DISCUSSIONS

THE CONTRIBUTION OF UNCERTAINTY TO THE PHILOSOPHY OF SCIENCE: GASTON BACHELARD'S EPISTEMOLOGY OF SCIENCE

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ABSTRACT

Bachelard, one of the 20th century's most important thinkers, interpreted the course of scientific thought up to his own time and evaluated the scientific dimensions of the process of human knowledge, addressing them under the concepts of phenomenology and image, rationalism and emotionality, and poetic philosophy of science. He has made an in-depth examination of the nature of science, the mechanism of the human mind in its search for meaning, and the processes of the formation of knowledge through some of the problems he has made the subject of his philosophy. Thinking that knowledge is constructed through images and symbols, the philosopher emphasized that knowledge is not a cold and objective activity. In this respect, Bachelard's epistemology of science, which emphasizes poetic, phenomenological and emotional balance, is important in understanding and analyzing today's scientific progress. This study tries to understand and discuss Bachelard's philosophy of science and discusses today's developments through his view of philosophy of science.

Keywords: Bachelard, philosophy of science, epistemology, knowledge, mathematical knowledge.

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I. THE PROBLEM OF CERTANITY-UNCERTANITY AND EPISTEMOLOGY OF SCIENCE

With the increasing influence of positive thinking in modern times, the sciences have entered into a new understanding of science (Çüçen, 2012: 17-28). This new science, operating with a mechanical understanding of causality, sought the causes of events in material processes and material causes. Scientists sought to establish their foundations without relying on a metaphysical phenomenon. This way of thinking, based on the premise that nature has a physical and mathematical explanation, subjected all existence to a scientific and mechanical analysis. The idea that human life and nature, which were to be given new meaning within the framework of scientific and mechanical analysis, would cease to be an unknowable phenomenon and would have content that could be fully presented to human knowledge, gained widespread influence. So much so that this ingrained way of thinking and the propositions that underlie this way of thinking have maintained their influence even in the late modern period. In his work on quantum and relativity theories, even in his old age, Einstein pointed out that the universe could be understood with a single basic formula by stating that God would not throw dice (Mlodinow, 2018: 390).

The reflection of the modern age's evaluation and formation of scientific developments with a mechanistic and mathematically deterministic approach to human life has been realized as the power of knowledge. Thanks to knowledge as the object of scientific activity, human life has shown a different orientation from the previous history of mankind and developed the idea that sovereignty can be established over the world in which we live. The inevitable rise of knowledge as a prerequisite for power has shaped social, religious, and political life. While it is undeniable that science is dependent on material nature in terms of practice and content, the result of the discoveries made is the belief that man has the power to dominate or change everything. In the modern period, as the position of the subject became clearer, the justification of this power was based on scientific developments, and thus man as a subject gained unquestionable power. With this, scientific discoveries have increased, and new centers of power have emerged accordingly. As a result of scientific discoveries, new settlements, firearms, and new formulas for transforming or "taming" nature were created. Another aspect of these developments, which have brought about serious changes in the political, social and daily life of human beings, has also manifested itself in the intellectual life of human beings. Previously, the cause of an event was linked to a religious context, but

with modern scientific thought, this context was severed, and the belief that nature has its own laws was established. The idea that humans are needed to discover and make use of these laws has been strengthened. Thus, a human and nature-centered understanding of the universe replaced theological thinking. Similarly, the approach to human beings as subjects of scientific developments and the phenomena resulting from new discoveries took on a positivist content. The truth and accuracy of an event or proposition depend on its conformity to the laws of the positive sciences. Any statement that did not contain these laws lost its credibility and reliability. As the sciences gained a prominent place in human life, all kinds of metaphysical phenomena lost their influence.

The positive sciences, based on the idea of certainty, have dealt with scientific developments in the form of a system of criteria that accepts them as certain and reliable. This axiomatic way of thinking, based on Euclidean foundations, has pushed itself to produce necessary levels in accordance with the principle of simplicity, which Descartes also saw as a necessary methodology. In this context, the validity of every event in nature and the universe and of every statement made has become acceptable as long as it conforms to scientific laws. Giving the sciences the meaning of truth through axiomatic propositions containing certainty has led to the decline of theological thought. With this tendency, questioning and doubting the nature of knowledge, especially scientific knowledge, became a methodological phenomenon. Descartes expressed this method by saying that all scientific propositions should be reconsidered and the principle of simplicity and clarity should be applied to the most basic proposition, which can never be doubted. Historically, the phenomenon of the sciences gaining a measure of certainty and truth in human life and thought has become established today. So much so that scientific statements have acquired the phenomenon of being the absolute truth and the criterion of everything. All kinds of problems in the world of things (including phenomena of a metaphysical nature) are given their truth and their validity by means of scientific statements. Human respect for knowledge has taken precedence over everything else (Güzel, 1999: 7). In this context, two features of knowledge have been attempted to be both revealed and turned into an absolute and general statement. First, all kinds of discoveries and definitions made up to the modern era contain false content and have a meaning that should be doubted. In fact, the essence of the emergence of modern thought and the implementation of scientific developments without theological content has been the acceptance that all kinds of discoveries, acts, and phenomena have a meaning in themselves and that the context is not theological but based on natural events. Therefore, for knowledge to become power, in a positivist sense, the

