

RESEARCH ARTICLE

ON THE UNITY AND VARIETY OF THE FORCES OF NATURE.

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Abstract

It is shown that any forces in their general physical understanding arise as a result of spatial inhomogeneity of the systems under study. Universal expression of external and internal, mechanical and nonmechanical, long-range and short-range, active and reactive, useful and dissipative forces as negative gradients of the corresponding potential is proposed. Such (energodynamic) forces were found for a large number of known and a number of unknown processes. It is concluded that a unified method for finding clearly distinguishable forces can serve as an alternative to the unified field theory.

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Introduction:-

The idea of the divine origin of forces as the emergence of the movement was not questioned until the seventeenth century, as confirmed by the works of ancient and medieval philosophers and natural scientists, including R. Descartes [1]. Being the founder of the new direction in natural science, called "kinetism", R. Descartes considered the movement of an abstract geometric point in extended space as something given from above, setting as its goal to find only mathematical correlations between the measures of this movement. He considered this measure the amount of motion, defining it as the product of the amount of substance m and its velocity v. At the same time, he believed that the "Creator" took care not only of the organization of the movement but also of preserving this quantity of P = mv.

The founder of another direction - "dynamism" I. Newton, also built mechanics on the basis of kinematics. The concept of inertia force introduced by him F = dP/dt (lat, vis insita) explicitly defined it as a function of the process [2]. At the same time, the law of gravity found by him described the gravity $F_g = Gm_1m_2/R^2$ (lat. vis impressa) as a function of state, defined by the mutual arrangement of two point "masses" m1 and m2, separated from each other by a distance R. Such duality in the absence of Newton's general definition of the concept of force was the cause of endless discussions about whether forces are the cause or effect of a process (state function or process function), how to distinguish active forces from reaction forces, and whether inertia forces exist if they arise only in the process Oren. These disputes became particularly lively by the end of the nineteenth century, with the transition to the study of discrete processes in the microworld and the emergence of quantum mechanics (QM) [1]. They led to the conclusion that the concept of force in QM should be replaced by the concept of "exchange interaction" in connection with the existence of massless particles and processes proceeding without acceleration. The "standard model" of the OM distinguishes between the carrier particles of matter and the carrier particles of interaction and divides all types of interaction by the magnitude of the coupling constant into strong and weak, and by nature into gravitational and electromagnetic. However, the replacement of power by exchange interaction entailed the QM refusal to perform the most important function of science - explaining the reasons for the great diversity of the phenomena of the world around us. The problem of the incompatibility of mechanics with electrodynamics, and in

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essence - quantum and relativistic theory as two main directions of development of physics, arose. There was an urgent need to unite all interactions, which received the sonorous name of the "Great Unification". However, the problem of developing a unified field theory did not find its solution even a century after its proclamation. The more interesting is the alternative to this direction, which consists in developing a unified method for finding clearly distinguishable forces.

A unified method for finding the driving forces of various processes

Some progress in understanding the unity of forces of any nature of forces was achieved when it became clear that the cause of the processes was the heterogeneity of the system (lack of internal equilibrium in it). The thermodynamics of irreversible (non-equilibrium) processes (TIP) arose, which shed new light on the evolution of living and inanimate nature and on the origin of the interrelationships of heterogeneous processes and [3-5]. Its natural continuation was the unified theory of energy transfer and energy conversion [6], which generalized TIP first to locally nonequilibrium systems [7] and then to systems that perform useful external or internal work [8].

Energodynamics [8] takes into account that the non-uniform density distribution $\rho_i(\mathbf{r},t) = d\Theta_i/dV$ of some independent extensive quantity Θ_i (mass M, number of moles of k-th substances N_k, entropy S, electric charge Q_e, impulse **P**, its momentum **L**, etc.,) by the volume of the system V leads to a displacement of the position of its center \mathbf{r}_i defined by the well-known expression:

$$\mathbf{r}_{i} = \Theta_{i}^{-1} \int \rho_{i}(\mathbf{r}, t) \mathbf{r} dV, \qquad (1)$$

where r, t is the running (Eulerian) spatial coordinate and time.

