Explosion as a phase transition due to the change of the gradient symmetry of the distortion tensor.

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Explosion as a phase transition due to the change of the gradient symmetry of the distortion tensor.

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Abstract

It is shown that the destruction of a continuous elastic medium is a phase transition associated with a change in the gradient symmetry of the equations of state for the distortion tensor. The equations of state for the distortion tensor, as a compensating field of the minimal fundamental interaction, are derived from the action minimum. In a continuous elastic medium, the distortion tensor is proportional to the conjugate stress tensor. The continuous medium is destroyed at critical stresses or pressures. At the same time, the vortex tension of the distortion tensor penetrates into it and the elasticity disappears. As a result of this phase transition, linear defects and cracks are formed in solids state, and high-temperature plasma occurs in the gas and an explosion occurs. It is shown that the explosion and lightning are the same phase transition, which is caused by the occurrence of a critical vortex tension of the distortion tensor.

Introduction

In 1964, Higgs [1] described a phase transition in which an unobservable compensating interaction field becomes observable. Higgs suggested that the gauge symmetry of the minimal interaction may be broken spontaneously. In this case, the gradient or gauge symmetry of the equations of state for the compensating interaction field disappears, and the interaction field becomes proportional to the conjugate observed field.

Currently, the only known macroscopic example of a Higgs transition is a phase transition to a superconducting state with the Meissner effect. This phase transition is associated with a breach of the gradient symmetry of Maxwell's equations [2, 3].

Indeed, in the superconducting state, the London equations are fulfilled [4] and the conjugate physical quantities become proportional to each other $A_i = -\delta'^2 j_i$, here A_i - the electromagnetic potential, j_i - the current density, δ' - the depth of penetration of the magnetic field into the superconductor. Consequently, in the superconducting state, the gradient symmetry of Maxwell's equations is broken, and the electromagnetic potential becomes an observable quantity proportional to the current density.

In this case, the Maxwell equations turn into the "massive" wave equations, similar to the Klein-Gordon massive field equation, with a minimum frequency. The "massive" wave equation is a wave equation in which the source of the field, in the inhomogeneous d'Alembert equation, is proportional to the field itself.

On the other hand, in [5] it was shown that the distortion tensor, as a compensating field of minimal interaction, in an isotropic continuous medium is proportional to the conjugate stress tensor $\sigma_{pj} = \rho c^2 A_{pj}$, here c - the speed of sound, and ρ - the density of the continuous medium. The equation of a "massive" wave with a minimal frequency for the distortion tensor A_{pj} in a continuous elastic medium was also obtained. It was shown in [5] that the waves of the distortion tensor in a continuous medium describe the sound waves.

It is known [2, 3] that the minimal frequency in the spectrum of the compensating interaction field corresponds to a gap. Thus, the minimal frequency of the distortion tensor in a continuous medium [5] indicates the existence of a low-symmetric state for the compensating interaction field A_{pj} in a continuous medium.

The purpose of this article is to describe the destruction of a continuous elastic medium as a phase transition in which the gradient symmetry of the equations of state for the distortion tensor A_{pj} is restored. This phase transition is analogous to the superconducting state destruction phase transition for the electromagnetic field.

In the article [6], it was shown that in the gas, the centrally symmetric tension of the distortion tensor ε_{ij} results in a high-temperature plasma. Indeed , since the charge for the tensor field of interaction - the distortion tensor A_{pj}, is a quantum momentum, then, when a continuous elastic medium is destroyed, the centrally symmetric tension acts on the momentum of gas molecules in the following way: $f_j = p_i\delta_{ij}\varepsilon = p_j\varepsilon$. The isotropy of the gas is taken into account here, so the centrally symmetric tension has a diagonal symmetric form: $\varepsilon_{ij} = \delta_{ij}\varepsilon$.

Knowing the force, we obtain the equation of motion $\partial p_j / \partial t = p_j\varepsilon$ for gas molecules, which is a necessary and sufficient condition for the existence of high-temperature plasma in gases. Indeed, in a large homogeneous field, the equation has a solution in the form of an exponent, and describes a sharp change in the magnitude of the momentum of gas molecules in a certain volume, where the field acts. An exponential increase in the momentum of gas molecules results in an increase in the kinetic energy of all gas molecules in the field: ε. In elastic collisions of gas molecules at large momentum resulting to electromagnetic radiation, which eventually stabilizes the plasma temperature or the average kinetic energy of the gas molecules.

On the other hand, to obtain a high-temperature plasma, it is necessary to sharply increase the kinetic energy of gas molecules in a certain volume, which is described by an exponential increase in the kinetic energy of all gas molecules in this volume.

This obvious description of a high-temperature plasma is based on a simple formula: $\partial p_j / \partial t = p_j\varepsilon$, without which it is impossible to describe a high-temperature plasma. Thus, to describe a high-temperature plasma, we must recognize that the momentum of gas molecules is a charge. In [7], it was proved that the quantum momentum is the charge of the fundamental interaction induced by a subgroup of translations. In this case, the compensating field of minimal interaction is the distortion tensor A_{pj}.

However, it remains an open question in which cases the centrally symmetric tension ε_{ij} acts on the gas molecules, turning the gas into a high-temperature plasma. After all, in the "normal" situation of a continuous medium, gas is not a high-temperature plasma. This article is devoted to the study of the phase transition of the destruction of the gas as a continuous medium.

1. Minimal interaction and vortex tension of the distortion tensor.

In [6] it was proved that the distortion tensor A_{pj} is a compensating field of minimal interaction:

$$D_j\psi_{\vec{k}} = \left(\frac{\partial}{\partial x_j} - i\sum_p \kappa_p A_{pj}\right)\psi_{\vec{k}} . \tag{1}$$

for a local representation $k_p = k_p(x_j)$ of an order parameter (PP) $\psi_{\vec{k}}$ induced by a translation subgroup $\hat{a}_q\psi_{\vec{k}} = \exp(i\delta_{pq}k_p a_q)\psi_{\vec{k}}$. In this case, the compensating tensor is converted as:

$$\hat{a}_q(\kappa_p A_{pj}) = \kappa_p A_{pj} + \delta_{pq}\,\partial(k_p a_q)/\partial x_j . \tag{2}$$

Expressions (1) are eigenfunctions for the operator of the translation subgroup $\hat{a}_q$, hence, from the components one $D_j\psi_{\vec{k}}$ can construct translation invariants for the Lagrangian in the form: $D_j\psi_{\vec{k}}D_j^*\psi_{-\vec{k}}$.

