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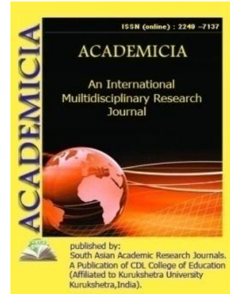

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WORLDVIEW ASPECTS OF SYMMETRY AND CONSERVATION LAWS IN THERMODYNAMICS

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ABSTRACT

The article discusses the stages of development of the concept of symmetry, conservation laws, entropy and dissymmetry, its characteristic functions in the form of conservation laws and principles of symmetry imposed on certain processes under certain conditions. In connection with the ideological aspect, attention isdrawn to the congruence inherent in synergetic constructions and constructions based on dissymmetry. The task of the theoretical substantiation of the conservation laws is determined not only to reveal from the connection with each other, with the structure of fields, with such universal principles as the principle of the non-creativeness and indestructibility of matter and motion and the principle of the unity of the attributes of matter.

KEYWORDS: *Symmetry, Asymmetry, Dissymmetry, Thermodynamics, Energy, Momentum, Inertia, Matter, Motion, Conservation Laws, Entropy, Synergetics.*

INTRODUCTION

The development of natural science, and above all physics, provides new and new data confirming the inviolability of the universal idea of symmetry, the laws of conservation and transformation of energy, matter and motion, displayed with the help of particular laws of conservation and transformation, the number of which is constantly increasing in physics.

For the human mind, symmetry seems to have a very special attractive force. We like to look at the manifestation of symmetry in nature, at the perfectly symmetrical spheres of planets or the Sun, at symmetrical crystals, at snowflakes and other things that are almost symmetrical. "Symmetry is the idea through which man has been trying for centuries to comprehend and create order, beauty and perfection", said G. Weil [1, - p. 7]. Since ancient times, the symmetry of the forms observed in nature has made a strong impression on a person. He saw in symmetry the order, harmony, perfection brought by the almighty creator into the primordial chaos.

The modern view of symmetry: the idea of conservation, the identification of commonalities in objects or phenomena, the limitation of the number of possible options, and therefore symmetry is associated with conservation. It identifies invariants, peculiar “reference points”in our changeable, dynamic world. Thus, the order isintroduced. Parallel symmetry-general, connected with the parallel symmetry-conservation – both go to the conservation laws.

Among all the laws of nature, conservation laws play a special role, being one of the methods of cognition of the hidden forces of nature. One of the characteristic features of conservation laws is that they can manifest themselves in the form of restrictions or even categorical prohibitions imposed on certain processes under certain conditions. This is often the beginning of their knowledge. When a person is faced with the fundamental impossibility of any processes, he eventually comes to the discovery of a new conserved quantity. At the same time, an important feature of conservation laws is that they generally determine the possibility or impossibility of certain processes, regardless of their specific nature. The very process of discovery and cognition by the idea of symmetry and conservation laws has passed a number of historical stages.

The connection of symmetry with conservation laws

The idea of symmetry has often served as a guiding thread for scientists when considering the problems of the universe. Symmetry determines the necessity: it acts in the direction of reducing the number of possible options, in many cases suggests those options that are possible, i.e. allows you to make predictions. For example, in 1869, D. I. Mendeleev predicted the existence and properties of scandium, gallium, and Germany. In 1931, V. Pauli predicted the existence of neutrinos.

Observing the chaotic scattering of stars in the night sky, we understand that the external chaos hides quite symmetrical spiral structures of galaxies, and in them – the symmetrical structures of planetary systems. The symmetry of the external shape of the crystal is a consequence of its internal symmetry – the ordered mutual arrangement of atoms (molecules) in space. It is the crystals that bring the charm of symmetry into the world of inanimate nature. Each snowflake is a small crystal of frozen water. The shape of snowflakes can be very diverse, but they all have a symmetry – a turning symmetry of the 6th order and, in addition, mirror symmetry. Although there is a lot of complexity in physics, there is also a lot of simplicity and grace in it, which is largely due to the symmetry of physical laws and physical systems. The concept of symmetry not only occupies an important place in physics, but also plays a powerful role in modern physical research. To investigate the physical consequences of the symmetry of the system, we obviously need to learn something about transformations and especially about the set (set) of transformations that leave some functions of the potential type unchanged.

