I. INTRODUCTION

The investigations of the open nonequilibrium systems collided with the big difficulties. One of them is contradiction between classical mechanics and thermodynamics. Since Boltzmann and up to now the attempts to remove this contradiction are undertaken [1-4]. But, as a rule, offered solution cannot overcome Poincare’s theorem of the recurrence which forbid an establishment of equilibrium in Hamilton’s systems [2, 3]. The contemporary explanation of the mechanism of an establishment of equilibrium in Hamilton’s systems basing on the condition of mixing is not rigorous enough as it demands postulation “coarse grain”, i.e. averaging of the phase space on physically small volume. The nature of such average is impossible to explain in the frame of the classical mechanics.

With the purpose of finding-out of the physical reason of the contradiction between thermodynamics and classical mechanics, we had been analyzed a hard-disks system [5, 6]. The non-equilibrium system of disks was represented by a set of interacting equilibrium subsystems (IES). Their analysis has shown that the process of an establishment of equilibrium is caused by transmutation of kinetic energy of IES motion to their internal energy in a result of a chaos increasing of the disks velocities. I.e. the dissipation for a disks system is determined by the transformation of energy of relative motion of IES into internal energy by the work of the collective force of interaction IES. Therefore the problem about evolution of nonequilibrium systems is reduced to determining of the forces between IES. For a hard-disks system of these forces are easily enough determined due to the energy of disks has only a kinetic component. But fundamental forces of interactions is potential, therefore the establishment of equilibrium is determined by the forces which work redistributes between IES both kinetic, and potential energy. Therefore to determine the process of evolution in system, it is necessary to determine, what character energy streams between IES created by the intrasystem forces. It is impossible to do basing on the Hamilton formalism because formalism is applicable only for system as a whole. However streams of energy between IES can be determined with the help of equation of the systems (EQS) which determine energy exchange between IES [7].

The EQS allows offering the new approach to the analysis of nonequilibrium systems. This approach is based on the following assumptions and conditions: 1). The closed nonequilibrium system can be submitted by a set of motioning in relative to each other of interacting IES; 2). Dynamics of nonequilibrium system is equivalent of the dynamics of interacting IES; 3). The energy of IES should be submitted by the sum of internal energy and energy of IES motion as the whole; 4). Each element of system should be fixed for corresponding IES without dependence from its mixing in space; 5). During all process of a subsystem are considered as equilibrium.

The applicability of the first condition is guaranteed by that it was successfully used earlier, for example, in case of a substantiation of a principle of entropy maximum for the equilibrium systems [8]. The second condition follows from the first. The third condition is necessary for introduction in the description of dynamics of systems of internal energy, as one of key parameters describing dynamics of interacting IES. The fourth condition allows avoiding a problem of redefinition IES due to particles mixing. Last condition is known from statistical physics. It, not depriving a task of a generality, removes the problems connected to complication of the analysis of redistribution of various types of energy between IES. The offered approach allows to connect thermodynamics with classical mechanics and to analyze some laws of evolution of nonequilibrium system.

Here the substantiation of this approach is offered. The EQS is obtained. The expression for the dissipative force determining change of internal energy IES is obtained also. The analysis of Lagrange, Hamilton and Liouville equations for IES is given. Formulas for the entropy and it production are submitted. The connection EQS and the basic equation of thermodynamics is shown.
II. THE EQUATION OF SYSTEM DYNAMICS

The analytical mechanics as usually constructed from a postulate: "virtual work of forces of reaction is always equal to zero on any virtual displacement which is not breaking set kinematics connections" [9]. Basing on this postulate and a condition of monogenic of the active forces, come to a principle of the least action, functions Lagrange and Hamilton. It is possible to build mechanics based on the principle of the least action [10]. But it is possible to do basing on the law of conservation of energy without the requirement monogenic forces. Here by this way the equation of the systems interaction will be obtained. It will help us discover that the dynamics of the system is determined by two types of energy: energy of motion of system as the whole and internal energy. To each of this type of energy the force which change this type are corresponds.