Since the tensor A_{pj} is a compensating field (1), it is an independent interaction field similar to the electromagnetic potential A_j [2, 3]. Just as the electromagnetic potential A_j has a vortex tension $B_j = e_{jkn}\,\partial A_n/\partial x_k$, the compensating tensor A_{pj} has vortex invariants in the form of antisymmetric derivatives $\rho_{pj} = -e_{jkn}\,\partial A_{pn}/\partial x_k$, which are the observed force characteristics of the compensating field [6].

The antisymmetric derivative of the distortion tensor ρ_{pj} is called the dislocation density in elasticity theory [8]. The analogy between electrodynamics and the continuum theory of dislocations has been known for a long time [9-12]. This paper will show that the analogy between the electromagnetic potential A_j and the distortion tensor A_{pj} extends not only to the equations of state, but also to the phase transformations for the fields: A_j and A_{pj} . Since the distortion tensor A_{pj} , like the electromagnetic potential A_j , is a compensating interaction field (1).

A superconducting phase transition with the Meissner effect is associated with a breach of the gradient symmetry of the electromagnetic potential A_j .

The phase transition to a continuous elastic medium is associated with a violation of the gradient symmetry of the equations of state for the distortion tensor A_{pj} . Indeed, when the stress tensor is proportional to the distortion tensor in a continuous elastic medium $\sigma_{pj} = \rho c^2 A_{pj}$ [5], the gradient symmetry of the distortion tensor (2) disappears, and it describes an elastic continuous medium. And when plastic deformations occur, the elasticity disappears, the gradient symmetry of the distortion tensor (2) is restored, and it is responsible for the minimal interaction (1).

Thus, the destruction of a continuous elastic medium is described as a phase transition in which the gradient symmetry of the distortion tensor is restored. In this case, the vortex tension of the distortion tensor: $\rho_{pj} = -e_{jkn}\,\partial A_{pn}/\partial x_k$, in the form of linear defects penetrates into the continuous medium. It is known that as a result of the formation of linear defects in solids, cracks occur and elasticity disappears.

It is necessary to prove that in gases, when the gradient symmetry of the distortion tensor changes, a high-temperature plasma occurs and an explosion occurs. To see what happens when the gradient symmetry of the distortion tensor is broken, we will write down the equations of state for the 4-distortion tensor and investigate them.

2. Equations of state for the 4-distortion tensor: υ_p , A_{pj} .

For a dynamic model, the equations of state must take into account the dependence of the PP or wave function on time. The compensating field for the time derivative of PP is the velocity field υ_i , as the fourth or time component of the distortion tensor [6]:

$$D_0\psi_{\vec{k}} = \left(\frac{\partial}{\partial t} - i\sum_n \kappa_n \upsilon_n\right)\psi_{\vec{k}}\,, \qquad (3)$$

$$\hat{a}_q(\kappa_i \upsilon_i) = \kappa_i \upsilon_i + \delta_{iq} \frac{\partial (k_i a_q)}{\partial t}. \qquad (4)$$

In [5], we studied the Kadich-Edelin equations of state [11, 12] for the 4-distortion tensor: υ_p, A_{pj}, similar to the Maxwell equations:

$$p_i = -\frac{\gamma}{c^2} \frac{\partial \varepsilon_{ij}}{\partial x_j}, \qquad (3)$$

$$\sigma_{ij} = \gamma\, e_{jkp} \frac{\partial \rho_{ip}}{\partial x_k} - \frac{\gamma}{c^2} \frac{\partial \varepsilon_{ij}}{\partial t}. \qquad (4)$$

Here γ - is the size coefficient, and ρ_{pj}, ε_{pj} - is the tensions of the 4-distortion tensor.

$$\rho_{ij} = -e_{jpq} \frac{\partial A_{iq}}{\partial x_p} \text{ -} \qquad (5)$$

dislocation density [8] or vortex tension of the distortion tensor, similar to magnetic induction.

$$\varepsilon_{ij} = -\frac{\partial \upsilon_i}{\partial x_j} + \frac{\partial A_{ij}}{\partial t} \text{ -} \qquad (6)$$

the centrally symmetric tension of the distortion tensor, similar to the electrical tension.

The momentum p_i and stress tensor σ_{ij} in (3) and (4) are sources for the force tensions ρ_{pj} and ε_{pj} (5) and (6), similar to the charge and current in Maxwell's equations [13].

The equations of state (3) and (4) were derived from the Lagrangian:

$$L = p_i \upsilon_i - \sigma_{ij} A_{ij} + \frac{\gamma}{2}\left(\frac{1}{c^2} \varepsilon_{ij}\varepsilon_{ij} - \rho_{ij}\rho_{ij}\right) \qquad (7)$$

analogous to the electromagnetic Lagrangian [13]. The Lagrangian (7) follows from the interaction (1, 3) for the case when p_i and σ_{ij} are external sources of fields: υ_p, A_{pj}.

From (3) and (4) follows the continuity equation:

$$\frac{\partial \sigma_{ij}}{\partial x_j} = \frac{\partial p_i}{\partial t}, \qquad (8)$$

which is a differential record of the law of conservation of momentum.

In [5], it was shown that in a continuous elastic medium characterized by density ρ, the distortion tensor is proportional to the conjugate stress tensor $\sigma_{pj} = \rho c^2 A_{pj}$, and the momentum is proportional to the velocity $p_i = \rho \upsilon_i$. Consequently, the equations of state (3) and (4) in a continuous elastic medium turn into inhomogeneous d'Alembert wave equations for the 4-distortion tensor:

$$\frac{c^2 \rho}{\gamma} \upsilon_p = \left(\Delta - \frac{1}{c^2} \frac{\partial^2}{\partial t^2}\right) \upsilon_p, \qquad (9)$$

$$\frac{c^2 \rho}{\gamma} A_{pj} = \left(\Delta - \frac{1}{c^2} \frac{\partial^2}{\partial t^2}\right) A_{pj}. \qquad (10)$$

The pseudo-Lorentz calibration condition was taken into account [11, 12]:

$$\frac{\partial A_{ij}}{\partial x_j} = c^{-2} \frac{\partial \upsilon_i}{\partial t}, \qquad (11)$$

to get the d'Alembert operator in (9) and (10)

This means that the gradient symmetry of the equations of state (3) and (4) is broken in a continuous elastic medium with a density ρ of:

$$\upsilon_p \to \upsilon_p + \partial u_p / \partial t \, , \; A_{pj} \to A_{pj} + \partial u_p / \partial x_j \, , \tag{12}$$

and appear a wave $\upsilon_i = \upsilon_{i0} \exp(i\vec{q}\vec{x} - i\omega t)$, $A_{ij} = A_{ij0} \exp(i\vec{q}\vec{x} - i\omega t)$ with a spectrum :

$$\omega = c\sqrt{\vec{q}^{\,2} + c^{-2}\omega_0^2} \tag{13}$$

and the minimal frequency

$$\omega_0 = c^2 \sqrt{\rho/\gamma} \, . \tag{14}$$

The equations (9) and (10) are called "massive" wave equations, similar to the equation for the Klein-Gordon massive field in field theory [2].