Mathematics, art and architecture have been paying attention to the principles of symmetry since ancient times, but they entered natural science, especially physics, relatively recently, and they were subjected to a deep theoretical and philosophical understanding only in the XIX century when their close connection with the principles of conservation was realized. With complete and quite unambiguous certainty of the laws and uncertainty of the initial and boundary conditions, we get the entire diverse range of physical phenomena and processes. The terms “symmetry” and “invariance”are often used as synonyms, at least in the physical literature, where they denote “the property of remaining unchanged with respect to one or several different operations” [2, - pp. 96-99]. The symmetry or invariance of objects always takes place with respect to certain, clearly fixed operations. The invariance of the laws of nature is a consequence of those essential symmetries, which, however, are not fully included in their content. Without the category of symmetry, it is impossible to give a complete description of the category of the law, since each law includes certain symmetry. Therefore, the most general principles are the principles of symmetry or invariance, which permeate all modern physical theories.

The principles of symmetry and invariance, according to the famous American physicist E. Wegner, are a kind of super principle that relates to the laws of nature in the same way as the laws of nature relate to phenomena. Physical laws have symmetry with respect to a given transformation (shift, rotation, mirror reflection, etc.). Conservation laws indicate that the state of the system will not change without its interaction with other systems. These laws can be obtained directly from the condition of a particular symmetry, and therefore the scope of their application is wider than the laws of motion of classical Newtonian dynamics, phenomenological in origin and valid only for macroscopic systems and moderate velocities of movement [3, - p. 56].

The symmetry of physical laws directly applies to the laws of conservation of substances (matter, energy, momentum, etc.). At the beginning of the twentieth century, Emmy Netr showed that for differential equations derived from the Lagrange variational principle, each conservation law is a consequence of the corresponding symmetry: from time invariance follows the law of conservation of energy, rotation-the law of conservation of angular momentum, shift in space - the law of conservation of momentum, etc. These laws follow from a symmetry called the Poincare group. The connection of conservation laws with symmetries determines their leading position among all the laws of nature [4, - p. 20].

Stages of development laws conservation

The law of conservation of mass is historically the first of the conservation laws known by man. Guesses about the existence of a certain universal principle of the conservation of matter as a synonym for matter go back to the philosophers of ancient India, China, from where they penetrated into the ancient world. Thus, Empedocles believed that nothing can come from nothing and nothing can be destroyed. According to Aristotle, matter does not come from nothing, is not subject to multiplication or reduction, is not created and does not disappear, but only changes. The ideas about the eternity of matter are presented by Lucretius Kara, Democritus, Epicurus, Gassendi, Lomonosov, Dalton.

This idea was not lost in the wilds of history from antiquity to the science of the early medieval (VII – XI centuries) Islamic culture of Central Asia and was already more specifically embodied in the idea of Beruniy about the force of attraction of the earth to the center, and Ibn Sina’s theory of the driving force, introducing the concept of “aspiration” (impulse), his justification of“inertia” as a principle about preserving the amount of movement. From this understanding, the principle of inertia in the idea of R. Deckard arose, which assumes that if matter is at rest, it will not start moving by itself. There is also no reason to believe that if it begins to move, then this movement will stop by itself or weaken. To do this, it must meet something on its way that stops weakening it. This idea found expression in the works of G. Galileo, who defended the idea of preserving “natural motion”, in the understanding of which he, in a certain sense, followed the ideas of Aristotle, considering, for example, the“circular” movements of the planets as natural. At the same time, he defended the position on the preservation of “rest” as natural, which later, after Newton's works, led to the development of such a concept of inertia, which is interpreted as a certain idea of conservation. After Newton introduced the concept of mass into physics as a measure of the amount of matter, the law of conservation of mass was implicitly introduced, that is, the idea that the amount of matter in the world should always remain the same due to the non-creativeness and indestructibility of atoms.