analysis of any phenomenon must be based entirely on the laws of physics and scientific content. Religious concepts and explanations should not be the subject of this research, nor should any explanation be based on these statements. The second characteristic is based on the idea that knowledge should have a simple and clear content. In this respect, the exclusion of propositions that cause doubt in knowledge and the idea that knowledge should have a meaning in itself as a definitive criterion constitute the theoretical content of modernism. In this way, the possibility of thinking, the concepts that are the objects of thinking, the knowledge that is the cause of the revelation of concepts, and the phenomena that are the objects of knowledge must be subjected to constant purification and methodological doubt.

Modernism and positivist thinking have placed humankind at the center of all natural phenomena. This is due to all the ways of understanding and methodologies that position humankind as the subject. So much so, that even though the existence of nature itself is accepted, the right to organize this nature, to make it meaningful, and to eliminate the harmful aspects within it has been left entirely to human beings. Human beings have received this sacred duty from the Creator, also in a theological sense. In other words, God created human beings and nature and put nature at the service of human beings. Humankind is a sovereign with the right to correct everything that is harmful and excessive in nature. This power is not only over nature but also over other human beings as part of a duty that carries with it a sense of responsibility.

The aim of this work is to evaluate Bachelard's assessment that knowledge, especially scientific knowledge, contains the meaning of certainty and truth, which are considered to be characteristic features of knowledge, from a different perspective, and to outline the main features of his idea of the concept of uncertainty-probability. It is quite interesting that he grounds his criticism of the characteristic features of science, such as certainty and truth, by using disciplines such as physics-geometry-mathematics, which are considered fundamental to the sciences.

In his *New Scientific Spirit* (Bachelard, 2008), the thinker establishes a complementary relationship between the non-Cartesian and non-Euclidean and the current understanding of the epistemology of science and begins his theory by first defining science and the philosophy of science.

> Science is a product of the human mind: it conforms to the laws of our thought and is adapted to the external world. Science has two equally necessary faces, one subjective

> and the other objective, and it is impossible for us to change the laws of our spirit or the laws of the world in any way. (Bachelard, 2008: 8)

In terms of modern science, which looks at scientific statements with certainty, the contribution of science to the individual or the role of the subject in observation and discovery has been ignored. So much so that the role of the subject, which has a mediated effect, has been neglected as an effect that does not change the existing. In his work, however, Bachelard rejects the sciences' neglect of this role of the subject. According to him, there is a double effect in the discoveries, observations, and experiments of science. What is observed, experienced, or discovered has its own relations and the role of a subject that places it in a design outside these relations. The first is the things in themselves, which are objective and independent of the subject, and the second is the role of the direct observer.

While there is a dual basis for the objective and subjective role of science, the question of how to evaluate science from a philosophical point of view is before philosophy. Bachelard has discussed the modern scientific attitude and the existence of two methods for evaluating this attitude. These two philosophical attitudes constitute the trace of the basis of scientific thought. He calls these two philosophical attitudes rationalism and realism, which he evaluates in more detail in the following sections of his work (Bachelard, 2008: 8). He states that scientific development has two methodological methods and that there is neither absolute realism nor absolute rationalism in terms of scientific philosophy. Therefore, he says, one should not start from a general philosophical attitude in order to judge scientific thought (Ibid, 2008: 8). Bachelard excludes the existence of metaphysical judgments by stating that science should be the basic trace to be applied for the evaluation of an idea or a phenomenon and reveals how he thinks about the relationship between science and philosophy by saying, "*In fact, science creates philosophy*" (Ibid). Bachelard sees science as the source to which the philosopher should turn for the solution of problems arising from scientific statements. Given that science is an applied field and has progress based on experimentation and observation, the philosophy of science should also have an applied philosophical possibility.