Thus, the regularities of a phase transition analogous to a superconducting phase transition with a gap in a low-symmetric state are fulfilled [2-4].

Due to the fact that the gauge symmetry group was not used in the construction of the extended derivative (1) [14], and the translational invariance of the Landau potential [6] was taken into account, here and in the future we will talk about the gradient symmetry (12) of the equations of state (3) and (4).

In [6, 7], it is proved by direct calculations that the wave vector κ_i or quantum momentum $\hbar\kappa_i$ is the interaction charge (1). Therefore, the momentum p_i and momentum flow σ_{ij} (8) set the tensions of the distortion tensor ρ_{pj} and ε_{pj} in (3) and (4), just as the charge and charge flow set the electromagnetic field tensions in the Maxwell equations.

Since the stress tensor σ_{ij} is defined in the field theory as the momentum flow according to (8), it is also possible to define the associated distortion tensor A_{pj} as the velocity field flow according to (11). It is obvious that with this definition the distortion tensor A_{pj}, as an independent interaction field (1), is not always associated exclusively with a solid state.

Therefore, in the future we will use the name distortion tensor [8] for the compensating tensor field of interaction A_{pj}, understanding that it exists everywhere, and not only in a solid state.

The vortex tension of the distortion tensor ρ_{pj} - the dislocation density tensor (5), was defined in the elasticity theory to describe dislocations in a continuous medium [8]. It must be admitted that the expression "density of dislocations in a continuous medium" is an unsuccessful name for the vortex tension of the distortion tensor (5).

Firstly, there are no locations of atoms in a continuous medium. This is the difference between a continuous solid medium and a crystal lattice. The phrase "continuous medium" does not imply discreteness.

Secondly, when linear defects appear, the continuous medium is destroyed, it loses its elasticity and passes into a different physical state.

In this paper, it will be shown that when linear defects appear in a continuous medium, there is a phase transition of destruction of a continuous elastic medium as a physical state. There are no dislocations in continuous media and the tensions ρ_{pj} of the distortion tensor is pushed out of the continuum [5], as well as the magnetic field is pushed out from the superconductor (see below), because a continuous medium the absence of defects.

Moreover, it was shown in [5, 6] that vortex tension ρ_{pj} is a force characteristic of the distortion tensor and in air it is proportional to the pressure gradient:

$$\rho_{pj} = \beta e_{jkp} \partial p / \partial x_k \, , \tag{15}$$

here β is the compressibility of air. From this it is clearly seen that the vortex tension ρ_{pj} is proportional to the components of the force acting in the air as a pressure gradient. Obviously, there are no dislocations in the air. Therefore, in the future ρ_{pj} - we will call the vortex tension of the distortion tensor (5), and not the density of dislocations [8].

We will study the destruction of a continuous elastic medium by analogy with the destruction of a superconducting state. However, the destruction of the superconducting state is not used here as an argument, but only as an example. All conclusions in this article follow from the minimum of action and the minimum of free energy.

It is obvious that the destruction of the continuous medium and the explosion are critical phenomena since there is no more critical phenomenon than an explosion. However, in the physical literature there is no description of the explosion as a phase transition because it was not known between what phases or physical states this transition occurs, and it was not clear what symmetry changes during the explosion.

In this paper, it will be shown that the gradient symmetry (12) of the equations of state for υ_p, A_{pj} (3) and (4) is restored during the explosion. As a result of this phase transition to the gas, the force tensions of the 4-distortion tensor (5) and (6) act. The vortex tension ρ_{pj} (5) destroys the continuous elastic medium, and the centrally symmetric tension ε_{pj} (6) turns the gas into a high-temperature plasma, accelerating the gas molecules exponentially [6].

3. Lightning as a phase transition of destruction of the elastic state of the distortion tensor.

In [5] it was shown that the wave solutions of the equations of state for a fields υ_p, A_{pj} in a gas describe the sound wave.

Indeed, since in gas $\sigma_{pj} = -\delta_{pj} p$, then from: $\sigma_{pj} = \rho c^2 A_{pj}$, it follows that: $\rho c^2 A_{pj} = -\delta_{pj} p$, or $A_{pj} = -\beta\delta_{pj} p$. Substituting this expression in equation (10), we get the equation for the pressure in the sound wave:

$$\frac{c^2\rho}{\gamma} p = (\Delta - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}) p . \qquad (16)$$

Note that in gas or liquid, the stress tensor and the distortion tensor remain tensors, they just have a symmetrical diagonal form: $\sigma_{pj} = -\delta_{pj} p$, $A_{pj} = -\beta\delta_{pj} p$. Therefore both the stress tensor σ_{pj} and the distortion tensor A_{pj} exist in the gas and liquid, and not just the scalar pressure p.

As you know, the equations for a "massive" wave (9) and (10) differ from the homogeneous d'Alembert equations in the spectrum: $\omega = c\sqrt{\vec{q}^{\,2} + c^{-2}\omega_0^2}$ (13), and the presence of a minimal frequency: $\omega_0 = c^2\sqrt{\rho/\gamma}$ (14).

As a result of an obvious relationship in a continuous medium: $p_i = \rho\upsilon_i$, the twelve equations of state (3) and (4) for the distortion tensor degenerated into the same equation for a "massive" wave (9) and (10) with the same spectrum. Note that the minimal frequency $\omega_0 = c^2\sqrt{\rho/\gamma}$ is not zero when the density ρ is not zero. The presence of a minimum frequency in the spectrum (13) clearly indicates the possibility of a reverse phase transition of the "massive" field υ_p, A_{pj} to a highly symmetric state defined by a system of equations of state (3) - (6) with gradient symmetry (12) [5].

This situation is similar to a superconducting state with an energy gap that sets the depth of penetration of the magnetic field into the superconductor, and indicates the possibility of a reverse phase transition to the "normal" state of the electromagnetic field [3].
As it is known [2-4], the superconducting state has specific physical properties. It pushes the magnetic field out of the sample – the Meissner effect. In addition, the superconducting state is destroyed when the magnetic induction exceeds the critical value B_j^C .

We show that for the field A_{pj} and its vortex tension ρ_{pj} in a continuous elastic medium, there are analogs of the properties listed above.

