terms. Subtracting them after substitution u' from Eq.(6.1) into Eq.(4.1) one can get the following equation

$$\dot{\mathrm{V}}+\mathrm{F}\,\mathrm{V}+\partial\delta\,\mathrm{w}=0 \tag{6.12}$$

where

$$\delta\,\mathrm{w}=\mathrm{w'}-\mathrm{w} \tag{6.13}$$

Eq.(6.12) wrote by components will look like the Lorentz equation of motion for a charged particle

$$\dot{\mathbf{V}}+\mathrm{V}\times\mathbf{h}+\mathrm{V}_4\mathbf{e}+\nabla\delta\,\mathrm{w}=0 \tag{6.14}$$

and like the equation for the changing of the kinetic energy due to electric field [5]

$$\dot{\mathrm{V}}_4-\mathbf{e}\cdot\mathbf{V}+\partial_4\delta\,\mathrm{w}\,=\,0 \tag{6.15}$$

Really, after the integration along x_4 -axis and the multiplication on $\sqrt{\rho_4}/L$ the lastt equation takes the following form if vector $\boldsymbol{V}$ is not dependent from x_4

$$\frac{1}{\sqrt{\rho_4}L}\delta\,W=\boldsymbol{E}\cdot\boldsymbol{V} \tag{6.16}$$

Here we are taken into account that due to Eqs.(6.7) and (6.8) $\int d\,x_4\,\dot{V}_4=\dot{\psi}^f=0$, where $\delta\,w^f$ stands for $\delta\,w$ on the border. It equals the difference between the intrinsic kinetic energy $½u'^2$ and $½u^2$. If there is the dependence $\boldsymbol{V}(x_4)$, then the additional term $-\int d\,x_4\,\boldsymbol{E}\cdot\partial_4\boldsymbol{V}$ is appeared at the left side of Eq.(5.16). These equations again let us treat the velocity **V** as the velocity of charged fundamental particle. The missed sign before the square root balked everywhere above points out on the charge of the particle. In the next paper we show in what relation is between the charge of the particle and $\sqrt{\rho_4}L$.

While integrating Eq.(6.14) on x_4 we get the mean acceleration $\sqrt{\rho_4}\dot{\boldsymbol{V}}^{\boldsymbol{m}}$ of the particle in the first term and $\boldsymbol{V}\times\boldsymbol{H}$ in the second one if again discard the dependence $\boldsymbol{V}$ on x_4 . Otherwise the term $-\int d\,x_4\,\partial_4\boldsymbol{V}\times\boldsymbol{H}$ will be appeared while integrating by parts. The third term gives $V_4\boldsymbol{E}$ and $-\int d\,x_4\,\partial_4 V_4\boldsymbol{E}$

The greater comparison of Eq.(5.6) with the Lorentz equation will be under condition

$$\nabla\delta\,\mathrm{w}=0 \tag{6.17}$$

or, what is the same, under condition of $\dot{\psi}=\mathrm{W_p}-\mathrm{U}$, where U is constant. It let us to find potential in the form

$$\psi=(W_p-U)t+\psi_0 \tag{6.18}$$

Then $\nabla\mathrm{W_p}$ will be equal $\dot{\mathrm{V}}$ in Eq.(5.6).

The equation (5.1) can be integrated to get local form of the Galilean transformation

$$\mathrm{x'}=\mathrm{x}+\,\mathrm{Vt} \tag{6.19}$$

So eq.(5.3) will has been wrote as

$$\partial' W_p=0 \tag{6.20}$$

in the reference frame where velocity V is vanished. Again the energy density W_p remains constant in these coordinates in any velocity field u where intrinsic electromagnetic field F is not absent. We think this fact is in the close relation with the Helmholtz's theorem for this field (4.20).

We also can make the gauge transformation in the determination of the electric field $\boldsymbol{E}$ in the form of Eq.(4.19). Then the latter can take the simple form due to eq.(5.2)

$$\boldsymbol{E}=\sqrt{\rho_4}\boldsymbol{u}'^0 \tag{6.21}$$

if we set

$$\varphi=\sqrt{\rho_4}\psi \tag{6.22}$$

So by measuring $\boldsymbol{E}$ and $\boldsymbol{u^0}$ we can determine the coefficient ρ_4 . The condition

(5.13) can be reached when the velocity $\boldsymbol{V}=\nabla\psi$ will be equal to $1/\sqrt{\rho_4}\nabla\varphi$.