In the uniform state, the position of this center \mathbf{r}_{io} always coincides with the center of the volume V occupied by the system. Therefore, the redistribution of the energy carrier Θ_i when the system deviates from the homogeneous (internally equilibrium) state is accompanied by the appearance of a certain "distribution moment"

$$\mathbf{Z}_{i} = \Theta_{i} \mathbf{r}_{i} \tag{2}$$

with the shoulder \mathbf{r}_i , which we call the "displacement vector" [6, 9]. This shoulder tends to zero when $\rho_i \rightarrow \overline{\rho}_i$ or as the system "tightens" to a "material point" with the same amount of energy carrier Θ_i .

Due to the introduction of such parameters, the energy U of the inhomogeneous system becomes a function not only of the equilibrium (thermostatic) parameters Θ_i but also of their displacement vectors \mathbf{r}_i . If its energy U is represented as the sum of "partial" energies (from Latin partialis is partial), that is, we set $U = \Sigma_i U_i(\Theta_i, \mathbf{r}_i)$, then the expression of the total internal differential can be given the form of identity:

$$d\mathbf{U} \equiv \Sigma_{i} \Psi_{i} d\Theta_{i} + \Sigma_{i} \mathbf{F}_{i} \cdot d\mathbf{r}_{i}, \qquad (3)$$

where $\Psi_i \equiv (\partial U_i / \partial \Theta_i)$ is the potential of the i-th form of energy; $\mathbf{F}_i \equiv (\partial U_i / \partial \mathbf{r}_i)$ are the forces in their general physical understanding, which acquire in the energodynamics the single meaning of the partial energy gradient, the single mathematical expression, and the same dimension.

The most important conclusion that follows from identity (3) is that any force fields are generated not by masses, charges, and currents themselves, but by their inhomogeneous distribution in space¹⁾.

To establish the connection of forces \mathbf{F}_i with the known "thermostatic" parameters of the system state, we compare identity (4) with the expression of the energy conservation law for non-equilibrium systems proposed by N. Umov (1873) [9]:

$$dU/dt = -\int \mathbf{j}_{\mathbf{u}} \cdot d\mathbf{f} = -\int \nabla \cdot \mathbf{j}_{\mathbf{u}} dV, \tag{4}$$

where \mathbf{j}_u is the energy flux density through the vector element df of the closed surface of a system of constant volume V in the direction of the outward normal **n**.

Energy transfer across system boundaries can be accomplished by heat conduction, electrical conduction, diffusion of k-th substances across system boundaries, etc. Each component jei of such a flow can be expressed as the product of the corresponding potential ψ_i (thermal T, electric φ , chemical μ_k , etc.) and the flux density of the corresponding energy carrier \mathbf{j}_i (entropy, number of moles of the kth substance, charge, etc.), i.e. $\mathbf{j}_u = \Sigma_i \psi_i \mathbf{j}_i$. If we now express the divergence $\nabla \cdot \mathbf{j}_e = \Sigma_i \nabla \Box (\psi_i \mathbf{j}_i)$ as the sum of two terms $\Sigma_i \psi_i \nabla \cdot \mathbf{j}_i + \Sigma_i \mathbf{j}_i \Box \nabla \psi_i$, we get:

¹⁾ Thus, the necessary and sufficient signs of the existence of force fields as functions of the distribution of forces in space are distinguished.

$$dU/dt = -\sum_{i} \int \psi_{i} \nabla \cdot \mathbf{j}_{i} \, dV - \sum_{i} \int \mathbf{j}_{i} \nabla \psi_{i} dV.$$
(5)

Putting the integral value $\overline{\Psi}_i$ of the potential ψ_i and its gradient $\overline{\nabla}\Psi_i$ as the integral sign and taking into account that $\int \nabla \cdot \mathbf{j}_i d\mathbf{V} = -d\Theta_i/dt$, and $\int \mathbf{j}_i d\mathbf{V} = \Theta_i d\mathbf{r}_i/dt$, by comparison with the identity (3) we find that $\Psi_i = \overline{\Psi}_i$, and $\mathbf{F}_i = -\Theta_i$ $\overline{\nabla}\Psi_i$. The last expression indicates that the specific value of the force $\mathbf{X}_i = \mathbf{F}_i/\Theta_i$ as an analog of the concept of mass, volume, surface, etc. force in mechanics has the meaning of the gradient of the corresponding potential, averaged over the system volume, taken with the opposite sign