Let us obtain the dynamics equations for elements and their systems in a field of external forces. If time is homogeneous, for system of energy, $E$, we have: $\dot{E} = 0$. In non-homogeneous space at presence of interaction of particles, energy of system depends on both velocities of elements, $v$, and from their coordinates, $r$. In this case the equality, $\dot{E} = 0$, takes place only when the energy depends on two additive parts. One part should be a function of velocity, and the second one - coordinates. i.e. the energy can be written down as: $E = \varphi[T + U] = const$, where $T = \sum_{i=1}^{N} T_{i}(v_{i}^{2})$, $v_{i}$ is a velocity of $i$- element, $T$ is the kinetic energy of the system, and $U(r)$ is the potential one [10].

The $\varphi$-function should be linear in order to be constant when the coordinates and velocities are being changed. It is always possible to represent such function as $E = T + U$ by means of scale transformation and usage of the necessary system of coordinates. Thus, the sum of kinetic and potential energies of the system in a non-homogeneous space should be constant.

Let us take elementary particle with mass $m$ and velocity $v$. The kinetic energy corresponding to the particle will be $T(v^{2}) = mv^{2}/2$, and the potential energy $-U(r)$, so $E = mv^{2}/2 + U(r) = const$. In this case from equality $\dot{E} = 0$ follows that:

$$v(m\dot{v} + \partial U/\partial r) = 0$$

(1)

The eq. (1) is a balance equation of the kinetic and potential energies. The first term of the equation determines the change of energy caused by inertness of a particle, and the second term is the change of energy caused by heterogeneity of space. It is obvious, that the equation (1) is carried out, if the condition takes place:

$$m\dot{v} = -\partial U/\partial r$$

(2)

It is Newton equation (NE). This equation is determining the connection of acceleration of the particle with the external force. The right hand side of eq. (2) is the active force. The left hand side is the inertial force [9, 10]. The particle moves along the gradient of a potential function. The work of forces on the closed line in a potential field is equal to zero. The dynamics of the particle is reversible.

Let us take a system, which consists of $N$ potentially interacting elements: the mass of each element is equal to 1. The force acting on each element is equal to the sum of the forces from another elements and the external force. The force between elements is central and depends on the distance between them.

The energy of the system is equal to the sum of kinetic energies of elements - $T_{N} = \sum_{i=1}^{N} mv_{i}^{2}/2$, potential energies in the field of external forces - $U_{N}^{env}$, and the potential energy of their interaction $U_{N}(r_{ij}) = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} U_{ij}(r_{ij})$, where $r_{ij} = r_{i} - r_{j}$ - is a distance between elements $i$ and $j$. So, $E = E_{N} + U_{env} = T_{N} + U_{N} + U_{env} = const$.

The time derivative of the energy will be as follows:

$$\sum_{i=1}^{N} v_{i}\dot{F}_{i} = 0$$

(3)

Where $\dot{F}_{i} = m\dot{v}_{i} + \sum_{j \neq i}^{N} F_{ij} + F_{i}^{env}$ is effective force for $i$ particle; $U_{env} = \sum_{i=1}^{N} v_{i}F_{i}^{env}; F_{ij} = \partial U_{N}/\partial r_{ij}; F_{i}^{env}(r_{i}) = \partial U_{env}/\partial r_{i}$.

The eq. (3) can be rewritten as: $\dot{E} = \sum_{i=1}^{N} v_{i}\dot{F}_{i} = 0$. This equality can be treated as orthogonality of the vector of effective forces with respect to the vector of velocities of elements of the system. If there are no restrictions imposed on the $v_{i}$ directions, the requirement $\dot{F}_{i} = 0$ is satisfied [9]. Then from eq. (3) we obtain:

$$m\dot{v}_{i} = -\sum_{i=1}^{N} v_{i}\dot{F}_{i} - F_{i}^{env}$$

(4)

It is NE for the system’s elements in non-homogeneous space. From it follows, that the motion of an element of system is determined by the force equal to the sum of vectors of forces, acting from all other particles and external force [11, 12].

Let us obtain an equation of motion of the system as a whole in an external field. In variables in which energy of system is represented in the form of the sum of energy of its motion and the internal energy, the external force acting on system also is represented us a two corresponding forces. For it show, we shall take advantage of equality: $T_{N} = \sum_{i=1}^{N} mv_{i}^{2}/2 = m/(2N)\{V_{N}^{2} + \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} v_{ij}^{2}\}$ (a), where $V_{N} = \bar{R}_{N} = 1/N \sum_{i=1}^{N} \bar{r}_{i}$ -are velocities of the
center of mass (CM); \( R_N \) - are coordinates of the CM; \( v_{ij} = \dot{r}_{ij} \). We will write the energy of the system in such a way: \( E_N = T_N^{\text{tr}} + E_N^{\text{ins}}, E_N^{\text{ins}} = T_N^{\text{ins}} + U_N \). Then the eq. (3) can be written as follows:

\[
\dot{T}_N^{\text{tr}} + \dot{E}_N^{\text{ins}} = - \sum_{i=1}^{N} v_i F_i^{\text{env}}
\]