VII. The rotational transformation of electromagnetic fields

Along with the gauge transformation of the field u which does nothing with the tensor field F, the rotation of space makes some changes of the fields **e** and **h**. Obviously rotation in four dimensions leaves unchanged not an axis as in 3D case but some two-dimensional plane. The rotation around the plane composed by any 3D vector and x_4 -axis does not change $\boldsymbol{h}$ and change direction of $\boldsymbol{e}$. More interesting the rotation around a plane composed by any 3D vector. Let us choose x_2 and x_3 orths as such vectors. Then it is easily can be done if affect on field u by the matrix

$$\mathrm{M}=\begin{bmatrix} \cos\alpha_4 & . & . & -\sin\alpha_4 \\ . & 1 & . & , \\ . & . & 1 & . \\ \sin\alpha_4 & . & . & \cos\alpha_4 \end{bmatrix} \tag{7.1}$$

Then the next expressions can be obtained when the tensor F transforms into tensor $\mathrm{F'=M^{-1}FM}$

$$\begin{aligned} & h'_1=h_1 \\ & h'_2=\cos\alpha_4 h_2-\sin\alpha_4 e_3 \\ & h'_3=\cos\alpha_4 h_3+\sin\alpha_4 e_2 \\ & e'_1=e_1 \\ & e'_2=\cos\alpha_4 e_2-\sin\alpha_4 h_3 \\ & e'_3=\cos\alpha_4 e_3+\sin\alpha_4 h_2 \end{aligned} \tag{7.2}$$

From it one can easily see that the next equations are satisfied

$$\begin{aligned} & \boldsymbol{e}'^2+\boldsymbol{h}'^2=\boldsymbol{e}^2+\boldsymbol{h}^2 \\ & \boldsymbol{e}'\cdot\boldsymbol{h}'=\boldsymbol{e}\cdot\boldsymbol{h} \end{aligned} \tag{7.3}$$

It means that the sum of squares and the scalar product of magnetic and electric fields are invariants under any orthogonal rotation because he latter can be composed from the any rotations similar to those that is presented in (7.1).

We can rewrite Eqs.(7.2) in the form of the transformation obtained in special theory of relativity if we change $\sin\alpha_4$ by ratio V_1/c . Then the action of matrix M will be similar to the boost of the inertial reference frame along the x_1 axis. In general case where rotation occurs around any 2D plane in 3D space tranversed to x_4 axis we get the following relations after transition from intrinsic fields to extrinsic ones

$$\begin{aligned} & \boldsymbol{H}'_{\perp}=\boldsymbol{H}_{\perp} \\ & \boldsymbol{H}'_{\parallel}=\sqrt{1-\frac{|\boldsymbol{V}|^2}{c^2}}\boldsymbol{H}_{\parallel}-\frac{1}{c}\boldsymbol{V}\times\boldsymbol{E} \\ & \boldsymbol{E}'_{\perp}=\boldsymbol{E}_{\perp} \\ & \boldsymbol{E}'_{\parallel}=\sqrt{1-\frac{|\boldsymbol{V}|^2}{c^2}}\boldsymbol{E}_{\parallel}-\frac{1}{c}\boldsymbol{V}\times\boldsymbol{H} \end{aligned} \tag{7.4}$$

where velocity $\boldsymbol{V}$ is put down through the direction cosines $\{\cos\alpha_i\}$ for which $\cos^2\alpha_1+\cos^2\alpha_2+\cos^2\alpha_3+\cos^2\alpha_4=1$

$$V = c\begin{pmatrix} \cos\alpha_1 \\ \cos\alpha_2 \\ \cos\alpha_3 \\ \cos\alpha_4 \end{pmatrix} = \begin{pmatrix} \boldsymbol{V} \\ V_4 \end{pmatrix} \tag{7.5}$$

In special theory of relativity this velocity is told to be related to the velocity of the inertial reference frame with respect to the other reference frame. Really this theory will be true in our consideration only if Eq.(4.17) is true. Then the following will be true after integration on t

$$x_4=ct+x_4^0=ct' \tag{7.6}$$

with constant of integration x_4^0 that can be set to zero under choosing the new time t'. Then the rotational transformation (7.1) "transforms" to the Lorentz one if it will be operated on the coordinate system x = {x_1, x_2, x_3, ct'} to the new coordinate system x' = {x'_1, x'_2, x'_3, ct}

$$\begin{gathered} x_1=\frac{x_1'-Vt'}{\sqrt{1-V^2/c^2}} \\ x_2=x_2' \\ x_3=x_3' \\ t=\frac{t'-V\,x_1'/c^2}{\sqrt{1-V^2/c^2}} \end{gathered} \tag{7.7}$$