The conservation of mass in chemical reactions was experimentally proved for the first time in history in 1755 by M.V.Lomonosov. But, for a long time, this law of conservation was not given much importance, it was considered self-evident, self-evident. In 1789, Lavoisier wrote: “Nothing happens either in artificial processes or in natural ones, and it can be argued that in every operation, the quality and quantity of the beginnings are the same, that only changes, changes have occurred” [5, -pp. 505-506]. M.V. Lomonosov in 1748 expressed in a very general form the idea of preserving matter and motion. In a letter to L. He wrote to Euler: “All the changes that occur in nature occur in such a way that as much as has been added to something, the same amount will be taken away from another… This law of nature is so universal that it also extends to the rules of motion: a body that excites another with a push to move loses as much of its movement as it gives away this movement to another body” [6,- p.160].

Quantitative analysis, as well as the atomistic hypothesis of Higgins, and then Dalton, are entirely based on the law of conservation of all matter, because the weight of Dalton atoms does not change during chemical reactions, as well as their number.

The effect of the second law of Newton's mechanics is based on the fact that force is associated with the inert properties inherent in any body, it is often interpreted as an example of the fact that mass is only a coefficient between force and acceleration, i.e. mass is a measure of inertia. Careful studies have shown that the inert and gravitational masses are numerically equal to each other and are, as it were, two manifestations of the same property of bodies. As is known, the identity of inertial and gravitational masses is the basis of Einstein’s general theory of relativity, in which the geometric properties of space are related to the distribution of available masses. The theory of relativity created by Einstein at the beginning of the twentieth century showed that the dependence on speed has a mass of any origin. Mass is one of the decisive criteria for the stability of atomic nuclei: they are stable if the difference between the mass number and the charge of the nucleus does not exceed narrow boundaries. The stability of the nucleus is characterized by the binding energy of nucleons (protons and neutrons). In the physical and philosophical literature, we still meet with statements that mass is an adequate expression of matter, that mass is the amount of matter and energy, etc.

The law of conservation and transformation of energy is very important for theory and practice, for the scientific worldview. It is interesting to note that physicists themselves almost did not put their hands to the formulation of the law of conservation of energy. A significant contribution to the solution of this problem was made by: doctor Robert Mayer (1814-1878), technological engineer August Kolding (1815-1888), brewer James Joule (1818-1889), physiologist, physicist Hermann Helmholtz. Here we should also note the works of Russian academicians E. Lenz and G. Hess, which were a vivid expression of not only the conservation, but also the transformation of energy.

The law of conservation and transformation of energy was, as it were, the result of the development of mechanics. Thanks to practice, experimental and theoretical research, its deep content as a universal law of nature was revealed more and more. But the law of conservation and transformation of energy has played a particularly important role in the study of electric and magnetic phenomena. Thanks to the works of Clausius, Thomson, Maxwell, Boltzmann, Gibbs and others, since the 60s of the XVIII century, the law of conservation and transformation of energy has become a recognized tool of scientific research. There was a need for a more complete physical, as well as philosophical understanding of this fundamental law of nature. The physical analysis of it was brilliantly carried out by M. Planck in the book "The Principle of conservation of Energy " published in 1887. This allowed the rapid development of the theory of thermal processes, and led to the emergence of thermodynamics.

Conservation laws in thermodynamics.

All simple thermodynamic systems and complex objects initially contain single entities-microparticles (molecules, atoms, etc.), which eventually generate an enormous variety of structures and phenomena. Hence, we can expect the existence of few general laws that can comprehensively characterize the states of material systems. Indeed, thermodynamics is based on three fundamental laws (principles).

According to the first law of thermodynamics, when processes occur in closed systems, the total energy remains unchanged, which corresponds to the universal law of conservation and transformation of energy:

$$dU=\delta Q+\delta A \quad (1)$$

that is, the change in the internal energy of the system consists of increments with the corresponding signs of heat and work, which are not complete differentials. Only the internal energy U is a function of the state, and the heat and the work of the system are functions of the process. The work on overcoming the dissipative forces is converted into the bound energy $\delta Q= TdS$, and an equilibrium state is established in the system with a corresponding increase in the entropy **S**. Therefore, the law of conservation of energy can be formulated in the following form: "The energy of a material system in a certain state, taken in relation to another certain "zero" state, has an unambiguous value" [7, -p.96], i.e. it is independent of the method of transition. Thus, the first law of thermodynamics requires the energy balance of all interactions to be observed.