The analog of the Meissner effect [2-4] for the distortion tensor A_{pj} in a continuous elastic medium consists in the ejection of the vortex tension ρ_{pj} (5) from the continuous medium. Vortex tensions ρ_{pj} are linear defects that destroy a continuous elastic medium. This is why it is a continuous medium, so that it does not allow linear defects to enter it. Therefore, the elastic continuous medium pushes out the field ρ_{pj} (5).

We calculate the depth of penetration of the field A_{pj} and the vortex tension ρ_{pj} into the continuous medium. From equation (10) in the stationary case, we obtain: $\rho c^2\gamma^{-1}A_{pj} = \Delta A_{pj}$. For vortex tension ρ_{pj}, the same equation is obtained by substituting $\sigma_{pj} = \rho c^2 A_{pj}$ in (4) and the action of the rotor operator:

$$\rho c^2\gamma^{-1}\rho_{pj} = \Delta\rho_{pj} . \tag{17}$$

The depth of penetration of the field ρ_{pj} into a continuous elastic medium is given by the coefficient on the left side of the equation (17):

$$\delta = c^{-1}\sqrt{\gamma/\rho} . \tag{18}$$

The depth of penetration is related to the minimal frequency (14) by a simple ratio: $\delta = c\omega_0^{-1}$, from $\delta\omega_0 = c$.

In [5], we conditionally selected the minimal frequency in the air $\omega_0 \approx 3.2$ Hz, for convenience of calculations. Then the depth of penetration of the field ρ_{pj} in the air will be about $\delta \approx 100m$. At the same time, there is reason to believe that the penetration depth can be an order of magnitude greater, then the minimal frequency will be an order of magnitude less, this issue is discussed in more detail below.

According to thermodynamics, the vortex tension ρ_{pj} will be pushed out of the continuous medium to a certain critical value ρ_{pj}^C. When a critical value is reached ρ_{pj}^C, the source of which is external stress or pressure (4), the field ρ_{pj} penetrates into a continuous elastic medium and destroys it. It is known that the process of destruction of a solid elastic continuous medium is studied by the science of the resistance of materials under critical stresses.

Indeed, in a solid elastic medium, the stress tensor is proportional to the distortion tensor $\sigma_{pj} = \rho c^2 A_{pj}$, and when a solid elastic medium is destroyed, the distortion tensor A_{pj} describes plastic deformations and is not proportional to the stress tensor. Recall that the distortion tensor was introduced in the theory of elasticity to describe plastic deformations. This is well known [8], but it was not previously assumed that the destruction of a continuous elastic medium is a phase transition between different symmetry states of the distortion tensor.

This description became possible after obtaining the equations of state for the 4-distortion tensor (3) and (4) and proving the fact that the distortion tensor A_{pj} is an independent interaction field (1) and (2) that describes the physical state.

In addition, it was proved in [5] that the waves of the distortion tensor in a continuous medium correspond to sound waves. The process of destruction of a solid elastic medium is accompanied by a loud characteristic sound or crackle, since the energy density of the sound wave $E = \frac{\gamma}{2}\rho_{pj}\rho_{pj}$ is a function of the vortex tension ρ_{pj} [5].

Moreover, the process of penetration of the critical field ρ_{pj}^{C} (5) into the continuous medium results in the appearance of a large centrally symmetric tension ε_{pj} (6), since ε_{pj} it is a derivative of the distortion tensor $\partial A_{pj}/\partial t$ (6). Therefore, ε_{pj} it is proportional to the speed of penetration of the critical field $\rho_{pj} = -e_{jkn}\,\partial A_{pn}/\partial x_k$ into the continuous medium during the phase transition, or the speed of destruction of the continuous medium.

In [6], it was shown that a large field ε_{pj} results in a high-temperature plasma in the gas. Indeed, in gas, the distortion tensor has a diagonal form and is described by a scalar function. Therefore, there is reason to believe that the tension $\varepsilon_{pj} = \partial A_{pj}/\partial t$ in gas will also have a diagonal appearance $\varepsilon_{pj} = \delta_{pj}\varepsilon$.

When gas is destroyed as a continuous medium, the centrally symmetric tension ε_{pj} acts on the momentum of the gas molecules by force: $f_j = p_p\delta_{pj}\varepsilon = p_j\varepsilon$, since the momentum is the charge for the tension ε_{pj} [6,7]. Therefore, the equation of motion for gas molecules in the field $\varepsilon_{pj} = \delta_{pj}\varepsilon$ has the form:

$$\partial p_j/\partial t = p_j\varepsilon\,. \tag{19}$$

When the field ε is large, it accelerates the gas molecules exponentially $p_j = p_{j0}\exp(\varepsilon t)$. As a result, the value of the momentum of the gas molecules or the kinetic energy of the gas molecules changes. Therefore, in places where the critical field ρ_{pj}^{C} penetrates, high-temperature plasma is formed in the air. Since for gas molecules: $p_{j0} \neq 0$.

Thus, the process of destruction of air as a continuous medium has the form of a linear defect filled with plasma, and is accompanied by a characteristic loud sound like a crack. This phenomenon is observed in the atmosphere in the form of lightning. Lightning occurs when excessive pressure is generated in clouds associated with condensation of water vapor. The pressure in storm clouds is the source of the vortex field ρ_{pj}, according to equation of state (4), when $\sigma_{pj} = -\delta_{pj}p$.

It is known that air is used in many technological processes as a amortization since it is believed that air cannot be destroyed. We will show that when air is destroyed as a continuous medium, lightning or an explosion occurs. For the calculation ρ_{pj}^{C}, we will do the same as when calculating the critical magnetic field in superconductivity, which is calculated from the minimum free energy.

It is known that the energy density of air is equal to its atmospheric pressure p_{atm}. The energy density of the distortion tensor in the stationary case is equal to $E=\frac{\gamma}{2}\rho_{ij}\rho_{ij}$ [5]. It follows from the Lagrangian (7), since the centrally symmetric tension ε_{ij} (6) in the stationary case is zero.

Consequently, the phase transition of air destruction as a continuous elastic medium will occur when the energy density of the vortex tension ρ_{pj} reaches a value equal to the energy density of the continuous medium: $\frac{\gamma}{2}\rho_{ij}\rho_{ij}=p_{atm}$. From this it follows that the critical vortex tension (5) in the air according to (14) is equal to:

$$|\rho_{ij}^{C}|=\frac{\omega_0}{c^2}\sqrt{2\rho^{-1}p_{atm}}\ . \qquad (20)$$

Substituting in (20) the values: $\omega_0 \approx 3.2 Гц$, $c \approx 340 м/с$, $\rho \approx 1{,}2 кг/м^3$, $p_{atm} \approx 10^5 Па$, we get $|\rho_{ij}^{C}| \approx 0.011 м^{-1}$ on the surface of the Earth. Here you can immediately calculate the value of the coefficient $\gamma = c^4\omega_0^{-2}\rho$ (14): $\gamma \approx 1{,}6\cdot 10^9 дж\cdot м^2$, which is included in the Lagrangian (7).