One has to note that the time t in the last equation is not the same time t as in Eq.(6.6). The former is the time of special theory of relativity that can coincide with the "normal" time t under small velocity V and under next condition

$$x_4{}^0=x_1'V/c=x_1'\sin\alpha_4 \tag{7.8}$$

We see that the so-called inertial reference frame marked by apostrophe using in special relativity refers to the coordinate system which drew the boundary hypersurface of the universe, the world, out from the medium into the 4D emptiness and into the depth of the 4D medium. It goes ou t from the 3D world. The so-called proper time in this theory refers to time measured in the distances in 4D vacuum but not to the world.

Otherwise the Galilean transformation (5.2) doesn't change the fields. Because the relations aforecited in Eqs.(7.4) has never be checked at any experiment, there is some doubt in its equity.

VIII. Field invariants

As usually we can determine the invariants of the intrinsic electromagnetic field F from the characteristic equation

$$det(F_{ij}-\lambda\,\delta_{ij})=0 \tag{8.1}$$

Using fields $\boldsymbol{e}$ and $\boldsymbol{h}$ we get the next expression

$$\lambda^4-(\boldsymbol{e}^2+\boldsymbol{h}^2)\lambda^2+(\boldsymbol{e}\cdot\boldsymbol{h})^2=0 \tag{8.2}$$

By direct calculation it is easy to show that the last term vanished

$$\boldsymbol{e}\cdot\boldsymbol{h}=0 \tag{8.3}$$

So the eigen values of field F can be found from the solutions of the equation

$$\lambda^2-(\boldsymbol{e}^2+\boldsymbol{h}^2)=0. \tag{8.4}$$

So we get

$$\lambda_{1,2}=\pm\sqrt{(\boldsymbol{e}^2+\boldsymbol{h}^2)} \tag{8.5}$$

One can compare Eqs.(8.3) and (8.5) with those in (7.3).

Here we can return to the determination of the Bernulli hypersurface. As far as concern to the that hypersurface it is obvious from Eq.(3.5) that the normal to it ∂f must be perpendicular to velocity vector u that can be only if $\dot{f}=0$ as it follows from Eq.(2.10). Then we can determine such hypersurface where the vectors u , ∂f , $\boldsymbol{e}$ and $\boldsymbol{h}$ are tangent in every point as it presented in Fig.1. These four vectors being normalized can be used as the basis of the local system of coordinates. Thus by the analogy of the 3D

Berrnulli surface where the triplet of vector of velocity $\boldsymbol{u}$, $\nabla\times\boldsymbol{u}$ and ∇f forms the orthogonal system on this surface we can write the next system of equations of Frenet for 4D space [Postnikov]

$$\begin{aligned}
&\partial_t\left(\frac{u}{|u|}\right) = k\frac{\partial f}{|\partial f|}\\
&\partial_t\left(\frac{\partial f}{|\partial f|}\right) = -k\frac{u}{|u|} + \tau_1\frac{\boldsymbol{e}}{|\boldsymbol{e}|}\\
&\partial_t\left(\frac{\boldsymbol{e}}{|\boldsymbol{e}|}\right) = -\tau_1\frac{\partial f}{|\partial f|} + \tau_2\frac{\boldsymbol{h}}{|\boldsymbol{h}|}\\
&\partial_t\frac{\boldsymbol{h}}{|\boldsymbol{h}|} = -\tau_2\frac{\boldsymbol{e}}{|\boldsymbol{e}|}
\end{aligned} \tag{8.6}$$

Here k, τ_1 and τ_2 are curvatures. The former is usual curvature of the stream line and the latters are two tortions. As it follows from this system 2D plane composed by intrinsic electromagnetic fields must be normal to 2D plane composed by the vectors u and ∂f . It is interesting task to prove that these equations are compatible with those given above.