Where \( \dot{T}_N^{\text{tr}} = M_N V_N \dot{V}_N; M_N = m_N; \dot{E}_N^{\text{ins}} = \dot{T}_N^{\text{ins}} + \dot{U}_N^{\text{ins}} = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} v_{ij}(m \dot{v}_{ij} / N + F_{ij}). \)

Let us represent velocity of the motion of elements of the system as the sum of velocities of their motion with respect to the CM of the system - \( \tilde{v}_i \), and velocity of the CM of itself - \( V_N \), i.e. \( v_i = \tilde{v}_i + V_N \). Using these variables we will have the following: \( T_N = m \sum_{i=1}^{N} \dot{v}_i^2 / 2 = m/(2N) V_N^2 + mV_N \sum_{i=1}^{N} \dot{v}_i + \sum_{i=1}^{N} m \dot{v}_i^2 / 2 \). As \( \sum_{i=1}^{N} \dot{v}_i = 0 \), then \( T_N = m/(2N) V_N^2 + \sum_{i=1}^{N} \dot{v}_i^2 / 2 \). Therefore \( \sum_{i=1}^{N} m \dot{v}_i^2 / 2 = 1/(2N) \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} v_{ij}^2 \). Thus the kinetic energy of the relative motion of particles of the system equals the sum of kinetic energies of the particles’ motion with respect to the CM.

Let us take into account that \( r_{ij} = \tilde{r}_{ij} = \tilde{r}_i - \tilde{r}_j \), where \( \tilde{r}_i, \tilde{r}_j \) - are coordinates of the elements with respect to the system’s CM. In this case we can write: \( U_N(r_{ij}) = U_N(\tilde{r}_i) = U_N(\tilde{r}_i) \). That is \( \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} v_{ij} F_i(r_{ij}) = \sum_{i=1}^{N} \dot{v}_i F_i(\tilde{r}_i) \), where \( F_i = \partial U_N / \partial \tilde{r}_i = \sum_{j \neq i}^{N} \partial U_N / \partial r_{ij} \).

By means of generalization of corresponding equalities for the kinetic and potential energies of the system, we will obtain from eq. (5):

\[
V_N M_N \dot{V}_N + \sum_{i=1}^{N} m \dot{v}_i (\dot{v}_i + F(\tilde{r}_i)) =
\]

\[
= - V_N F^{\text{env}} - \sum_{i=1}^{N} \dot{v}_i F_i^{\text{env}} (R, \tilde{r}_i)
\]

Here \( F^{\text{env}} = \sum_{i=1}^{N} F_i^{\text{env}} (R, \tilde{r}_i), R \) - is a coordinate of CM.

The eq. (6) determines the balance of energy of the system in non-homogeneous space. The first term in the right hand side corresponds to change of kinetic energy of motion of system as the whole. The second term determines the change of internal energy. If the external forces are absent the eq. (6) breaks up on independent equations: one of them is the equation of motion of the CM, and the others are the equations of motion of particles.

Let us take into account that \( F^{\text{env}} = F_{iR}^{\text{env}} (R + \tilde{r}_i) \), and suppose that \( R \gg \tilde{r}_i \). Then it is possible to expand the force \( F^{\text{env}} \) in a series using a small parameter, \( \tilde{r}_i / R \). Keeping the terms up to first-order of infinitesimal, we will have: \( F_i^{\text{env}} = F_{iR}^{\text{env}} (R + \tilde{r}_i) \approx F_i^{\text{env}} (R) \). Taking into account that \( \sum_{i=1}^{N} \tilde{v}_i = \sum_{i=1}^{N} \tilde{r}_i = 0 \) and \( \sum_{i=1}^{N} F_i^{\text{env}} = NF_i^{\text{env}} = F_{i0}^{\text{env}} \), we can set from (6):

\[
V_N (M_N \dot{V}_N) + \sum_{i=1}^{N} m \ddot{v}_i (\dot{v}_i + F(\tilde{r}_i)) \approx
\]

\[
\approx - V_N F_{i0}^{\text{env}} - \sum_{i=1}^{N} \ddot{v}_i \tilde{r}_i
\]

In the eq. (7) the force \( F_{i0}^{\text{env}} \) is potential and depends on \( R \). It is determines the change of kinetic energy of system as the whole. The second term in the right hand side is depending on coordinates of particles and their velocities in relative to the CM. It is determines the change of internal energy of system. The force corresponding to this term is non-potential and do not change the system’s momentum as the whole.