$$\mathbf{X}_{i} = \mathbf{F}_{i} / \Theta_{i} = -\nabla \Psi_{i} \tag{6}$$

Such forces are expressed through the internal parameters of the system and therefore are also parameters of the state of the system. This is where they differ from reaction forces such as Newton's inertial force, which arise only when an acceleration process occurs and therefore are functions of the process, not states. In order to distinguish reaction forces from active forces, it is advisable to indicate that in this case the state parameters \mathbf{r}_i and \mathbf{F}_i become functions of the process $\mathbf{r}_i(t)$ and $\mathbf{F}_i(t)$. Active forces as a function of state are akin to internal stresses and are the cause and not the result of the occurrence of relaxation processes in it. This is their difference from the "thermodynamic" forces \mathbf{X}_i introduced into the theory of irreversible processes (TIP) [3-5] based on the expression for the entropy rate d_iS/dt and having not only a different analytical expression but also the meaning of the reaction forces disappearing in lack of relaxation process. Therefore, in order to avoid confusion, we will call forces (6) "energodynamic". They allow us to introduce into consideration a special class of inner workings W^T "against equilibrium" performed by a non-equilibrium system during its relaxation:

$$\mathbf{d}\mathbf{W}^{\mathrm{T}} = \Sigma_{\mathrm{i}}\mathbf{F}_{\mathrm{i}} \cdot \mathbf{d}\mathbf{r}_{\mathrm{i}} = \Sigma_{\mathrm{i}}\mathbf{X}_{\mathrm{i}} \, \mathbf{d}\mathbf{Z}_{\mathrm{i}} \,. \tag{7}$$

The forces X_i that perform such work can be mechanical and non-mechanical, active "and reactive, external and internal, long-range and short-range, useful and dissipative. Due to such universality, the work described by expression (7) characterizes the process of interconversion of energy, which consists in creating disequilibrium in some degrees of freedom of the system due to nonequilibrium of others. This underlines the fact that only internal nonequilibrium (inhomogeneous) systems can transform W^T energy.

It is easy to verify the validity of the universal expression \mathbf{F}_i obtained above for a number of known cases. Consider, for example, the Newtonian definition of inertia force $\mathbf{F} = d\mathbf{P}/dt$, given by him at the time when vector algebra did not exist yet, and the amount of motion \mathbf{P} was determined by the value of mo. In this case, the displacement of the center of inertia of the system with the redistribution of the velocity field inside the inhomogeneous system is equivalent to its movement with the velocity $v(\mathbf{r}, t) = d\mathbf{r}(t)/dt$, where $\mathbf{r} = |\mathbf{r}|$. In this case, the system acquires the external kinetic energy $\mathbf{E}^{\kappa} = mv^2/2$. In this case, the expression for the force $\mathbf{F}_i \equiv (\partial U/\partial \mathbf{r}_i)$ takes the form:

$$F = \upsilon d(m\upsilon)/dr = dP/dt$$
(8)

Similarly, we can obtain the expression of the centrifugal force F_z , arising when the mass m rotates with a linear velocity $v = \omega R$ at a distance R from the center of rotation. Then its kinetic energy $E^{\kappa} = mv^2/2$ is more convenient to express in terms of the angular velocity of rotation ω by the expression $E^{\kappa} = m\omega^2 R^2/2$, and the force expression takes the form:

$$F_{z} \equiv (dE^{\kappa}/dR) = m\omega^{2}R.$$
(9)

In the same way are the forces emanating from external force fields with energy E^p:

$$\mathbf{F}_{i} = (\partial \mathbf{E}^{\mathbf{p}} / \partial \mathbf{r}_{i}). \tag{10}$$

The achieved unity of analytical expressions of external and internal (long-range and short-range) forces reveals the unity of their origin and opens up the possibility of a more detailed analysis of their specificity in various phenomena.

