On the connection between physics and philosophy

Popkov Vladimir Ivanovich

Candidate of Technical Sciences, Full Professor

Bryansk State Technical University

Abstract. The views of prominent physicists on philosophy and the influence of philosophy on the development of physical science are considered.

Keywords: physics; philosophy; philosophical problems of physics; quantum mechanics; theory of relativity; materialism; positivism.

Physics, as a science that studies the most general laws of nature, is not only the leader of natural science and the scientific basis of most modern technologies, but also represents one of the most important elements of the culture of society. The general cultural significance of physics is primarily due to the fact that the achievements of physics form the basis of the modern natural science worldview and form the basic scientific ideas of mankind about the world around us [1]. Due to the generality and breadth of its laws, physics has always influenced the development of philosophy and itself was under its influence. Physics has always been closely associated with philosophy. Outstanding natural scientists, founders of modern physics M. Plank, A. Einstein, N. Bohr, M. Born, V. Heisenberg and many others not only made a significant contribution to the development of physics, which determined the main directions of its further development, but also in a significant way influenced the style of scientific thinking of their time, his worldview. Therefore, the views of physicists themselves on philosophy and the place of philosophy in their scientific work are of particular interest. There have been no special sociological studies on this issue. But in the works of many physicists one can find statements on this matter. Physics, in their opinion, underlies the scientific worldview, the essence of which is that there are laws of nature that are never violated within the framework of their applicability. The law provides the necessary connection between the present state of the world or any part of it and the state immediately following it. This is the predictive function of physics. At the same time, physics, like other natural sciences, is associated with universal human culture and, according to E. Schrödinger, its "constructions, which are most relevant and important, serve as a result for inclusion in concepts designed for reliable assimilation by an educated stratum of society and transformation into the organic part of the general picture of the world" [2]. This connection with philosophy and the place of physics in the cultural background of civilization should be paid attention to when presenting a physics course in higher education.

The philosophical understanding of the achievements of science began to acquire especially great importance since the XVII century, when science, primarily physics, began to turn into a significant social phenomenon. But only from the second half of the XIX century, the philosophical and methodological problems of science turned into an independent area of research. The novelty of the ideas of the theory of relativity and quantum mechanics, the impossibility of applying classical concepts to the phenomena of the microworld put before physicists the problem of philosophical generalization of new data. The attention of scientists began to be attracted by such philosophical and methodological problems as the content of the concepts of space, time, causality, mass, force, energy; discontinuity and continuity, a combination in scientific knowledge of analysis and synthesis, induction and deduction, theory and experience; the role of empirical and theoretical hypotheses; the role of intuition in cognition, etc. These problems concern not only physicists, but also philosophers. N. Bohr wrote about this: "The significance of the physical sciences for philosophy lies not only in the fact that they continually replenish the sum of our knowledge about inanimate matter, but above all in the fact that they make it possible to test the foundations on which our most primary concepts, and find out the area of their applicability" [3].

The philosophical foundations of physics are formed through the selection and subsequent adaptation of ideas developed in philosophical knowledge to the needs of physics, which leads to the concretization of the initial philosophical ideas, their refinement and development. M. Born wrote: "True science is philosophical; physics, in particular, is not only the first step towards technology, but also the path to the deepest layers of human thought. Just as three hundred years ago, physical and astronomical discoveries debunked medieval scholasticism and opened the way to a new philosophy, today we are witnessing a process that, starting with seemingly insignificant physical phenomena, leads to a new era in philosophy"[4].

Philosophy is often viewed as a methodological basis for scientific research, as a result of the ultimate generalization of empirical data from various disciplines, as a way to integrate particular sciences into a single whole, as a basis for creating a holistic picture of the world. This is true, physics can operate with extremely generalized categories formulated in philosophy (matter and motion, space and time, finite and infinite, necessary and random, cause and effect, etc.). On the other hand, physics provides a huge amount of factual material for concretizing and developing philosophical laws and categories, understanding many methodological problems of science; physics data can be a starting point for the creation of philosophical concepts and their development. The most important achievements of physics of the XX century led to the destruction of the immovable system of both physical and philosophical concepts of the XIX century. So, established in the framework of the general theory of relativity, the connection between the geometry of space-time and the distribution of gravitational masses in the Universe in a new form

raised the old questions about the finiteness and infinity of space, the beginning and end of time, etc. [5].