Thus, dynamics of system in an external field is determined by transformation of two types of energy: the energy of motion of system as the whole and its internal energy. For each of this type of energy the force determining its change is corresponds. Energy of motion of system is determined by macroparameters - velocities and coordinates of the CM. The change of internal energy is determined by macroparameters and microparameters. Thus, the system is similar to the structured particle. Its dynamics is determined by the forces changing its internal energy and energy of its motion as the whole.

Let us note, that the eq. (5) can be obtained, directly basing on the NE for elements. For this purpose we shall multiply the eq. (4) on the corresponding velocity. After summation the obtained equations for all particles we shall have the eq. (5) (if we have summarized the eq. (4) without multiplying it on velocity in this case the internal forces in the second term of the eq. (5) will be lost [13]). It is confirms validity of the equation (5).

**III. THE EQUATION OF INTERACTION OF TWO SUBSYSTEMS**

The nonequilibrium system can be submitted by a set of IES [8]. The dynamics of a set of IES is determined by the eq. (6) if the external forces replace on the forces of interaction of IES. Thus, to find the equation of motion of IES, it is necessary to determine collective forces of their interaction.

Let us the system consists of two IES - \( L \) and \( K \). We take all elements to be identical and have the same weight 1, and \( L \) to be a number of elements in \( L \) - ILS, \( K \) - is a number of elements in \( K \) - ILS, i.e. \( L + K = N \).

\( V_L = 1/L \sum_{i=1}^{L} v_i \) and \( V_K = 1/K \sum_{i=1}^{K} v_i \) - are ILS’s velocities
with respect to the CM of system. The velocity of the system’s CM we take equal to zero, i.e., \(LV_L + KV_K = 0\).

We can represent the energy of the system as \(EN = E_L + E_K + U^{\text{int}} = \text{const}\), where \(E_L\) and \(E_K\) are the ILS, and \(U^{\text{int}}\) - is the energy of their interaction. According to the eq. (6), the energy of each ILS can be represented as \(E_L = T_L^{tr} + E_L^{\text{ins}}, E_K = T_K^{tr} + E_K^{\text{ins}}, \) where \(T_L^{tr} = M_L V_L^2 / 2; T_K^{tr} = M_K V_K^2 / 2; M_L = mL, M_K = mK\). \(E_L^{\text{ins}}, E_K^{\text{ins}}\) is the internal energy of a ILS. The \(E^{\text{ins}}\) consists of the kinetic energy of motion of the elements with respect to the CM of IES - \(T^{\text{ins}}\) and their potential energy - \(U^{\text{ins}}\), i.e., \(E^{\text{ins}} = T^{\text{ins}} + U^{\text{ins}}\), where \(U^{\text{ins}} = \sum_{i_L=1}^{L-1} \sum_{j_L=i_L+1}^{L} U_{iLjL}(r_{iLjL})\). The energy \(U^{\text{int}}\) is determined as \(U^{\text{int}} = \sum_{jK=1}^{K} \sum_{jL=1}^{L} U_{jKjL}(r_{jKjL})\). Indexes \(jK, jL, iK, iL\) determine belonging of the elements to corresponding ILS. In equilibrium we have: \(T^{tr} = 0\). Hence, if the system aspires to equilibrium, then \(T^{tr}\) energy for each ILS will be transformed into the internal energy of IES.