The application of energodynamics to finding previously unknown forces

From the standpoint of energy dynamics, it becomes extremely clear that the conversion of energy from one form to another is connected with the change of its material carrier¹). In this regard, it becomes clear the need to generalize the third principle of Newton's mechanics, formulated at a time when vector algebra did not exist. According to him, the applied (active) forces of \mathbf{F}^{a} are always equal to the forces of counteraction (reaction) F^{p} and are directed along one straight line towards them. In inhomogeneous systems with many degrees of freedom, where there are forces of

¹⁾ In this respect, energy resembles a rider changing horses on a long journey.

different nature, the active force \mathbf{F}_i is counteracted in different measure in principle, all reaction forces $\mathbf{F}_j(\mathbf{r}_j)$, arising in it, so this law should be written in the form:

$$\mathbf{F}_{i} = -\Sigma_{j} \mathbf{F}_{j}(\mathbf{r}_{j}), (i, j = 1, 2, \dots, n)$$

$$(11)$$

This circumstance is illustrated in Figure 1, in which the gravitational forces of \mathbf{F}_g are opposed by a whole "fan" of external forces. When the nature of the applied forces and reaction forces is unified, and the forces themselves are equal in magnitude and opposite in direction, the system maintains balance and energy conversion does not occur1). It follows that the nature of the energy conversion process depends on the nature of what forces oppose the active force. Hence one step to the concept of efficiency, if, following S. Carnot (1824), we measure the action of "horsepower" and understand \mathbf{F}_i as the "driving force of heat", and \mathbf{F}_j the mechanical force developed by the heat engine: $\eta_{ii} = \mathbf{F}_i/\mathbf{F}_i \leq 1$, (12)



Picture1:-"Fan" counterforces

The meaning of this efficiency has changed little with the establishment of the energy conservation law when under the action of force they began to understand the work done by force $dW_i = \mathbf{F}_i d\mathbf{r}_i$ and $dW_j = \mathbf{F}_j d\mathbf{r}_j$. At the same time, the irreversibility associated with the "branching" of the process trajectory in the space of "side" forces \mathbf{F}_j ($j \neq i$), including the scattering forces, is preserved. Thermomechanical, thermoelectric, thermodiffusion, etc. effects that arise in this case study the TIP, explaining them, however, by "imposing" irreversible fluxes $\mathbf{J}_i = \Theta_i d\mathbf{r}_i/dt$ and $\mathbf{J}_j = \Theta_i d\mathbf{r}_i/dt$, and not by converting energy into "extraneous" ($j \neq i$) forms [14].

As we can see, the difference in the behavior of systems in statics and dynamics and the dependence of the process efficiency on its speed is due precisely to the participation of "outside" forces in these processes. Therefore, no study of the processes without knowledge of these forces will not be complete. This is the advantage of energy dynamics, which not only returned the concept of force to thermodynamics but also proposed a universal method for finding its many varieties. These advantages are manifested, in particular, in finding previously unknown forces. Consider this in a number of examples

The driving force of radiant energy exchange.

The study of the characteristics of the radiant energy exchange between bodies is radically simplified with the recognition of the fact of the existence of a material medium separating them, which has an oscillatory degree of freedom. Such a medium was at various times called ether, electromagnetic field, photon gas, hidden, dark, nonbarion, etc. matter. According to the law of Stefan-Boltzmann, that part of this type of energy exchange, which is referred to as "radiant heat transfer" is proportional to the difference between the fourth degrees of the absolute temperatures of the bodies. However, the phenomena of photosynthesis, photo effect, photoionization, photoluminescence, photoacoustic phenomena, photonuclear reactions, etc., cannot be attributed to radiant heat transfer, which is limited to the wavelength range from 0.4 to 4 microns. This raises the question of finding the driving force of this type of energy exchange single for all the forces of vector nature. For this purpose we use the theory of waves, which determines the density of the oscillations of the continuum ρv at frequency v by the expression [10]:

$$\rho_{\rm v} = \rho A_{\rm v}^{2} v^{2} / 2, \tag{13}$$

where ρ is the density of the oscillating medium; A_v and v - amplitude and frequency of oscillations.

According to the set (3), each form of energy has its own quantitative measure of the energy carrier (in this case Θ_{ν}) and its own measure of the intensity of movement (potential ψ_{ν}). It is easy to find them by presenting the full

differential ρv as a product of an extensive quantity величиныі as well as an intensity factor (potential ψ_i of the same form of movement), which in this case leads to the expression:

$$d\rho_v = (A_v v) d(\rho A_v v), \tag{14}$$

where $\psi_v = A_v v$ (m s-1) is the potential of the wave, which we called amplitude-frequency; $\rho A_v v = d\Theta_v/dV$ is the pulse density of the vibrational motion of the light-carrying medium Θ_v (H s). From this it follows immediately that the driving force of the \mathbf{X}_v radiative energy exchange process is the quantity [11]:

$$\mathbf{X}_{v} = -\nabla(\mathbf{A}_{v}v). \tag{15}$$

This means that the condition for the radiative equilibrium between the emitter and the radiation field (light-carrying medium) is the equality of the amplitudes of their oscillatory motion at any frequency v. If this is violated, the energy will be transferred to bodies with a lower potential potential 1. Such forces are also countless since the range of studies in principle is not limited. Their existence allows us to explain a number of phenomena, ranging from non-gravitational "redshift" to the incompatible "feeding" with the radiant energy of the so-called "overunity" devices, whose output power exceeds that consumed from known sources [12].

The driving forces of "selective mass transfer"

In open systems (exchanging substance with the environment), a class of processes associated with the selective permeability of system boundaries (including biological membranes) for various substances is distinguished. This category of processes we called selective mass transfer. From the usual convective mass transfer, these processes differ in the composition of the system. These include diffusion processes across the system's boundaries, accompanied by a change in the number of moles of injected k-th substances N_k in the absence of heat exchange and volumetric deformation of the system components (s_k , $v_k = \text{const}$), osmosis processes that differ from diffusion in the presence of thermal and volume effects of mixture formation, electro-osmosis charged k-x substances, filtration, sedimentation (sedimentation of suspended impurities under the action of the forces of the force), centrifugation (separation of substances under the action of centrifugal forces), etc.

To find the potential ψ_k for different input conditions N_k , we will proceed from the combined equation of the 1st and 2nd principles of thermodynamics for any kth substance:

$$du_k = Tds_k - pdv_k \tag{16}$$

Multiplying all members of this equality by N_k and applying the Legendre transformation $N_k du_k = dU_k - u_k dN_k$, after summing up (17) on all components of the system, we find that for a multicomponent system as a whole, expression (16) takes the form:

$$dU = \Sigma_k dU_k = \Sigma_k T ds_k - \Sigma_k p dv_k + \Sigma_k u_k dN_k$$
(17)

This expression goes into the relation of J. Gibbs [13] $dU = TdS - pdV + \Sigma_k \mu_k dN_k$ when applied to its 2nd and 3rd sum of the same Legendre transformations $N_k ds_k = dS_k - s_k dN_k$; $N_k dv_k = dV_k - v_k dN_k$. However, expression (17) takes into account the fact that the entropy $\Sigma_k s_k N_k$ and the volume of the system $V = \Sigma_k v_k N_k$ necessarily change when the composition of the system changes even with a constant mass M due to the difference in partial molar entropies s_k and volumes v_k . In this case, the potential of the injected substance as a partial derivative $\psi_k = (\partial U/\partial N_k)$ cannot remain the same, equal to the chemical potential of the system μ_k [14].

In this regard, expression (17) is more convenient in that it allows one to vary the conditions for introducing k-x substances into the system. Then it becomes obvious that in the case of isobaric-isothermal diffusion (s_k , $v_k = const$) the diffusion potential $\psi_k^{\mu n \phi}$ is equal to the molar energy of the substance u_k , and in the case of osmosis through rigid mebrane (s_k , V = const), the potential of the component will acquire the meaning of partial molar enthalpy энтальним $\psi_k^{\mu n \phi} = h_k = u_k + pv_k$. In the absence of a semipermeable membrane, that is, under conditions of convective mass transfer without changing the composition of the system, the last sum (17) takes the form udM, and the convective potential $\psi^{\text{KOHB}} = (\partial U/\partial M)$ becomes identical to the specific energy $u = \Sigma_k u_k$. Accordingly, the driving forces of these processes $\mathbf{X}_k = -\nabla \psi_k$ [8] will be different. Due to the diversity of such processes, only some of them are given in Table 1.

Particular attention should be paid to the driving forces of chemical reactions. Usually, these reactions are described as a purely scalar process, the coordinate of which is the "path" (degree of completion) of some independent r-th reaction $0 < \xi_r < 1$. In this case, the driving force of the reaction becomes a scalar quantity, called its "affinity" A_r . However, this description does not correspond to the vector nature of force. Meanwhile, the "reversible" chemical reactions that take place in "Van't Hoff boxes", chemical and fuel cells, as well as in in-line type reactors and

biological membranes are of a vector nature. In them, the reagents and reaction products are separated in space, as a result of which chemical affinity gradients \mathbf{X}_r = - ∇A_r appear. The vector character of these forces explains the ability of such reactions to perform useful work [8].