The formulated law is derived from the experimental fact that it is impossible to create work from nothing (perpetuum mobile) and destroy it-from the fact that "positive work can neither arise from nothing nor disappear into nothing" [7, - p. 138]. This makes it possible to interpret the energy contained in the system already "as a quantity that is independent of external actions in its meaning". The change in the internal energy of a closed thermodynamic system is equal to the sum of the thermal energy communicated to the system and the thermodynamic work applied to the system.

The second law of thermodynamics states (R.Clausius) that there is a quantity that, with all changes in a closed system, evolves in one direction – growth. This value, which is a function of the state, is entropy. The growth of entropy is an indicator of an increase in structural disorder, it establishes the existence of a fundamental asymmetry in thermodynamic systems – one direction of spontaneous processes. And although the total amount of energy is preserved in a closed system, its distribution changes irreversibly: the inevitable loss of free energy means the loss of part of the value of energy; at the same time, the organization and structure tend to replace diversity with uniformity. From this we can say that this law plays a very special role in understanding the meaning of the arrow vector of time. The value of entropy:

dS=δQ/T (2)

Here, a small change in the entropy (full differential) ***dS*** is equal to the ratio of the elementary heat ***δQ***(***δ*** is the sign of the incomplete differential), reported to the system or derived from it, to the temperature level ***T*** (on the Kelvin scale). In 1865, R. Clausius introduced this concept and explained the origin of the name of the new concept: “I propose to call the value ***S*** entropy from the Greek τροπη-transformation. I specifically chose the word entropy so that it would be consonant with the word energy, since these two quantities are so similar in their physical meaning that the consonance of their names seems useful to me” [8,- p.76].

Entropy is the most important function of a thermodynamic system that has the property of the thermal coordinate of the state, i.e. it is uniquely associated with the presence of an energy exchange in the form of heat.

Thus, the second law of thermodynamics indicates the direction of spontaneous state change – degradation (scattering, depreciation) of energy. It is valid only for a large collection of particles (the macrocosm) and does not make sense in the microcosm.

And, the ambiguity of the relationship between the concepts of chaos and entropy is also manifested in the fact that entropy, according to the second law of thermodynamics, is a “measure of the disorder of the system”. In the context of the synergetic theory, entropy is the “progenitor of order” (A. Toffler). In such an interpretation of chaos and entropy, the emphasis is not on the increase in disorder (with an increase in entropy and chaos), but on the creativity inherent in the state of disorder, which carries the possibility of order formation [9, -p.658]. The concept of chaos, and its synergetic understanding, is completely congruent to the concept of dissymmetry: both chaos and dissymmetry are represented as containing the creative potential to become either order and symmetry, or completely subject the system to elimination.

In connection with the worldview aspect, the congruence of another worldview conclusion, characteristic of synergetic constructions and constructions based on dissymmetry, attracts attention [10,- p.376]. Both points of view recognize the material unity of the world at its various structural levels. And if in synergetics, in this regard, the emphasis is placed on the idea of the Universe as a “complete system” (N. N. Moisov), then the view of this problem from the standpoint of dissymmetry was expressed by Louis Pasteur and for the first time introducing the concept of “dissymmetry” into scientific circulation, who considered the world as a “dissymmetric ensemble”, explaining this by the fact that “... the properties of certain figures are not combined by a simple overlay with their mirror image” [11, - p. 383]. Continuing the theory of L.Pasteur, P.Curie, in the logic of his scientific research on the influence of the environment on the bodies in it, determined that “...they retain mainly those elements of their own symmetry that coincide with the symmetry of the environment”. According to the principle of dialectical unity of symmetry and dissymetry, every living object has one or another form of this unity [12, p. 74]. V. I. Vernadsky also noted that “there is a dissymmetry in the world, manifested in the existence of entropy in it...” [13, - p. 350]. It seems to us that dissymmetry should be understood as a system-forming concept. This allows us to offer, as it seems to us, the most visual representation of the mechanism of self-organization. The phenomenon of self-organization should be represented as the desire of any particle to subordinate the oscillation phase of other particles to its oscillation phase, as a result of which a self-consistent interaction field, or response field, is formed around each particle. The phase correlation between the particle interaction field will lead to the formation of a self-consistent oscillating particle field. The use of a new physical invariant made it possible to discover an internal connection between all phenomena in Nature and to explain all phenomena from a unified point of view: from intra-nuclear to cosmic [14, - p.71]. From the standpoint of the dissymmetric concept of transformation, entropy is a measure of the degree of dissymmetrization of a system [15, -p.114], i.e., the growth of entropy in a system depends on the degree of its dissymmetrization. Energy is a property that allows a system to achieve specified states, or, figuratively speaking “energy creates an organization”. Then entropy determines the quality of energy, the measure of its ability to create, the “measure of creativity”, its final result.