We have obtained the equations of dynamics of \(L\) and \(K\) of IES in the following way. Let us differentiate energy of system on time. In order to find the equation for \(L\) - IES, at the left hand side of obtained equality we have kept only those terms which determine the change of the kinetic and potential energies of interaction of elements of \(L\) - IES. We replaced all other terms in the right hand side and combined the groups of terms in such a way when each group contained of the terms with identical velocities. In accordance with NE (see eq. (5)), the groups which contain terms with velocities of the elements from \(K\) - IES are equal to zero. As a result the right hand side of the equation will contain only the terms which determine the interaction of the elements \(L\)-IES with the elements \(K\)-IES. The equation for \(K\)-IES can be obtained in the same way. Then we execute replacement of variables: \(\dot{v}_i = \ddot{v}_i + V\) and take into account equality (a). As a result we will have [7, 14]:

\[
V_L M_L \ddot{V}_L + \sum_{i_L=1}^{L-1} \sum_{j_L=i_L+1}^{L} \left\{ \dot{v}_{iLjL} \left[ \frac{\ddot{v}_{iLjL}}{L} + F_{iLjL} \right] \right\} = -\Phi_L - V_L \Psi
\]  

(8)

\[
V_K M_K \ddot{V}_K + \sum_{i_K=1}^{K-1} \sum_{j_K=i_K+1}^{K} \left\{ \dot{v}_{KjK} \left[ \frac{\ddot{v}_{KjK}}{K} + F_{KjK} \right] \right\} = \Phi_K + V_K \Psi
\]  

(9)

Here \(R_K = (1/K) \sum_{i_K=1}^{K} r_{iK}; R_L = (1/L) \sum_{i_L=1}^{L} r_{iL}; \Psi = \sum_{i_L=1}^{L} F_{iL}; \Phi_L = \sum_{i_L=1}^{L} \ddot{v}_{iL} F_{iL}; \Phi_K = \sum_{i_K=1}^{K} \ddot{v}_{iK} F_{iK}\). The terms: \(F_{iL}^{K}(R_K, r_{iL}) = \sum_{jK=1}^{K} F_{iLjK} \) and \(F_{jK}^{L}(R_L, r_{iK}) = \sum_{iL=1}^{L} F_{iLjK}\) - are forces between the corresponding particle of one IES and all particles of the other IES. The work of these forces determines the change of energy of IES.

The eqs. (8, 9) are the EQS. They are describe energy exchange between IES. Independent variables EQS are macroparameters - coordinates and velocities of motion IES, and also microparameters - coordinates and velocities of elements. So, EQS connects among themselves two types of the description: at a macrolevel and at a microlevel. The description at a macrolevel determines dynamics IES as the whole, and at a microlevel determines dynamics of elements IES.

The force, \(\Psi\), determines motion of IES as the whole. This force is the sum of the potential forces acting on elements of one IES at the side of another IES.

The forces which determined by the terms \(\Phi_L\) and \(\Phi_K\), transformed of the motion energy of IES to internal energy as a result of chaotic motion of elements of one IES in a field of the forces of another IES. It is non-potential force which cannot be expressed as a gradient from any scalar function. These forces are equivalent to dissipative forces. It can be shown with the help of some transformations of the eqs. (8, 9). For this purpose we take into account that \(\sum_{iL=1}^{L} m \ddot{v}_{iL} \ddot{v}_{iL} = (1/L) \sum_{iL=1}^{L} \sum_{jL=iL+1}^{L} m v_{iLjL} \ddot{v}_{iLjL}, \ddot{U}_L = \sum_{iL=1}^{L} F_{iL} \ddot{v}_{iL}\) = \(\sum_{iK=1}^{K} \sum_{jK=iK+1}^{K} m v_{jK} \ddot{v}_{jK}, \ddot{F}_{iL} = \sum_{jL \neq iL} \partial U_L / \partial \ddot{r}_{iL}\). Then EQS can be rewritten so:

\[
M_L \ddot{V}_L = -\Psi - \alpha_L V_L
\]  

(10)

\[
M_K \ddot{V}_K = -\Psi - \alpha_K V_K
\]  

(11)

where \(\alpha_L = -(E_L^{\text{ins}} + \Phi_L) / V_L^2, \alpha_K = -(E_K^{\text{ins}} - \Phi_K) / V_K^2\). \(E_L^{\text{ins}} = \sum_{iL=1}^{L} \ddot{v}_{iL}(m \ddot{v}_{iL} + F_{iL}), E_K^{\text{ins}} = \sum_{iK=1}^{K} \ddot{v}_{iK}(m \ddot{v}_{iK} + F_{iK})\).

Here ”\(\alpha_L\)”,”\(\alpha_K\)” are coefficients determining efficiency of transformation of energy of relative motion the IES into internal energy. They are equivalent to the friction coefficients. Thus the role of friction is reduced to redistribution of energy of motion IES between their elements.