Due to Eq.(8.3) the vector

$$\boldsymbol{s}=\boldsymbol{e}\times\boldsymbol{h} \tag{8.7}$$

which can be named as the *intrinsic vector of Poynting* togather with $\boldsymbol{e}$ and $\boldsymbol{h}$ are formed the orthogonal system of coordinates on the tangent hyperplane too. As it following from the pictures on Fig.1 the former cannot consider as the real "pointing" to the direction in 4D space for the streamline but only the projection to it. In other words the directions of $\boldsymbol{s}$ and $\boldsymbol{u}$ are coincided.

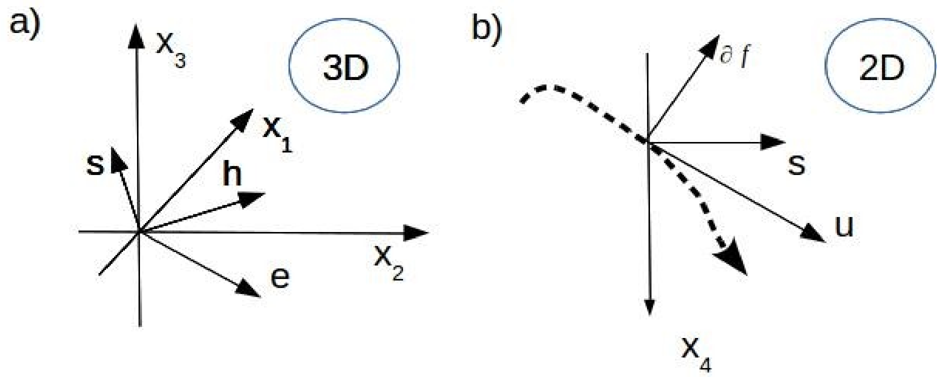

Fig.1. a) It is shown that 3D vectors $\boldsymbol{e}$, $\boldsymbol{h}$ and $\boldsymbol{s}$ are formed orthogonal system in 3D hypersurface. b) It is shown that vector $\boldsymbol{s}$ and the fourth axes X_4 form 2D plane. Every vectors lying on it are tangent to $\boldsymbol{e}$ and $\boldsymbol{h}$. The Bernulli surface the trace of which is figured by the dash line has 4D vector ∂f as the normal and 4D vector u as the tangent. So normalized $\boldsymbol{e}$, $\boldsymbol{h}$, ∂f and u can be taken as the basis for the stream line of the 4D Bernulli surface.

IX. Free electromagnetic field

A rather simple task is the considering of the situation without intrinsic (and therefore extrinsic) charge and current densities. Giving rotor operation of Eqs.(4.4) and (4.9) and using Eqs.(4.8) and (4.5) for $\rho=0$ and $j=0$, we easily get the following equations of Poisson

$$\begin{aligned}
&\partial^2\boldsymbol{e} = 0\\
&\partial^2\boldsymbol{h} = 0
\end{aligned} \tag{9.1}$$

The most trivial solution is $\boldsymbol{e}=C\,\boldsymbol{r}+\boldsymbol{e}_0$ with constant C and $\boldsymbol{e}_0$ and the similar for $\boldsymbol{h}$. C C may be called as *intrinsic capacity*. These solutions represent the fields as the set of the concentric 3D spheres where the values of the fields are the same.

Another solutions has the next form

$$\begin{aligned} \boldsymbol{e} &= \boldsymbol{a} \exp i\, k \cdot x \\ \boldsymbol{h} &= \boldsymbol{b} \exp i\, k \cdot x \end{aligned} \tag{9.2}$$

where 4D vector k has a property $k^2 = 0$. The real parts of these solutions can be considered as the infinite long wave. The most interesting case is to represent (2) as follows

$$\begin{aligned} \boldsymbol{e} &= \boldsymbol{a} \exp i\, \boldsymbol{k} \cdot \boldsymbol{r} \exp - \kappa x_4 \\ \boldsymbol{h} &= \boldsymbol{b} \exp i\, \boldsymbol{k} \cdot \boldsymbol{r} \exp - \kappa x_4 \end{aligned} \tag{9.3}$$

where vector k is divided on two parts, 3D vector $\boldsymbol{k} = (k_{1,} k_{2,} k_3)$ and $\kappa = i k_4 = i|\boldsymbol{k}|$.