Hydrodynamic forces.

For a long time, it was not possible to understand how small friction forces, which in classical mechanics were considered to be negligible, have a decisive influence on the movement of bodies in a liquid or gas. Understanding came only when they began to take into account the heterogeneity of the velocity fields \mathbf{v} , sharply increasing in the boundary layer of the fluid in close proximity to the moving body. Together with it, the viscous friction forces $\mathbf{X}_{v} = -\nabla \mathbf{v}$ increase. These forces are rank 2 tensors, which can be decomposed into 3 components. One of them, the trace of the tensor $\mathbf{X}_{v}^{0} = -\nabla \mathbf{v}$, characterizes the strain rate per unit volume of the medium and is associated with the appearance of bulk viscosity. The other, the symmetric part of the tensor $\mathbf{X}_{v}^{s} = -(\nabla \mathbf{v})^{s}$, characterizes the sliding of the fluid layers and is responsible for the shear viscosity phenomenon. The third, the antisymmetric part of the tensor $\mathbf{X}_{v}^{a} = -(\nabla \mathbf{v})^{a}$, is a vortex vector equal to twice the angular velocity of rotation of a unit volume of fluid $\boldsymbol{\omega}$. This component is responsible for the phenomenon of turbulent viscosity [8]. As a result, viscous friction forces, as reaction forces, turn out to be orders of magnitude larger than the active forces that create the fluid flow itself.

Electromagnetic forces

As follows from the foregoing, some of the potentials Ψ_i are of a vector nature Ψ_i . For them, the energy-dynamic forces \mathbf{X}_i are expressed by the gradient vectors $\text{Grad}\Psi_i$ and become rank 2 tensors, as well as the conjugate moments $\mathbf{Z}_i = \mathbf{\Theta}_i \times \Delta \mathbf{r}_i$. Such, in particular, are the reaction forces due to the nonuniform field of angular rotational velocities $\boldsymbol{\omega}_e$ of charged particles $\mathbf{X}_e = -\nabla \boldsymbol{\omega}_e$. Like the gradient velocity vector $\text{Grad}\boldsymbol{\upsilon}$, they include the symmetric $\nabla \Psi_i^s$ and the antisymmetric $\nabla \Psi_i^a$ part. The force fields $\mathbf{X}_e^s = -(\nabla \boldsymbol{\omega}_e)^s$ and $\mathbf{X}_e^a = -(\nabla \boldsymbol{\omega}_e)^a$ generated by the symmetric and antisymmetric components of this tensor have a different character. The vector $\nabla \boldsymbol{\omega}_e^a$ has a vortex nature and meaning of the magnetic induction vector B [15]. His driving force \mathbf{X}_e^a can be called a magnet rotator.

The symmetric part $(\nabla \omega_e)^s$ s of the tensor $\nabla \omega_e$, which is an axial vector, has a different character. It has the meaning of a longitudinal magnetic field, the debate about the existence of which lasts more than a dozen years [16]. It is this magnetic field strength $\mathbf{X}_e^s = -\nabla \omega_e^s$ that is used in electromagnetic lifts [17]. Given this circumstance, we have to admit that the work of moving the charge

$$dW_e^{T} = \mathbf{F}_e \cdot d\mathbf{r}_e \tag{18}$$

can make both potential (electrostatic) and magnetic (electrokinetic) forms of energy.

Gyroscopic forces

Recently, the processes of interaction between rotating bodies and momentum transfer in space L have attracted close attention. The mere fact of an exchange between subsystems of the amount of rotational motion is not new. In particular, hydraulic clutches operate on this principle. However, in the "free space" of QM, which is not filled with matter, the transfer of "vorticity" is excluded. The more interesting is the approach from the standpoint of energodynamics, which relies not on model representations, but on the fact that such transport exists in the space environment, which indicates the existence of "primary" matter. This is most clearly manifested in cramped systems of binary stars, where there is a "dragging" of matter from one star or galaxy to another. This process affects the "dark" matter, which is manifested in the distortion of the rotational curves of galaxies due to the existence of an invisible "halo" that rotates with them [18].