If the nonequilibrium system is submitted by a set of IES, the state of the system can be determined by the point in the phase space which consists from \(6R - 1\) of independent variables, where \(R\) is a number of IES. In this space the role of a elementary particle is carried out by the IES. We will call this space as S-space to distinguish it from usual phase space with \(6N - 1\) of independent variables. We see that the S-space, unlike usual phase
space, is compressed, though total energy of all elements is preserved. The rate of compression of $S$-space is determined by velocity of transformation of energy of relative motion the IES into their internal energy. The volume of compression of $S$-space is determined by energy of the IES motion.

Thus, EQS determines the IES dynamics as a result of transformation of IES interaction energy into two types of energy: internal energy of IES and energy of its motion. The forces which are carrying out such transformation break up on potential and non-potential parts. Potential forces determine the change of the velocity of IES. The non-potential force determines the change of their internal energy. The work of non-potential forces connected with the chaotic motion of elements for one IES in a field of forces of another IES.

**IV. THE LAGRANGE, HAMILTON AND LIOUVILLE EQUATIONS FOR IES**

Let us explain how Lagrange, Hamilton and Liouville equations for the nonequilibrium system which submitted by a set of IES can be obtained [14]. The canonical types of these equations for elements are following from the integral principle of Hamilton [9]. In turn the integral principle of Hamilton follows from differential principle of D’Alambert. D’Alambert equation is constructed on the basis of EQS which take into account the transformable, D’Alambert equation should be written down on the basis of NE. In accordance with D’Alambert principle: "the virtual work of the effective forces which includes the inertial and active forces is equal to zero for all reversible virtual displacements of elements compatible with the given restrictions" [9]. But if the system consist of a set of IES this principle will be as follows: the sum of works of all forces of interaction the IES at their virtual displacements compatible to restrictions on dynamics is equal to zero.

If the change of the internal energy of the IES can be neglected, the work on their motion will be determined only by the potential part of interaction forces of IES. In this case instead of EQS we can use NE and accept the IES as elementary particle. As a result we come to the well known canonical equations of a classical mechanics.

If neglecting by the change of internal energy is impossible, D’Alambert equation should be written down on the basis of EQS which take into account the transformation of the IES motion energy into internal energies in the result of the work of the non-potential part of forces. As a result we will obtain Lagrange, Hamilton and Liouville equations for IES. Let us explain briefly a way of these equations of obtaining. Firstly, the D’Alambert equation on the basis of EQS can be obtained. Basing on it we obtain Lagrange equation. After that the Hamilton and Liouville equations are deduced.

Let us take a system consisting of $N$ elements which can be represented by a set of IES. Required Lagrange equation for nonequilibrium system looks like [14]:

$$\frac{d}{dt}(\partial \mathcal{L}/\partial v_n) - \partial \mathcal{L}/\partial r_n = -F_n$$

Here $\mathcal{L}$- is a Lagrange function for the system, $n = 1, 2, 3...N$ -is a number of the particle.

At absence of internal degrees of freedom in IES, the work of non-potential forces is equal to zero. In this case the right hand side of eq. (3.1) is equal to zero and the equation becomes canonical [10-12].

The Lagrange equations for two $L$ and $K$ of IES can be written as:

$$\frac{d}{dt}(\partial \mathcal{L}/\partial v_{iL}) - \partial \mathcal{L}/\partial r_{iL} = -F_{iL}$$

$$\frac{d}{dt}(\partial \mathcal{L}/\partial v_{iK}) - \partial \mathcal{L}/\partial r_{iK} = -F_{iK}$$

Here $\mathcal{L}_L$ and $\mathcal{L}_K$ - are Lagrange functions for the IES.

The Hamilton’s equations for non-equilibrium systems can be written as:

$$\frac{\partial H}{\partial r_n} = -\dot{p}_n - F_n$$

$$\frac{\partial H}{\partial p_n} = v_n$$

The non-potential part of force of interaction IES together with potential force determines the right hand side of the eq. (15).

The Liouville equation for non-equilibrium systems can be written as [6, 7]:

$$\frac{df}{dt} = f \frac{\partial F_n}{\partial p_n}$$

Her $f$-is a distribution function for the system’s particles.