To destroy the air as a continuous medium, it is necessary to create an excess pressure in the atmosphere (4), which will lead to the emergence of a critical field ρ_{pj}^{C} (20). We will calculate the excess pressure p for a critical vortex field ρ_{pj}^{C} for a model of an infinite flat thundercloud with a thickness d of, in the approximation of a uniform pressure distribution in the cloud layer. A similar problem exists in electrodynamics, when the magnetic field created by an infinite plate with a linear current is calculated.

Let's build a speculative rectangular frame in the vertical plane, the upper and lower sides of which lie above and below the storm cloud and have a length a along the axis OX_1, and the vertical side has a length b along the axis OX_3. By building more than the thickness b of the cloud d. Calculate the force acting on this frame.

In the stationary case, the force acting on the frame is equal to: $f_2=\int_{S_L}\sigma_{22}ds_2$. Since $\sigma_{pj}=-\delta_{pj}p$, then $f_2=\int_{S_L}\sigma_{22}ds_2=-pad$.

On the other hand, it follows from (4) and Stokes theorem that $f_2=\gamma\oint_L \rho_{2j}dl_j=2\gamma\rho_{21}a$, since, by virtue of symmetry, $\rho_{23}=0$. Therefore: $pd=2\gamma|\rho_{21}|$.

Taking into consideration that the atmospheric pressure and density at an altitude of 6-8 km decreases twice, we get a critical value for the vortex tension in a thundercloud (14, 20): $|\rho_{ij}^{C}| \approx 0{,}007 м^{-1}$. Assuming that the thickness of the thundercloud is about 7 km, and taking into account $\gamma \approx 1{,}6\cdot 10^9 дж\cdot м^2$, we get that the destruction of air as a continuous medium will occur when the excess pressure of the thundercloud is greater $p \approx 3{,}2\cdot 10^3 Па$.

It is known that such a change in pressure, of the order $5\cdot 10^3 Па$ of 0.05 bar, is actually observed in thunderclouds. It is caused by a change in the density of the storm cloud, due to condensation of water vapor. The above calculation is approximate, it does not take into account the inhomogeneous distribution of pressure in the storm cloud, but it qualitatively explains the picture of what is happening.

Thus, due to the occurrence of excess pressure in thunderstorms when water vapor condenses, a critical vortex field ρ_{pj}^{C} occurs and a phase transition occurs in the destruction of air as a continuous medium. This phase transition occurs with the absorption of energy, and is accompanied by a decrease in pressure in the thundercloud. Lightning occurs until the pressure in the thundercloud decreases or the density of the thundercloud changes, after precipitation.

When the critical field ρ_{pj}^{C} (5) penetrates into the air, a high-temperature plasma is formed due to the appearance of a large scalar tension $\varepsilon_{pj} = \delta_{pj}\varepsilon$ (6), which is proportional to the rate of penetration of the vortex tension ρ_{pj}^{C} into the continuous medium. The centrally symmetric tension $\varepsilon_{pj} = \delta_{pj}\varepsilon$ acts on the momentum of air molecules: $\partial p_j / \partial t = p_j \varepsilon$ (19), and accelerates them exponentially $p_j = p_{j0} \exp(\varepsilon t)$ [6]. Therefore, high-temperature plasma is formed in the air at the places where the critical field ρ_{pj}^{C} penetrates into the continuous medium.

Here we must understand that the centrally symmetric tension $\varepsilon_{pj} = \delta_{pj}\varepsilon$ acts on the gas molecules (19) only when the continuous medium is destroyed. Since in a continuous medium, the tension (5) acts on the momentum of the continuous medium, equal to $p_i = \rho \upsilon_i$. This is the meaning of the destruction of a continuous medium and a phase transition. Because a continuous medium is not a collection of molecules, as it is sometimes primitively represented. A continuous medium is a physical state in which $p_i = \rho \upsilon_i$ there is no discreteness. Therefore, it is impossible to imagine a continuous medium as a set of molecules. Moreover, in [5] it was proved that a continuous medium is a physical state in which the gradient symmetry of the distortion tensor is broken and there is a gap.

When a continuous medium is destroyed, the tensor ρ_{pj} is no longer "rigidly" bound to the pressure gradient (15), since the elasticity – linear dependence-disappears: $\sigma_{pj} = \rho c^2 A_{pj}$. In this case, we can say that the vortex tension is realized as linear defects. In this case, the vortex tension ρ_{pj} remains a force characteristic (5) of the interaction tensor field - the distortion tensor A_{pj}. It acts on the momentum of gas particles $f_j = e_{jmn} p_i v_m \rho_{in}$ (here v_m - the particle velocity) [6], just as a magnetic field acts on electric charges by the Lorentz force $f_j^L = e_{jmn} e v_m B_n$.

Note that an electric discharge in lightning is a consequence of the formation of high-temperature plasma when the gas is destroyed as a continuous medium. An electrical discharge actually occurs when lightning is grounded, when a potential difference occurs in the plasma, as in a short circuit. In this case, very large currents occur, since the plasma has a high conductivity. However, an electrical discharge is not the cause of lightning, as was previously thought. It is known that in thunderclouds there is no reason to believe that one part of the thundercloud is positively charged, and the other part, at a distance of about a kilometer, is negatively charged. This is confirmed by numerous measurements of the potential difference in storm clouds.

We chose the minimal frequency (14) from the representation of the critical field ρ_{pj}^{C} (20) as lightning streamers that have a length of about $\delta \approx 100 м$. It is known that streamers are sources of lightning, but not every streamer leads to lightning. In this sense, lightning resembles a crack, as a region of the existence space of the active field of the distortion tensor (3,4), which is formed as a result of the appearance of a critical field ρ^{C}_{pj}.

It is possible that the idea of lightning itself as a linear defect in the air is true. Then the penetration depth δ (18) of the critical field ρ^{C}_{pj} (20) will be more than a kilometer near the Earth's surface, and the minimal frequency ω_0 (14) will be of the order of $\omega_0 \approx 0.32$, given that $\delta\omega_0 = c$.

In this case, the considered simple model of an infinite flat thundercloud easily solves a global problem: explaining the origin of sprites – large lightning bolts higher than thunderclouds, discovered only at the end of the last century [15].