According to energodynamics, if there is an inhomogeneous field of angular velocity ω in a material medium, then inevitably there will be processes of exchange between individual areas of the system by angular momentum **L** or its transformation into a momentum of translational motion. These processes are initiated by the force $\mathbf{X}_{\omega} = -\nabla \boldsymbol{\omega}$. The components of this tensor generate the same reaction forces as in the previous cases, with the only difference that the energy carrier, in this case is electrically neutral. The trace of this tensor $\mathbf{X}_{\omega}^{\ o} = = \nabla \Box \boldsymbol{\omega} = \partial \omega_{\alpha} / \partial \alpha \ (\alpha = 1,2,3)$ characterizes the internal sources of angular momentum **L**, caused by the transformation of momentum of translational motion into a rotational one, as is the case with "oblique impact" or in inercoids. The symmetric part of this tensor $\mathbf{X}_{\omega}^{\ s} = (\nabla \boldsymbol{\omega})^{s}$ generates the transfer of "vorticity", and is responsible for the emergence of the force of "gyroscopic thrust", manifested in the rotation of a gyroscope suspended at one end, around a circle of a certain diameter [19]. The other, antisymmetric part of this tensor $\mathbf{X}_{\omega}^{\ a} = (\nabla \boldsymbol{\omega})^{a}$, is responsible for the occurrence of the gyroscopic moment holding the gyroscope axis in a certain direction. The same component is responsible for the so-

called "orientational interaction", which orders the orientation of the axes of rotation in one direction, whether it is a system of nuclear spins or rings of planets or galactic disks.

Systematization of the driving forces of various processes

For more convenience and clarity, the forces found above are summarized in Table 1. This table emphasizes the individual nature of the force for each of the independent processes and at the same time the unity of the active force and the reaction force for the same process. However, the variety of energodynamic forces is not limited to the framework of the table. Countless numbers become obvious if we consider that the driving forces of selective mass transfer exist for any independent component of the system in each of its independent phases, the driving forces of chemical reactions are for any chemically active element in any of its reactions, and the driving forces of radiant energy exchange are any frequency of the infinite spectrum of radiation. This means that the existing division of the whole diversity of forces and interactions by their nature into electromagnetic and gravitational is completely inadequate, and a further search for ways of unifying forces is necessary [20].

Conclusion:-

- 1. The real and only reason for the emergence of any processes is the non-uniform distribution of carriers of various forms of energy in space. The presence of these energy sources is a necessary, but not yet sufficient condition for the emergence of such processes. This also applies to the force fields, which are generated not by the masses, charges and currents themselves, but by their non-uniform distribution in space.
- 2. The current tendency to limit the study of homogeneous systems or their elements to the basis of the local equilibrium hypothesis and differential equations leads to the loss of the "system-forming" properties of the objects of study and to the incompleteness of the description of internal processes occurring in them. As a result, the whole diversity of the forces of nature is reduced to four types of interaction, of which only two (electromagnetic and gravitational) differ in their nature.
- 3. Relying on the law of conservation of energy in its most common (dynamic) form allows us to obtain a universal expression of any (mechanical and non-mechanical, external and internal, long-range and short-range, active and reactive, useful and dissipative) forces acting in the systems under study. These forces have a single analytical expression, a single physical meaning, and a single dimension.