The right hand side of eq. (17) is not equal to zero as forces between IES depend on velocities. It means that $S$-space for the nonequilibrium case is compressed. When relative motions of IES will disappear, the right hand side of eq. (17) will be equal to zero. Thus the descriptions in $S$-space and in the usual phase space for equilibrium systems are similar. I.e., at absence of IES motion energy, the dissipative processes do not exist.

**V. EQS AND THERMODYNAMICS**

Here we would like to show, how basing on the EQS it is possible to come from the classical mechanics to thermodynamics.

Let us take the motionless nonequilibrium system consisting from "$R"$ of IES. Each of IES consists from enough plenty of elements. Let us, $dE$ is a work which done above the system. In thermodynamics it is term as internal energy of a system (do not confuse $E$ with the $E^{ins}$ - internal energy of IES). The $dE$ is determined by the basic equation of thermodynamics as: $dE = dQ - PdY$ [8]. Here, according to common terminology, $E$ is energy.
of a system; \( Q \) is thermal energy; \( P \) is pressure; \( Y \) is volume.

As well as the basic equation of thermodynamics, Eqs. also is differential of two types of energy. According to the Eqs the volume \( dE \) is redistributed inside of the system so, that one part of its goes on change of energy of relative motion of IES, and another part changes their internal energy.

The first term in the left hand side of Eqs is a change of kinetic energy of motion of a IES as the whole, \( dT^{tr} \). This term corresponds to the term \( PdY \). Really [8], \( dT^{tr} = VdV = VVdt = Vdt = PdY \).

If the potential energy is a homogeneous function of a second order of the radius-vectors, then as it follows from the virial theorem [10], we have: \( E^{ins} = 2 \tilde{T}^{ins} = 2\tilde{U}^{ins} \). The line denotes the time average. Let us consider the system near to equilibrium. The average energy of each element is \( E^{ins} = E^{ins}/N = \kappa T^{0} V^{0} \) where \( N \) is a number of elements. As the increasing of the internal energy is determined by the volume \( dV \), then we will have: \( dQ \approx T^{0} \kappa [dE^{ins}/T^{0} V^{0}] \sim T^{0} \kappa [dV]/v_{0} \), where \( v_{0} \) is the average velocity of an element, and \( dV \) is its change. For the system in the closed volume we have: \( dv/v_{0} \sim d\Gamma /\Gamma \), where \( \Gamma \) is the phase volume of a system, \( d\Gamma \) will increase due to increasing of the system’s energy on the value, \( dQ \). By keeping the terms of the first order we get: \( dQ \approx T^{0} \kappa d\Gamma /\Gamma = T^{0} \kappa d\ln \Gamma \). By definition \( d\ln \Gamma = dS^{ins} \), where \( S^{ins} \) is an entropy [8]. So, near equilibrium we have \( d\tilde{E}^{ins} = dQ \approx T^{0} \kappa dS^{ins} \).

If we break IES into subsystems, these subsystems will not have the relative motion. Therefore the entropy increasing, \( \Delta S \), for nonequilibrium system is completely determined by the energy \( T^{tr} \) passing into \( E^{ins} \). Therefore \( \Delta S \) can be determined by the formula [7, 14]:

\[
\Delta S = \sum_{i=1}^{R} \left( \frac{N_{i}}{N} \int \sum_{s} F_{L}^{E_{L}^{0}v_{k}} \frac{dE^{ins}}{dt} \right) \tag{18}
\]

Here \( E^{L} \) is the kinetic energy of \( L \)-IES; \( N_{L} \) is the number of elements in \( L \)-IES; \( L = 1, 2, 3... R \); \( R \) is the number of IES; \( s \) is a number of the external element which interacts with element \( k \) belonging to the \( L \)-IES; \( F_{E_{L}^{0}v_{k}}^{L} \) is a force, acted on \( k \)-element; \( v_{k} \) is a velocity of the \( k \)-element.

Thus in agreement with eq. (18), the entropy is determined by the energy of the relative motion of IES, transformed in an internal energy as a result of work of non-potential part of forces between IES.