Taking into account Eqs.(8.3) and (8.5), we can put down such expressions

$$\begin{aligned} \boldsymbol{e} &= \boldsymbol{a} \cos \boldsymbol{k} \cdot \boldsymbol{r} \exp - \kappa x_4 \\ \boldsymbol{h} &= \boldsymbol{b} \sin \boldsymbol{k} \cdot \boldsymbol{r} \exp - \kappa x_4 \end{aligned} \tag{9.4}$$

It is the static plain waves with amplitude slowing down with the distance from the border hypersurface. So they can consider as the usual electromagnetic wave but with the phases shifted on $\pi/2$ with respect to each other. As well we got the next equations for the extrinsic fields by integrating Eqs.(4) over x_4 from zero to infinity

$$\begin{aligned} \boldsymbol{E} &= \boldsymbol{A} \cos \boldsymbol{k} \cdot \boldsymbol{r} \\ \boldsymbol{H} &= \boldsymbol{B} \sin \boldsymbol{k} \cdot \boldsymbol{r} \end{aligned} \tag{9.5}$$

where $\boldsymbol{A} = \boldsymbol{a}/\kappa$ and $\boldsymbol{B} = \boldsymbol{b}/\kappa$.

Then we can introduce the Galilean transformation from the frame where the wave is stayed alone to the frame where velocity is equal to speed of light.

$$\begin{aligned} \boldsymbol{u} &\rightarrow \boldsymbol{u}' = \boldsymbol{u} + \boldsymbol{c} \\ \boldsymbol{r} &\rightarrow \boldsymbol{r}' = \boldsymbol{r} + \boldsymbol{c}t \end{aligned} \tag{9.6}$$

The vector $\boldsymbol{c}$ we direct to alone the wave vector $\boldsymbol{k}$. So we have the usual form of the translational plain wave with the frequency $\omega = \boldsymbol{k} \cdot \boldsymbol{c} = kc$

$$\begin{aligned} \boldsymbol{E} &= \boldsymbol{A} \cos(\boldsymbol{k} \cdot \boldsymbol{r} + \omega t) \\ \boldsymbol{H} &= \boldsymbol{B} \sin(\boldsymbol{k} \cdot \boldsymbol{r} + \omega t) \end{aligned} \tag{9.7}$$

The various combinations in direction and in values of vectors $\boldsymbol{A}$, $\boldsymbol{B}$ and $\boldsymbol{k}$ gives the different forms of polarization of the wave. We see that Pointing vector $\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$ can have a common position with respect to the wave vector $\boldsymbol{k}$.

X. Conclusion

In the paper it is stated that the well-known electromagnetic fields that is named as extrinsic fields are originated by the so called intrinsic fields supposedly existed in the interior of the 4D universe. The intrinsic fields are the combinations of the first derivatives of the four-dimensional velocity field of the medium that are related to the vorticity of the this field. Therefore the electromagnetic fields not remain to be some entity those nature is unknown. It is needed only to use some coefficient to accommodate the dimensionalities.

Such conclusion stems from the model of the ideal fluid without viscosity in 4D Euclidean space. For the unknown nature of its compound we take the simplest form of the medium to describe it. In the early papers also we called it as the 4D aether leaving the term 4D medium afterwards, because the term "aether" has many meanings in the literature.

In our opinion the main difference of our approach from others aether theories lies in what we are think of the universe. It does not occupy all infinite space, so the boundary effects such as the light propagation can be taking place. The simple model of the electromagnetic wave with such property will be given in the next paper.

The aether as it is treating in former theories may stand for the boundary of the universe, for what we called by the world. Then really, all we see around is something like the aether but we never can take the piece of it because it is non-separable from the medium, from the universe. The aether like this differs from the gaseous and from solid forms of the aether proposed earlier. The only property that relates the border hypersurface with the old aether is the possibility to penetrate the light, the vibrations of the border, the details of which will be described in the next paper. Here one must say that the light in this theory involves the medium lying beneath the border too. Therefore such picture contradicts with the most aether theories where this substance usually fills all the space or situates between the bodies.

The boundary of the 4D universe can be also associated with so called “physical space” or “ physical vacuum”. We can see that in the picture proposed that space is not 3D Euclidean one. The so called “dark matter” that arose recently in modern cosmological theories has some resemblance to the 4D matter in our model but there is one distinction. The latter takes all 100% of matter in our Universe and in others if they are exist.