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N⁰	Природа силы	Аналитическое	Примечание
		выражение	
1	Gravitational force	$\mathbf{X}_{g} = -\nabla \Psi_{g} = \mathbf{g}$	ψ_g – gravitational potential
2	Sedimentation force	$\mathbf{X}_{kg} = -c_k \nabla \psi_g$	c _k – mass fraction of k-th substance
3	Accelerating force	$\mathbf{X}_{w} = \mathbf{a} = \mathbf{v} \nabla \mathbf{v}$	v – translational speed.
4	Inertial force	$\mathbf{X}_{\mu} = -\mathbf{a}$	a – acceleration movements
5	Centrifugal force	$\mathbf{X}_{\omega} = \omega^2 \mathbf{R}$	$R = \mathbf{R} - rotat. radius; \omega - angul. speed$
6	Aerodynamic force	$\mathbf{X}_{p} = -\nabla p$	p – absolute pressure
7	Radiation driving force	$\mathbf{X}_{\mathbf{v}} = -\nabla \psi_{\mathbf{v}}$	$\psi_{\nu} = A\nu - amplitude$ -frequency potential
8	Convection driving force	$\mathbf{X}^{k} = -\nabla \mathbf{u}$	u – specific internal energy
19	Diffusion driving force	$\mathbf{X}_{k}^{\mathbf{A}} = -\nabla \mathbf{u}_{k};$	u_k – part. molar energy of kth subst.
10	Osmosis driving force	$\mathbf{X}_{k}^{oc} = -\nabla h_{k}$	h_k – part. molar enthalpy of kth subst.
11	Driving force him. reactions	$\mathbf{X}_{r} = -\nabla \mathbf{A}_{r}$	A_r – affinity ща r th chem. reactions
12	Electric field	$\mathbf{X}_{\mathbf{e}} = -\nabla \mathbf{\phi} = \mathbf{E}$	φ – electric potential
13	Electrochemical force	$\mathbf{X}_{\mathrm{ek}} = - \nabla \mu_{\mathrm{ek}}$	$\mu_{ek} = \mu_k + e_k \phi - \text{electrochem. potential}$
14	Longitudinal magn. field	$\mathbf{X}_{M} = - \left(\nabla \boldsymbol{\omega}_{e} \right)^{s} = \mathbf{H}$	H – intensity magnet. fields
15	Swirl magnetic field	$\mathbf{X}_{M}^{a} = -(\nabla \boldsymbol{\omega}_{e})^{a} = \mathbf{B}$	ω_e – corners. soon charge rotation
16	Galvanomagnetic force	$\mathbf{X}_{eM} = \mathbf{a}_{x}\mathbf{H}$	a _x – Hall constant
17	Thermal motive force	$\mathbf{X}_{q} = -\nabla T$	T – absolute temperature
18	Thermoelectric force	$\mathbf{X}_{eq} = -s_e^* \nabla T$	s_e^* – electron transfer entropy
19	Thermal diffusion force	$\mathbf{X}_{kT} = - \mathbf{s}_k^* \nabla T$	s_k^* – k-th transfer entropy
20	Barodiffusion force	$\mathbf{X}_{kp} = -v_k^* \nabla T$	v_k^* - part. molar volume of k-th subst
21	Bulk viscosity force	$\mathbf{X}_{\boldsymbol{v}}^{o} = -\nabla \Box \boldsymbol{v}$	$\nabla \Box \mathbf{v}$ – speed tensor trace

Table 1:-Analytical expressions for the driving forces of dissimilar processes

22	Shear strength	$\mathbf{X}_{\upsilon}^{\ c} = -(\nabla \mathbf{v})^{s}$	$(\nabla \mathbf{v})^{s}$ - sim. part of the velocity tensor
23	Turbulent viscosity	$\mathbf{X}_{\upsilon}^{\mathrm{T}} = - (\nabla \upsilon)^{\mathrm{a}}$	$(\nabla \mathbf{v})^{a}$ - antisim. part of the tensor $\nabla \mathbf{v}$
24	Gyroscopic force. thrust	$\mathbf{X}_{\omega}^{s} = -(\nabla \boldsymbol{\omega})^{s}$	$(\nabla \omega)^{s}$ - sim. part of ang. veloc. tensor
25	Driving force of the "vortex"	$\mathbf{X}_{\omega}^{a} = -(\nabla \boldsymbol{\omega})^{a}$	$(\nabla \omega)^{a}$ - antisim. part of the tensor $\nabla \omega$
	transfer		

- 1. The definition of internal (energodynamic) forces as gradients of the partial energy of the corresponding degree of freedom drastically simplifies the existing procedure for finding them in the theory of irreversible processes, freeing them from the need to compile entropy balance equations. This opens up the possibility of building all fundamental disciplines on a common conceptual and mathematical basis.
- 2. The proposed approach to the classification of forces according to the nature of the processes that occur allows us to distinguish more than 20 types of independent energy-dynamic forces expressed by negative gradients of the corresponding potentials. Among them are previously unknown forces responsible for selective mass transfer, radiant energy exchange, the interaction of rotating bodies and the occurrence of a longitudinal magnetic field.
- 3. The diversity of the forces of nature and the proposed unified method for finding clearly distinguishable forces indicates the feasibility of using the concept of force in the microworld and the need to rethink the concept of a single field and "great unification".

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