Indeed, the critical field ρ^{C}_{pj}, which is set by the excess pressure of the thundercloud, is formed both above and below the thundercloud. However, sprites are distributed in a more sparse space. Therefore, the depth of penetration of lightning above the storm clouds will be an order of magnitude greater than the depth of penetration of lightning that is observed below the storm clouds. The length of lightning is directly related to the depth of penetration δ (18) of the vortex field ρ_{pj} into the continuous medium. Since the speed of sound does not change significantly in the atmosphere, and γ - the parameter of the Lagrangian, the length of lightning is inversely proportional to the square root $\left(\sqrt{\rho}\right)^{-1}$ of the density of air in the atmosphere. Therefore, lightning above storm clouds have a length of an order of magnitude greater.

The proposed description of lightning as a phase transition easily explains the lightning in the volcano's mouth by the presence of an area with excessive pressure, similar to a thundercloud. High pressure in the volcano's vent is caused by high air temperature. Indeed, an area with a high air temperature is created in the volcano's mouth, hence there is an area of increased pressure, which results in a critical field ρ^{C}_{pj} according to (4). Therefore, lightning in the volcano's mouth continues until the volcano cools down so that the critical pressure in the volcano's mouth disappears.

A critical field ρ^{C}_{pj} also occurs in places where there are tornadoes. Calculating the vortex tension ρ_{pj} created by reduced pressure in tornadoes is equivalent to calculating the magnetic field created by an infinite conductor with a current. Simple calculations show that lightning occurs in a tornado with a diameter greater than one kilometer at an average pressure drop of 0.1 bar (it is known that the maximum pressure drop in a tornado reaches 0.5 bar).

Generally speaking, lightning represents two phase transitions. Firstly there is a phase transition of destruction of air as a continuous medium, which is accompanied by energy absorption. Then there is a reverse phase transition to the "passive" state of the distortion tensor (9) and (10) and the pushing of the vortex tension ρ_{pj} from the continuous medium, which is accompanied by the release of energy and the thunder.

4. Explosion as a phase transition of destruction of a continuous medium induced by critical air acceleration.

It was shown above that there is an analogy between the destruction of a continuous elastic medium and the destruction of a superconducting state. However, the gas has a property of the distortion tensor, which has no analog for the electromagnetic field. It turns out that the phase transition of destruction of a continuous elastic medium can be associated with the dynamic characteristics of the continuous medium itself. This phase transition can be induced by a critical acceleration a_k^C of the gas.

Indeed, since the vortex tension in the air has the form: $\rho_{pj} = \beta e_{jkp} \partial p / \partial x_k$ (15), the components of the tensor ρ_{pj} are proportional to the components of the force $f_k = \partial p / \partial x_k$ acting on the unit volume of air. The expression (15) follows from the definition of vortex tension ρ_{pj} (5) and from the fact that in the air: $A_{pj} = -\beta \delta_{pj} p$. On the other hand, if a force f_k acts on a unit volume of air, it accelerates it according to the law: $f_k = \rho a_k$. Therefore, if there is a critical vortex tension ρ_{pj}^C at which the continuous medium is destroyed, then there is also a critical force f_k^C acting on the air, at which there is a phase transition to the "normal" state of the distortion tensor field, described by the equations of state (3, 4). But then there is also a critical acceleration of the air $f_k^C = \rho a_k^C$, at which the continuous medium is destroyed and a critical field penetrates it ρ_{pj}^C.

The critical vortex tension ρ_{pj}^C is related to the critical acceleration of air a_k^C by a simple ratio: $\rho_{pj}^C = \beta e_{jkp} \rho a_k^C$. Given that $\beta^{-1} = c^2 \rho$ we get:

$$\rho_{pj}^C = c^{-2} e_{jkp} a_k^C . \tag{21}$$

Consequently, the components of the critical vortex tension ρ_{pj}^C in the air are proportional to the components of the critical air acceleration a_k^C (21).

In general, the components of the antisymmetric derivatives of a field $\rho_{pj} = \beta e_{jki} \partial \sigma_{pi} / \partial x_k$ in a solid state when $\sigma_{pj} = \beta A_{pj}$ (5) are not proportional to the components of the symmetric derivative $\partial \sigma_{pj} / \partial x_j = f_p$ defining the force in (8).

They become proportional only in a gas or liquid as a result of convolution of the stress tensor: $\sigma_{pj} = -\delta_{pj} p$. Then $A_{pj} = -\beta \delta_{pj} p$ and the components ρ_{pj} are also expressed in terms of the components of the pressure gradient $\rho_{pj} = \beta e_{jkp} \partial p / \partial x_k$ (15).

It follows $|\rho_{ij}^C| \approx 0.011 м^{-1}$ from the expression that the critical acceleration of air at the Earth's surface has a value of order $a_j^C \approx 1{,}3 км/c^2$. With increasing altitude above the Earth's surface, the critical acceleration changes along with the critical value of the vortex tension ρ_{pj}^C as $\sqrt{\rho}$ (14) and (20), since the speed of sound is practically independent of the altitude in the atmosphere.

Therefore, in the upper atmosphere, at an altitude of 90-100 kilometers, where the air density is six orders of magnitude less than on the Earth's surface, phase transitions that destroy a continuous elastic medium can be induced by three orders of magnitude less air acceleration $a_j^C \approx 1{,}3 м/c^2$.

This is the expected result, since to destroy a physical state you need to spend less energy near the border of formation of this state. It is known that the boundary of the formation of a continuous medium, or so-called "dense layers of the atmosphere", is located at an altitude of 90-100 kilometers above the Earth's surface. The Northern lights are formed at the same height. The description of the Northern lights is beyond the scope of this article, but it is already clear that the observed clear boundary between the Northern lights plasma at an altitude of 90-100 kilometers above the Earth is an experimental confirmation of the existence of a phase boundary.

If we use an analogy with superconductivity, a mixed state occurs at an altitude of 90-100 kilometers above the Earth, similar to a mixed superconducting state [16]. This is an expected result, since the ionosphere can be considered as a mixed state of a continuous medium and a state with plasma.

At the same time, it is necessary to understand that to accelerate the air when moving solids near the Earth's surface, and to accelerate the air rarefied by six orders of magnitude at an altitude of 90-100 kilometers, to the same acceleration – these are different tasks. Therefore, solids will have different speeds to give the same acceleration in dense and rarefied air.

Phase transitions of air destruction as a continuous medium, due to the critical acceleration of the continuous medium, occur in many technological processes. For example, an explosion induced by critical acceleration of exhaust gases occurs when a shot is fired and when gas is released from the car's pipe. After all, the car motor makes more than 50 rotation per second, which can and does lead to a critical acceleration of exhaust gases at a speed of about 30 m/s. To avoid an explosion, a muffler is used in cars in order to extinguish the speed of exhaust gases.

In some cases, it is possible to avoid critical acceleration of the air when firing, using a muffler for a pistol and a sniper rifle, which removes some of the exhaust gases.