First of all, it should be noted the convict'ion of the creators of modern physics in the objectivity of the existing world and its cognizability. "It is essential...that the external world is something independent of us, absolute, which we oppose...We must admit that there is a real world that does not depend on our consciousness. The laws of nature are not invented by man, he feels them, nature makes itself felt. They are a reflection of its inherent order" wrote M. Planck [6]. I am convinced of the cognizability of the world around us and S. Hawking: "We still do not know a lot about the Universe, we do not understand a lot. But the progress already made, in particular over the past hundred years, should inspire us and give us confidence that full understanding is within the bounds of the possible. I think we are not doomed to feel forever in the dark. Having made a leap towards the creation of a complete theory of the Universe, we will become its true masters...".

Within the framework of physics, the philosophical categories "matter" and "motion" were further developed, the concepts of which were significantly changed by physics of the XX century. The deep meaning of the concept of matter is revealed not in classical physics, but precisely when the concepts of field, physical vacuum, dark matter and dark energy are introduced as different types of matter, i.e. in the theory of relativity, quantum mechanics, atomic and nuclear physics, physics of elementary particles. Here is the point of view of M. Born, expressed by him after the creation of the theory of relativity: "Thus, we have achieved a tremendous unity of our knowledge about the material world: matter in the broadest sense of the word (including light and other forms of pure energy in the language of classical physics) has two fundamental qualities: inertia, measured by its mass, and the ability to do work, measured by its energy. These two qualities are strictly proportional to each other" [7]. The material unity of the world, which is a moving matter, serves as the philosophical basis for the unity of the system of natural and technical sciences. Moreover, the humanities are gradually being included in this system. M. Plank noted: "Science is an internally unified whole. Its division into separate areas is due not so much to the nature of things as to the limited ability of human cognition. In reality, there is an unbroken chain from physics and chemistry through biology and anthropology to the social sciences, a chain that cannot be broken in any place, unless at will" [6].

The principle of relativity by A. Einstein, the principles of correspondence and complementarity proposed by N. Bohr, the principle of uncertainty by V. Heisenberg and others have become general philosophical principles. According to S. Hawking, "The principle of uncertainty has far-reaching consequences related to our perception of the world around us. Even after more than fifty years, many philosophers have so definitively disagreed with them, and these consequences are still the subject of controversy. The uncertainty principle meant the end of

Laplace's dreams of a scientific theory that would give a completely deterministic model of the Universe: in fact, how can one accurately predict the future without even being able to make accurate measurements of the state of the Universe even at the moment!" [8].

The exceptional generality and universality of conservation laws formulated in physics determine their methodological and philosophical significance. A. Einstein emphasized the role of physics in the development of philosophy: "The results of scientific research often cause changes in philosophical views on problems that extend far beyond the limited areas of science itself" [9].

A significant contribution to the development of philosophical thought in the XX century was the scientific work of A. Einstein. The special and general theories of relativity changed the scientific picture of the world, in which they found a new solution to the problem of the space-time structure of the Universe, the idea of its continuous evolution. Einstein's scientific work influenced the style of scientific thinking as a result of the development of new standards of scientific knowledge, in which the Copernican tradition of rejection of anthropomorphic evidence was further developed. Einstein's reflections on the fundamental philosophical problems faced by physics made him a staunch supporter of the materialistic idea of the objectivity of the existence of the world around us: "The belief in the existence of an external world, independent of the perceiving subject, lies at the basis of all natural science. But since sensory perception provides information about this external world, or about "physical reality", indirectly, we can grasp the latter only through reasoning. It follows from this that our ideas about physical reality can never be final. We must always be ready to change these ideas, i.e. change the axiomatic basis of physics in order to substantiate the facts of perception in the most logical way"[9].

The theory of relativity made it possible to revise the traditional views and ideas about the structure of the material world, revealed the closest connections between philosophy and natural science. It allowed to resolve the internal contradictions between classical mechanics and electrodynamics. The greatest influence on the development of physics was exerted by Einstein's concept of the unity of the world. The ontological aspect of this concept consists in the idea of a single basis of the world, epistemological in the requirement to search for a single general principle, from which special cases can be deduced as particular ones.