The velocity field of the medium particles which we have been called as apeirons is not observable patently due to the fact that all visible matter is the boundary effect id its essence also as the light. The usual 3D matter itself consists of the fundamental particles which are modeled as the 4D vorteces in the 4D matter. So no specific information can be reached the boundary from the bulk of the medium because of absence of intrinsic waves in the bulk of the in-condensible medium. It is so also because the velocity field can not be measured directly due to the gauge potential. The exception can be made only for such representatives of 3D matter as the charge and its aggregations with velocity $\boldsymbol{V}=\nabla\psi$. Then the Lorentz-like equation (7.7) will be true and the velocity and position of the charge can be determined with respect to the other charges and bodies.

The effect of the inertia can be explained in the 4D model. Eq.(6.12) tells that the velocity of the particle or the body will be constant if the electromagnetic field F is vanished. Then the Bernulli surface of the particle together with the Bernulli surface of the border of the universe forms the common Bernulli surface where the last term in the equation mentioned above is disappeared.

Then the relation (5.1) may be considered as the Galilean transformation for the two reference frames. One of them is connected with medium as a whole in some universe and another with the charge, or with the usual 3D body as the set of the biased charges moving in the medium. The former is the "absolute" reference frame in the local (for given universe) sense while the velocity field is not constant in global sense as in the latter case. Also it may considered as "absolute" frame in the global sense when it is connected with the whole universe.

But if we take into account that there are other universes except our one the only valid conclusion we will come to is that there is no absolute frame of reference. The possibility of the existence of other universes in that model is looking quite natural because of the infinite space where our universe is supposed to situate. Due to the absolute 4D vacuum between the universes there no any signals can be send from one universe to other. An indirect evidence of this proposition can be the galaxies formation as it was depicted in [???].

The intrinsic electromagnetic field connects with the velocity field via Eq.(4.2) and is not observable by some manners. To be more exactly, the former is the mean 4D-vector potential of the latter multiplied by factor $\sqrt{\rho_4}$. Without this factor the electromagnetic fields reduce to the quantities with the dimensionality of the usual frequency. Therefore the Larmor frequency for the precession of the magnetic moments is well known to be proportional to the applied magnetic field. It gives us the estimation of the $\sqrt{\rho_4}$ as e/2mc, where e is the charge of the electron and m is its mass.

Besides the third term Eq.(2.6) looks like the usual Euler equation for 3D-space. But the last term is not vanish only on the tangent 3D-plane at the point of touch with the medium. In the bulk of the medium the orientation of the axes may be chosen arbitrary. Therefore the magnetic and electric fields can be interchanged.

The equations for fields **e** and **h** contain additional members in comparison with Maxwell equations. It may be due to different regions where fields **e**, **h** and **E**, **H** are determined. The former is 4D space and the latter is 3D. The different sign in Eq.(4.9) is also due to orientational peculiarity of the polar vector **h** in 4D space.

Also it is interesting to notice that the field **h**, which is nothing more then 3D-vorticity, will be "frozen" into the medium if the last member in Eq.(4.20) is vanished. The latter condition can be represented as $\partial_4 u \times \nabla u_4 = 0$ and it means that both summands in the determination of the intrinsic electric field are parallel. Therefore the field $\boldsymbol{h}$ may play exclusive role in the stability of the vortex formation. The intrinsic electric field $\boldsymbol{e}$ doesn't have such property. Of course, the orientation of these fields must be in concordance with the orientation of the vortex axis. In the common case the tensor field F as it follows from Eq.(4.33) is biased with the flow stream

This effect appears in the magnetic hydrodynamics too [10]. The vortex motion of the simple model of the fundamental particle produces the local magnetic field as the magnetic moment. Therefore the spin of the particle, for example, is connected with the rotational motion of the whirl. Because the vortex must have strictly definite size [], its magnetic moment and spin must have strict values too. As for spinless particles they may consist from the other particles bound up in fourth dimension in such a manner that the sum rotation can not be detected. Of course, the model of the fundamental particle is demanded further investigation but in some main aspects the concept of the vorteces works.

The Eq.(2.3) is related with the global property of the medium. Some other gravitational consequences of the model is published [4]. Because the model gives us the uniform view on the nature, it gives some ground to hope that one may discover other laws governing it both on the large and small scales.

The quantity M_4 is similar to the Lorentz momentum [5]

$$\mathrm{N} = \mathrm{tP} - \mathrm{Er}/\mathrm{c}^2$$

where P is the impulse and E is the energy of the body, if as in SRT to associate x_4 with $u_4 t = ct$ and E with c^2 for unit mass.

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