A shot from a railgun [17], which occurs without the use of gunpowder, clearly proves that the explosion, when the projectile leaves the gun barrel, is caused by a critical acceleration of the air. Exactly the same explosion is observed when fired from any gun, but it is usually associated with a chemical reaction. However, there is no gunpowder in the railgun, but there is an explosion when fired. Most likely, the explosion when fired from any gun is associated with a critical acceleration of the gas.

In the nature of the phase transition induced by a critical acceleration of air occurs when the fall of meteorites. As known, meteorites fall to Earth at a speed of - . Consequently, meteorites will accelerate the air with an acceleration that significantly exceeds the critical acceleration at an altitude of 90-100 km. The quadratic dependence of the air resistance force on the speed of moving bodies occurs at relatively low speeds near The earth's surface. It is unlikely that this pattern was studied at speeds higher in a rarefied atmosphere. However, it is obvious that there is a correlation between the acceleration of air and the speed of falling solid.

At an altitude of 90-100 kilometers, the atmosphere becomes a continuous medium and there are collective movements of air molecules, which are characterized by the overall velocity of the continuous medium, this is what we are talking about when we talk about "dense layers of the atmosphere". The falling bolide results the air to a critical acceleration, it destroys the continuous medium and a phase transition to the active state of the distortion tensor (3, 4) takes place. As a result of the phase transition, high-temperature plasma is observed when meteorites fall.

The explosion is not a meteorite, and not as a result of the friction of the meteorite on the air, whose density at an altitude of 90-100 km is six orders of magnitude less than on the surface of the Earth. There is a phase transition of air destruction as a continuous medium due to its critical acceleration by a falling bolide. The temperature in the places of critical air acceleration, where the meteorite is flying, increases sharply, due to the appearance of a region where the centrally symmetric tension $\varepsilon_{pj} = \delta_{pj}\varepsilon$ of the distortion tensor (6) acts on the air molecules $\partial p_j / \partial t = p_j \varepsilon$.

The change in the value of the momentum $p_j = p_{j0}\exp(\varepsilon t)$ of each molecule, the accelerated part of the air located in front of the falling bolide, is set by a coefficient ε in the exponent, which is proportional to the rate of penetration of the field (6), when the continuous medium is destroyed. Obviously, this speed is not less than the speed of the bolide itself. A meteorite burns until it ceases to impart critical acceleration to the air, i.e. until it evaporates, or its speed decreases so that the bolide does not accelerate the continuous medium faster a_k^C .

Until the critical acceleration a_k^C is reached, the tensions ρ_{ij}, ε_{ij} was act on the air as a continuous medium by forces [6]: $f_j = e_{jmn} p_i \upsilon_m \rho_{in}$, $f_j = p_i \varepsilon_{ij}$. For air $A_{ij} = -\beta \delta_{ij} p$, according to (5, 6), these forces have the form: $f_j = e_{jmn} p_i \upsilon_m \beta e_{nki} \partial p / \partial x_k$, $f_j = -p_i \partial \upsilon_i / \partial x_j - p_j \beta \partial p / \partial t$. In this case, all known laws of motion of the continuous medium are fulfilled, both for stationary Bernoulli movements and for vortex air movements [18].

When the critical acceleration is reached, the air ceases to move according to the laws of the continuous medium, and the forces or tensions of the distortion tensor act on the air molecules. This is the meaning of the destruction of air as a continuous medium during a phase transition.

Until the destruction of the continuous medium of tensions ρ_{pj}, ε_{pj} "don't notice" that the air consists of molecules and don't act on the molecules directly. After the destruction of the air as a continuous medium, the centrally symmetric tension ε_{pj} acts on each air molecule at the site of the destruction of the continuous medium (19). Therefore, air molecules are rapidly accelerated exponentially. As a result, the average kinetic energy of the air, and, consequently, the air temperature, also increases exponentially. There is a high-temperature plasma and an explosion occurs.

The most famous natural explosion that is not associated with a chemical or nuclear reaction is the explosion of the Chelyabinsk meteorite. Its detailed description is beyond the scope of this work. Note only that the fall and explosion of the Chelyabinsk meteorite, which was recorded by numerous surveillance cameras, is described by three phase transitions of destruction of a continuous elastic medium.

1. Destruction of air as a continuous medium due to its acceleration by a falling bolide in the "dense layers of the atmosphere", when a meteorite falls from a height of 95 km to 30 km above the Earth. Knowing the time of the meteorite's fall, its speed, angle of incidence and height of the explosion above the Earth, it is easy to calculate that the Chelyabinsk meteorite ignited at an altitude of 95 km above the Earth, which corresponds to the idea of the appearance of a continuous environment or "dense layers of the atmosphere" at an altitude of 90-100 km above the Earth. In fact, the burning of the meteorite – this is a permanent blast of air.

2. Destruction of the meteorite itself (chondrite) under high pressure, which occurs at an altitude of 25-30 km above the Earth. This pressure arose due to a natural increase in the density of the atmosphere by four orders of magnitude, compared to the density at an altitude of 95 km, which led to a pressure of about 2000 bar in the high-temperature plasma around the meteorite at an altitude of 25-30 km. Ordinary meteorites are chondrites, they are composed of iron and silicon and, like granite, can withstand pressure up to 1500 bar. Therefore, the meteorite collapsed at an altitude of 25-30 km, when the plasma pressure reached 2000 bar. The meteorite collapsed literally into molecules and turned into a"stone cloud".

3. A phase transition or explosion of a "rock cloud" that was formed when a meteorite was destroyed. This explosion is similar to the explosion of a thundercloud, when there is a critical pressure in some volume.

Due to the large mass and high pressure inside the "stone cloud", the explosion of the Chelyabinsk meteorite was equivalent to an explosion of 500 thousand tons in TNT equivalent, while the mass of the meteorite itself was only 10 thousand tons.

This explosion, or increase in atmospheric pressure to a billion atmospheres, can be formally explained by an increase in the density on the surface of the " stone cloud "by almost six orders of magnitude: from the natural density of the atmosphere at an altitude of 25-30 km, to the density of the" stone cloud", which occurred when a meteorite (chondrite) was destroyed in a high-temperature plasma. As a result of an instantaneous increase in density in the atmosphere by six orders of magnitude, the pressure also increases by six orders of magnitude.

This is a heuristic explanation for the occurrence of a pressure of a billion atmospheres in the explosion of the Chelyabinsk meteorite. To get the correct result, you need to calculate what tensions ρ_{pj}, ε_{pj} are formed in the" stone cloud", and what pressure in the atmosphere this leads to. However, this task is beyond the scope of this article.