Considering that the philosophy of science is an applied activity, the importance of its relation to experimentation and the observer who experiments becomes clear. In addition to this importance, the other important aspect of his dual grounding is rationalization. Bachelard sees experimentation as the work of science itself and thinks that the point to which philosophy of science should move is the rational side of science. Bachelard says that

the epistemological direction from Aristotle to Bacon is not from the real to the general but from the rational to the real (Bachelard, 2008: 10). In a sense, this is the act of realizing the rational in the philosophy of science, and he states that this is the realization of mathematics. Bachelard bases his belief that mathematics is the field of the rational on the fact that it is less abstract and formal.

> A mathematical reality, with functions that are to one extent or another intertwined, to one extent or explicitly, sooner or later reinforces thought, gives it psychological permanence, and divides mental activity into two, there as everywhere else, by revealing the dualism of subjective and objective. (Bachelard, 2008: 10-11).

Mathematics, because of its subjects and the formulas it uses, necessarily remains within a rational field of operation. It is based on abstract operations isolated from experimentation and has its own essential certainty with symbols and formulas. The fact that physics, chemistry, and biology, in contrast to mathematics, have more experimental procedures shows the influence of the subject in these sciences. Mathematics differs from other sciences in that it is a possibility of pure thinking. Since there is such a difference between mathematics and other sciences, we are faced with the problem of where this difference comes together. Mathematics has the possibility of being a noumenon that reveals the thing-in-itself, which is the object of pure thought and from which its phenomenal values are excluded. In this way, it seems to be connected both to the phenomenal as mediated and to the thing-in-itself through its possibility. Through the relation of mathematics to other natural sciences, the relation of scientific experience to the philosophy of science, and the relation of the problematic of reality to pure thought are confirmed.

This intrinsic possibility of mathematics is constituted by the distinction between theory and practice in the natural sciences themselves. Physics, which is closer to experience or mathematics, is divided into applied physics and theoretical physics. Bachelard is interested in mathematical physics rather than empirical physics. According to him, thanks to the theoretical and rational scientific-philosophical attitude, the understanding of the empirical and its transformation into scientific knowledge gains an inclusive content. It requires a generalizing possibility for the knowledge of everyday life, which deals with individual singular experiences, to acquire a meaningful content. In the symmetrical return from the general to the particular, there is an expression of judgment that does not comprehensively

complete the particular in the return from mastery to reality, and this is the subject of the epistemology of science. The abstraction of physical knowledge based on multiple experiences means reasoning and is justified knowledge. However, with the attitude of generalization, the scientific content is abstracted from its object, acquires a theoretical content and is put in an orientation that loses its physical ground. In the process of forming scientific knowledge from the particular to the general, the particular and its knowledge are implicitly ignored. This is where the epistemology of science comes in, discussing the relationship of experience to the subject and the relationship of experience to time and space. This distinction points to Hume's discussion of subjectivity in the philosophy of science (Ökten, 2020: 63-66). Due to the singularity of experience, its subjectivity, and the problem of space and time in its repetition, the discussion that there is a problem on the ground of the meaning of scientific knowledge, which contains certainty and becomes a judgment, has been an important problematic issue in modern thought. However, again, from the point of view of transcendental philosophy, these two fields, namely experiential and mathematical physics, should complement each other (Heimsoeth, 2016). Bachelard, who says that the falsification-negation used in terms of methodology in this complementation is not a correct methodology, states that the falsification-negation in the sciences does not include an epistemology that denies the opposite or denies it since the existing scientific statements have a reasoned content.

> Non-Euclidean geometry did not arise to object to Euclidean geometry. Non-Euclidean geometry is rather a kind of auxiliary factor to ensure that geometric thought is completed, totalized, and massed in a pan geometry. Non-Euclidean geometry, which forms on the edge of Euclidean geometry, stands outside and marks out the boundaries of the old thought with striking precision. (Bachelard, 2008: 14).

Scientific ideas and new ideas created by negating them can be defined as a relationship between completion and determination. In terms of epistemology, knowledge derived from experience through reasoning can be subjected to negations based on new developments. These negations do not deny the reality of the sciences and the knowledge that constitutes them. According to Bachelard, this is due to the dialectical relationship between scientific Truth and scientific Reason. There has been a relationship between the world and spirit for centuries, and all kinds of scientific findings in this relationship, whether negations or affirmations are in a relationship of complementarity. The reason for this complementary relationship is that there

are many differences in the possibilities of the object. Therefore, an experimental environment that would constitute scientific proof is not completely possible. This impossibility also applies to the rational. For the physical sciences, there is no absolute experiment to determine the foundations of reality, nor is there any intuition to phenomenalize it in a rational sense (Bachelard, 2008: 15). For this reason, this impossibility is a methodological novelty that must be analyzed and explained separately.