The second principle of thermodynamics can be formulated in this form: the sum of changes in the entropy of the system and the external environment cannot decrease. Thus, the universe as a whole, i.e. as a kind of giant system, cannot return to its initial state and must (indefinitely?) strive for a state of thermodynamic equilibrium.

The entropy count starts from the absolute zero of temperature – this is the thermal theorem of V. Nernst, or the third law of thermodynamics. In this case, an absolute equilibrium of the system is achieved, i.e., the cessation of all movement of molecules in this basic energy state ***(T=0, S = 0)***. Only one microstate corresponds to such a macrostate, so the thermodynamic probability of the latter is***W=1.*** At***T=0,*** a closed system left to itself is characterized by a tendency to thermodynamic equilibrium with the highest degree of disorder, i.e. the transition from less probable states to more probable ones. The stable equilibrium condition is *dS=0 and S= max*. Entropy increases only in irreversible processes (processes with dissipation). “...In the redistribution of our geological and even cosmic time, the nature of the energy of the world always changes in the same direction – an increase in thermal energy that can no longer produce work in the world... It inevitably follows from the concept of entropy of the world that the center of symmetry cannot be in the space – time of a physicist”. In other words, it is in irreversible processes that the symmetry in time is broken [13, - p. 350]. However, idealized reversible processes do not depend on the direction of time: it is possible to calculate their states not only in the future, but also in the past. In such non-dissipative (conservative, Hamiltonian) systems, the direction of time can be any. It is believed that living beings have only a non-variant past and a multi-variant future, and the present is the interval where any processes can occur. This is the area of dissymmetry, or rather, its absence, the place of the alleged bifurcation, the place where Einstein’s postulate is not relevant. In places where there is no symmetry (in dissymmetry), the principle of cause and effect may even be violated. This is a kind of time tunnel.

Of great physical and philosophical interest is the question of the relationship of the law of increasing entropy with the direction of time. It is well known that the equations of classical mechanics are symmetric with respect to the replacement of time ***t*** by ***- t***, and it is natural to assume that such symmetry should be preserved in statistics based on classical mechanics. L.D.

Landau and E.M. Lifshits show that this is not the case. They come to the conclusion that “in quantum mechanics there is a physical nonequivalence of both directions of time, and, perhaps, its “macroscopic” expression is the law of increasing entropy. However, until now it has not been possible to trace this connection in any convincing way and show that it really takes place” [16, - p. 48].

Thus, it is also impossible to deduce all aspects of the conservation laws related to dynamic symmetries from the symmetry data. In this case, even the invariance of the conserved quantities isobtained only approximately. While recognizing the great importance of this aspect in the analysis of the theoretical justification of conservation laws, it is still necessary to note its limitations.

CONCLUSION

The connection of conservation laws with the principles of symmetry is accepted by physicists as so fundamental that they classify the conservation laws of modern physics depending on the types of symmetry, and they identify the conservation principles themselves with the principle of symmetry in their physical contents and “do not distinguish between symmetry and conservation principles”.

There is undoubtedly an essential connection between symmetry, asymmetry and conservation laws, but we think that it cannot be so exaggerated that the entire content of conservation laws can be reduced to forms of symmetry and asymmetry. The task of theoretical substantiation of conservation laws is not only to reveal their connections with each other, with the structure of fields, with such universal principles as the principle of the non-creativeness and indestructibility of matter and motion and the principle of the unity of the attributes of matter.

Thus, the conservation laws are associated with the presence of a certain symmetry, the role of group-theoretic understanding of them becomes clear, because group theory studies the most general consequences arising from the existence of a particular symmetry.

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