In the structure of scientific knowledge, empirical and theoretical levels are distinguished. But for an adequate description of the local area of knowledge, these two levels are not enough. It is necessary to highlight another significant level of the structure of scientific knowledge - the metatheoretical level, which includes the philosophical foundations of science, containing general ideas about reality and the process of cognition, expressed in the system of philosophical concepts. The philosophical foundations of science include philosophical ideas and principles that substantiate the ideals and norms of science, inscribing scientific knowledge in culture, as well as

the scientific picture of the world. Philosophical foundations reveal themselves to a greater or lesser extent, depending on what kind of science we are dealing with. But in any science, a scientist proceeds from the philosophical position that all real objects and phenomena that he encounters are causally conditioned. A. Einstein noted that "...philosophical prejudices prevent the correct interpretation of facts even by scientists with bold thinking and subtle intuition. The prejudice, which has survived to this day, is the conviction that facts by themselves, without a free theoretical construction, can and should lead to scientific knowledge"[10].

Physicists usually refrain from claims of belonging to a particular school of thought, even if they are aware of this. The influence of philosophical views on their scientific work is often decisive in the creation of new concepts. M. Jemmer believes that "philosophical considerations affect the thinking of a physicist rather as an underwater current, not visible from the surface, than as an obvious, clearly defined guiding force" [11]. All the more interesting is the recognition of V. Heisenberg about the influence of Plato's ideas on his views on the nature of elementary particles: "The smallest units of matter are really not physical objects in the usual sense of the word, they are forms, structures or ideas in the sense of Plato, about which we can speak unambiguously only in the language of mathematics. Both Democritus and Plato hoped, with the help of the smallest units of matter, to approach the "one", to the unifying principle, which obeys the course of world events. Plato was convinced that such a principle can only be expressed and understood in mathematical form. The central problem of modern theoretical physics is the mathematical formulation of the law of nature that determines the behavior of elementary particles"[12]. From the mathematical symmetry of Plato's regular bodies, Heisenberg throws a bridge to the group-theoretical structure of the equations of modern physics, to the Lorentz group, which determines the structure of space and time.

The development of theoretical thinking is inextricably linked with the development of philosophical categories. But their development should take place on the basis of new data on the objective properties of the world around us, established by physics and other natural sciences. W. Heisenberg believed that it is most expedient to consider philosophical conclusions from the ideas of modern physics on the basis of a historical analysis of the development of quantum mechanics [5]. The philosophical foundations of science are involved in the creation of new theories, the restructuring of the ideals of research. Paying attention to the importance of philosophy for scientific knowledge, L. Brillouin wrote that "scientists always work on the basis of certain philosophical premises, and although many of them may not be aware of this, these premises actually determine their general position in research." In modern conditions, the share of the philosophical component in decision-making systems, especially when choosing a research methodology, is increasing dramatically. A. Einstein wrote about this: "In our time, a physicist is

forced to deal with philosophical problems to a much greater extent than physicists of previous generations had to do. Physicists are forced to do this by the difficulties of their own science"[9].

With the development of physics, the complication of its tasks, the need for a special study of its philosophical foundations is increasingly revealed. According to M. Born, modern physics cannot do without turning to philosophy, which carries out "the study of the general features of the structure of the world and our methods of penetrating this structure" [4]. H. Bohr noted, in turn, the great importance of physics for the development of philosophical thinking: "In our century, the study of the atomic structure of matter has revealed an unexpected limitation of the range of applicability of classical physical ideas and shed new light on the requirements of scientific explanation contained in traditional philosophy. The revision of the foundations and prerequisites for the unambiguous application of our elementary concepts, which is necessary for understanding atomic phenomena, therefore has a meaning that goes far beyond the limits of physical science alone"[3].

However, there is a definite borderline between physics and philosophy. The problematic of philosophy is always fundamentally different from that of physics. Physics asks questions about the forms and ways of existence of the phenomena of the surrounding world, and philosophy - about the reasons and goals. Unlike physics and other natural sciences, philosophy strives for a holistic perception of the world. In philosophical knowledge, both the objective description of the world as a whole and the subjective, personal position of the philosopher, depending on his personal life and moral experience, are presented at the same time.