To obtain equation for the entropy production we take into account that: \( \Delta S = \Delta Q/\Gamma \). Thus \( dS/dt = [dE^{ins}/dt]/(kE^{ins}) \), where \( k \) is a coefficient. It is possible to express this formula through the work of forces of interaction IES. Let us \( E_{0} \) is a full system’s energy, \( E_{0}^{L} \) is a beginning energy of relative motion of \( L \)-IES. In accordance to eqs. (10,11) the rate of increasing of the internal system’s energy is equal to: \( \zeta = \sum_{L=1}^{R} \Phi_{L}^{t} \). The internal energy of a system is equal to: \( E^{ins} = E_{0} - \sum_{L=1}^{R} E_{L}^{t} \), where \( \sum_{L=1}^{R} \Phi_{L}^{t} \) is a sum of IES energy of relative motion. But \( \sum_{L=1}^{R} E_{L}^{t} = \zeta_{0} - \int_{0}^{t} \zeta(t) dt \), where \( \zeta_{0} = \sum_{L=1}^{R} E_{L}^{t}_{0} \). Then entropy production for the system, \( \theta_{prod} = dS/dt \), can be write: \( \theta_{prod} = D/(1 - D_{0} + \int_{0}^{t} D(t) dt) \), where \( D = \zeta/E_{0}, D_{0} = \zeta_{0}/E \).

The energy of \( T^{tr} \) characterizes the rate of nonequilibrium system while \( E^{ins} \) characterizes its degree of equilibrium. To be a stationary state of the system the loss of energy \( T^{tr} \) is necessary to compensate by the inflow of external energy. It is possible as a result of contact of system with thermostat or due to outflow of radiation. Then the stationary state of nonequilibrium system is characterized by the formula: \( \theta_{prod} = |\vartheta_{-} - |\vartheta_{+}| \), where \( \vartheta_{-} \) is entropy outflow, \( \vartheta_{+} \) is inflow of entropy, \( \theta_{prod} \) is entropy production, determined by the formula (18).

Thus, the Eqs leads to the consent between classical mechanics and thermodynamics. It is possible to explain by that the Eqs equation determines dynamics of the structured particles taking into account the change of their internal energy.

### VI. Conclusion

Creation of methods of studying of dynamics of the open nonequilibrium systems can be carried to a task: how to determine the properties and laws of a systems dynamics, knowing properties and laws of dynamics of its elements, at the external restrictions set on system. Within the frame of existing formalisms of a classical mechanics its solution collided with the contradiction between classical mechanics and thermodynamics. According to obtained here results the nature of this contradiction consists in the following.

Evolution is impossible for systems of elementary particles as processes determining it are caused by the dissipative forces. But such opportunity appears for the structural particles possessing an internal energy. The change of internal energy causing evolution is related to work of non-potential part of the interaction force of particles. In many cases: near to equilibrium, in the linear approach of the theory of perturbation, etc., the neglecting of this part of force is admissible. But, it is obvious, that at studying evolutionary processes its account is necessary.

Evolution of nonequilibrium system is determined by the intrasystem energy streams. Our key idea is that these energy streams can be found with the help of Eqs if the system is submitted by a set of IES. Dynamics of IES is determined by the internal energy. Only owing to occurrence of this parameter within the frame of classical mechanics the determination of entropy is appearing as the rate describing increase of internal energy of the IES.

Independent variables in Eqs are macroparameters - coordinates and velocities of IES motion and also microparameters - coordinates and velocities of elements. I.e., Eqs connects two types of the description: at
The dynamics of nonequilibrium systems is determined by other form of symmetry, than dynamics of the equilibrium systems. Really, both for elementary particles, and for equilibrium systems the dynamics is reversible because internal energy are absent. But for nonequilibrium systems these types of symmetry are broken. It is due to the work of the non-potential forces of IES interaction that change the internal energy. Thus it is possible to assume, that the broken of symmetry (for example, observable broken $CP$-symmetry in disintegrations $\beta$ - meson [15]), can testify that products of disintegration are the structured particles with time of a life commensurable with the period of supervision.

If we take into account that all particles are structured we come to the conclusion about existence of infinite hierarchical sequence of the microstructures enclosed in macrostructures. In turn, a macrostructure are a microstructure for the following hierarchical step. The occurrence and existence of such hierarchical sequence in the nature is provided with hierarchy of fundamental forces of interaction. As a rule, the force of interaction of the bottom hierarchical level there are more forces than the gravity force. Indeed, nuclear forces more than electromagnetic forces and electromagnetic forces more than the gravity force. We come to the infinite divisibility of a matter because of impossibility of occurrence of elementary particles. This conclusion has the experimental confirmation [15, 16].

Thus the offered approach allows us to expand a scope of formalism of classical mechanics on the open nonequilibrium systems and eliminate contradictions between classical mechanics and thermodynamics.

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