It is known that the explosion of the Chelyabinsk meteorite was not associated with either a chemical reaction or a nuclear reaction, since the chemical composition and radiation in the explosion zone did not change. The explosion of the Chelyabinsk meteorite is associated with the phase transition of the destruction of a continuous elastic medium or the transition of the distortion tensor to a highly symmetrical state. Therefore, most likely, the more general statement is true that a chemical and nuclear explosion are a phase transition and a manifestation of a strong fundamental interaction, described by the distortion tensor as an interaction field [5].

Note that this problem has never been set or solved before, since the tensions of the tensor distortion ρ_{pj}, ε_{pj} (5) and (6) and their effect on the momentum of molecules have not been studied before. Therefore, the power of the explosion is still measured by the TNT equivalent, and not by the force tensions of the distortion tensor ρ_{pj}, ε_{pj}.

Measuring the force of an explosion with a TNT equivalent is the same as measuring the gravitational field with weights and the electromagnetic field with the attraction of magnets, rather than with force tensions g, E_j and B_j, respectively.

It is obvious that the action of tensor tensions ρ_{pj}, ε_{pj} (5) and (6) is not limited exclusively to destructive effects equivalent to the explosion of TNT. For example, there is reason to believe that the vortex tension ρ_{pj} is directly related to such a phenomenon as "black holes" [6], and the centrally symmetric tension ε_{pj} explains the expansion of the Universe with acceleration.

Indeed, if we assume that there is a field $\varepsilon_{pj} = \delta_{pj}\varepsilon$ in the cosmos, even if it is very small, then equation (19) explains the expansion of the Universe with acceleration. Unlike lightning, there was no reverse phase transition to a continuous medium after the Big Bang, since space is not a continuous medium. So the Big Bang is still going on. Most likely, these tensions ρ_{pj} and ε_{pj} are directly related to "dark matter" and "dark energy", respectively, these questions are beyond the scope of this article.

Conclusion

The phase transition of destruction of a continuous elastic medium is induced by a critical stress or critical pressure in a certain volume. It occurs when the critical vortex tension ρ_{ij}^C of the distortion tensor (5) occurs, which is set by the critical stresses (4). As a result, cracks are formed in solids, and high-temperature plasma is formed in gases (19) and an explosion occurs.

The destruction of a continuous elastic medium is described by a phase transition for the 4-distortion tensor υ_i, A_{ij} from an elastic low-symmetric state of the continuous medium, where the conditions are executable: $p_i = \rho\upsilon_i$, $\sigma_{ij} = \rho c^2 A_{ij}$ and the gradient symmetry (12) is violated, to a high-symmetric state, in which the gradient symmetry of the equations of state (3) - (6) of the 4-distortion tensor is restored υ_i, A_{ij}.

For air, the critical vortex tension ρ_{ij}^C has the form (20). It destroys the air as a continuous medium when a critical pressure occurs in a certain volume. At the same time, the centrally symmetric tension $\varepsilon_{ij} = \delta_{ij}\varepsilon$ (6) turns the air into a high-temperature plasma, accelerating the air molecules exponentially: $p_j = p_{j0}\exp(\varepsilon t)$ (19). This phase transition is accompanied by a shock wave caused by a sharp expansion of the gas when the temperature rises in a certain volume and a loud sound whose energy density is equal to $E = \frac{\gamma}{2}\rho_{pj}\rho_{pj}$.

Thus, lightning is a consequence of the occurrence of critical pressure in storm clouds, which leads to a critical field ρ_{ij}^C, according to (4). In this case, the vortex tension ρ_{ij}^C penetrates into the air as a linear defect, and the value ε in the exponent (19) is proportional to the rate of penetration ρ_{ij}^C into the continuous medium, according to (5) and (6).

The phase transition of air destruction as a continuous medium can also be induced by critical air acceleration a_k^C. Since the critical acceleration of the air leads to a critical vortex tension: $\rho_{pj}^C = c^{-2} e_{jkp} a_k^C$ (21). This phase transition leads to an explosion – a sharp change in the momentum of air molecules exponentially $p_j = p_{j0}\exp(\varepsilon t)$ at places of critical air acceleration.

Therefore, lightning and explosion are the same phase transition, which restores the gradient symmetry of (12) interaction fields υ_i, A_{ij} (2, 4) and equations of state (3) – (6). It is induced by the critical value of the vortex tension ρ_{ij}^C in the air.

In fact, at this phase transition, the ratio of the interaction field to the substance changes, as the equations of state for the fields change υ_i, A_{ij}. Equations (9) and (10) turn into equations (3) and (4).

We can say that in the state of a continuous medium, the interaction field υ_i, A_{ij} "does not notice" that a substance consists of molecules, since it materializes in a continuous elastic medium and becomes proportional to the momentum p_i and stress tensor σ_{ij}, respectively.

It is obvious that lightning is a special case of explosion, since in both cases the cause of the phase transition is the occurrence of a critical field ρ_{ij}^C. Therefore, the question of the causes of lightning should be removed, since the explosion can not even be imagined as an electric discharge. An electric discharge in lightning is a consequence of the appearance of a high-temperature plasma during the phase transition of the destruction of air as a continuous medium. An electric discharge in lightning occurs when a potential difference occurs in the plasma, which has the form of a linear defect, when it is grounded.

Generally speaking, lightning and an explosion in the atmosphere are two phase transitions. First, there is a phase transition for the destruction of low-symmetric state of a continuous medium energy absorption, and then the opposite occurs, the phase transition to the continuous medium, which is accompanied by release of energy and ejection of the vortex tension ρ_{ij} from the air. The effect of pushing the vortex tension ρ_{ij} out of a continuous medium is similar to the Meissner effect of pushing the magnetic field out of a superconductor.

A continuous medium and a high-temperature plasma are described by different symmetry equations of state. In a continuous medium, the gradient symmetry of (12) fields υ_i, A_{ij} is broken. Plasma occurs when the state of the continuous medium is destroyed and gradient symmetry is restored (12). A continuous medium and a plasma are two mutually exclusive states. In this case not the symmetry of the substance but the symmetry of the interaction field υ_i, A_{ij} changes.

Therefore, it is impossible to describe the plasma as a continuous medium, even if ionized, using the equations of fluid dynamics of the continuous medium. The plasma is described by the equations of state of the 4-distortion tensor (3) – (6) and the Maxwell equations. Generally speaking, any physical state is described by a system of sixteen equations of state: equations (3) and (4) and Maxwell's equations. It is only necessary to distinguish two cases of degeneration of these equations when the gradient symmetry is violated. When the distortion tensor is materialized, it is a state of a continuous elastic medium, and when the electromagnetic potential is materialized, it is a superconducting state with the Meissner effect.

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