The correct philosophical orientation is especially important at the crisis moments in the development of physics, when old ideas are undergoing a radical revision. After the introduction of the quantum of action into physics by M. Planck, the positions of mechanical materialism were significantly shaken. The attention of physicists was attracted by the ideas of positivism, which asserts that every concept of the theory must refer to observable quantities. In the spirit of positivism, W. Heisenberg included only observable quantities in his version of quantum mechanics - matrix mechanics. However, with the development of the atomic theory dealing with unobservable objects, V. Heisenberg not only rejected positivism, but also sharply criticized it [5]. There are sad cases when an incorrect philosophical position led to rejection or denial of the theory of relativity, quantum mechanics, cybernetics, genetics, etc. Only an understanding of the relationship between absolute and relative truth, a conviction in the materiality and knowability of the world around us, within the framework of the correspondence principle, allow us to correctly assess the essence of revolutionary transformations in physics and accept only those of them that do not lead to the collapse of physical theories, but enrich and deepen our ideas about matter and motion. According to V. Heisenberg, "natural science has two tasks: to approach the understanding of nature, thereby

creating an opportunity to put it in the service of man, and to determine the place of man in nature by actually penetrating into its internal relations" [13]. It is a well-known point of view that the highest and ultimate goal of science is the construction of the latest theory of Everything, which would fully reflect the most fundamental properties of the real world, including the inner space of the person himself. Science will never be complete, since the process of knowing the limitless world is endless. In addition, an infinite number of particular problems that need to be solved appear all the time. Regarding the difficulties awaiting the researcher on the endless path of human knowledge, L. de Broglie wrote: "The progress of science cannot be compared with a circular motion, which all the time returns us to the same point; rather, it is comparable to a spiral movement; the spiral movement periodically brings us closer to some of the already passed stages, but we should not forget that the number of spiral turns is infinite and that the turns increase and rise up"[14].

The current stage in the development of an industrial society is often called the "risk society". Risk has become an attribute of today's unstable society. The degree of its uncertainty and instability began to grow since the rate of development of technology began to exceed the rate of understanding by human society of the causes and especially the consequences of this development. The risk is often directly related to the dangers of modern technology that threaten planetary civilization. Evaluation of the positive and negative consequences of a particular technology, which is based on new physical effects, on the environment is often hampered by the lack or even the absence of the knowledge necessary to solve it. For the first time in history, society is dealing with an artificially created prospect of self-destruction [15]. Under these conditions, the responsibility of science and scientists to society increases. V.F. Weisskopf stated: "Physics is not only a search for truth, but also a potential power over nature" [16]. Scientists must foresee what this or that discovery will bring to mankind and society, timely recognize the undesirable consequences of their discoveries and new technologies. Assessing the instability of the current state of civilization from the point of view of the principle of uncertainty, I. Prigogine wrote: "...the idea of instability not only in some sense theoretically supplanted determinism, it, moreover, made it possible to include human activity in the field of view of natural science, thus giving the ability to more fully include a person in nature. Accordingly, instability, unpredictability and, ultimately, time as an essential variable now began to play an important role in overcoming the disunity that has always existed between social research and the sciences of nature"[17].

Global models and forecasts of the development of human civilization made it possible not only to see the real situation of the global crisis, but also raised the question of the need to develop a strategy for the further development of mankind. Knowledge of the laws of the development of the Universe and living communities, knowledge of the causes of environmental and other global crises

that threaten civilization, allow mankind to navigate in choosing the path of development of human society, ensuring the survival of both individuals and civilization as a whole [18]. Saying that modern science has enormous achievements that can be used to the detriment of humanity, Heisenberg warns: "The task of science is, perhaps, precisely to awaken in people a sense of how dangerous this world has become, to show them how it is important that all people, regardless of their nationality and ideology, unite to reflect this danger"[13]. The words of V.F. Weisskopf also serve as a warning to scientists: "There is one more side of science... It recognizes the uniqueness of life on Earth, which took several billion years to develop. The loss of a living being means the irreparable loss of a certain genetic combination. The biological heritage fund, formed as a result of a slow evolutionary process, would be irretrievably lost if destroyed by a human-induced disaster. It is our responsibility to preserve and further develop this fund, which is in our hands and the best or worst future of which depends on us. We are now responsible for the successful continuation of this extraordinary experiment that nature began on Earth. Naturally, these aspects of science have a profound influence on our thinking; they can lead to the creation of some semblance of ethical laws, at least among the scientific community, whose members are imbued with these ideas"[16]. There is no doubt that the union of physics and philosophy will play a decisive role in the preservation of civilization on Earth.

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