> In a more general way, is there no advantage in bringing this important metaphysical problem, which concerns the reality of the external world, into the realm of scientific realization... how can it be argued that a simple and pure self can be grasped apart from its essential action in objective knowledge? (Bachelard, 2008: 16)

Considering the dominance of the positive sciences up to the present day, both the real and social values of objectification and objectification are manifested in science. Therefore, from the point of view of the philosophy of science, the only and important thing that is based on rationalization and whose existence cannot be denied is physical reality. Without the influence of the subject, the problems of the philosophy of science would not exist. To discuss the place of the reality of scientific statements would be nothing more than an unnecessary discussion, and it is equally unnecessary to ignore a phenomenal reality. It must be understood, then, that scientific facts are rational insofar as they are physical. Therefore, there is no physical truth separate from the purely rational from its subject (Vydra, 2014: 46-50).

> In reality, scientific truth is a prediction, or rather a sermon..., which means that the scientific world is our determination of truth. Modern science is founded above the subject, beyond the unmediated object, in the place of design. And scientific thinking, the subject's thinking about the object, always takes the form of design. (Vydra, 2014: 16-17).

The objective basis of science is based on physical reality, while its theoretical basis is based on the effect of observation. This is the dual characteristic of scientific reality. All objective knowledge is based on a prior assertion of identification. The content of observation is, therefore, open to debate. When we move from observation to experiment, the controversial identity of knowledge becomes more apparent. Extracting and purifying the phenomenon

and casting it into a mold is nothing but a technical orientation. This orientation, which will be called *phenomenon-technical*, is truly scientific phenomenology (Vydra, 2014: 18). In this context, the binary distinction of empirical content has an intrinsically singular content, such that scientific activity is a purely rational field of activity.

Euclidean conception of science, stemming from the intertwined relationship between the objective and the rational, which is the dual aspect of the philosophy of science, has evolved into a non-Euclidean conception of science. Euclidean simplicity, which forms the basis of modern positive sciences, has given a new content to mathematical reality with the development of modern sciences. On the mathematical plane, the goal of certainty in science, where the simplest surfaces and formulas lead to a single conclusion or cause, was replaced by the conviction that there should be no hurry to move from line to surface and that a line (being linear) does not belong to a surface. The relationship of truth and parallelism based on the Euclidean two-dimensional universe design (fifth postulate) changed with the discovery of the sphere and the curvature theorems of the sphere under modern scientific foundations. Some curved surfaces and curved lines have similar properties with straight lines and surfaces due to the surface and the possibilities it is found in. Therefore, for scientific philosophy, we do not get the chance to prove the validity of Euclidean propositions and axioms. In this case, we have to complement the relationship between experimental physics and mathematical physics with a non-Euclidean epistemology. Bachelard does not express this new epistemology as a negation of the first one. This new epistemology is the completion of the first one (Bachelard, 2008: 31-32).

Euclidean epistemology and the non-Euclidean epistemology between curved planes and two-dimensional planes make themselves felt in the Lobachevsky-Euclides distinction. However, the criticism of Euclidean geometry is based on the desire to generalize the existing understanding of geometry. Bachelard thinks that an intention to reconcile what is common between non-Euclidean geometry and Euclidean geometry, an intention of epistemological generalization that has an internal consistency in accordance with current mathematical developments and can include particular forms, can eliminate the misunderstanding of these two conceptions of geometry. In this context, the role of the subject in the experiment, which is one of the fundamental problems of scientific philosophy, places the sciences, which are a phenomenal reality, on a controversial basis. In order to get rid of these debates, it is necessary to separate phenomenal reality from the concrete. This abstraction expresses itself only in mathematics.

> Physics arrives at its most advanced and complete theories by reducing the implication of concepts to the extent that they correspond exactly to the predicates that appear in their contexts..., this process of abstraction goes so far in geometry that it has even been proposed to forbid any allusion to experiment..., and there we are at the point where mathematical truth is fully revealed. (Bachelard, 2008: 34-35).

However, the tendency to move from the abstract to the concrete and to deny the role of the subject is fraught with huge difficulties. For any substantive expression, the selective extraction of a relation that is intrinsic to it would again make it impossible for that substantive expression to form the basis of reality. But even though negation and abstraction have a purifying function, this process also has the tendency to cause the negation of the knowledge that belongs to the particular. Submitting a substantive expression to purification within a scientific-philosophical analysis would also have the negative quality of producing an epistemological concept that is independent of the relations of the concept being formed to the same extent and that is distant from reality. For this reason, geometric thinking, which should be seen as a completion within the totality of relations, can only give the impression of completeness in this way, and to the same extent, an objective consistency for thinking will be formed. This coherence can only be achieved in mathematics. When numerous relations require a complementary element, they engage in a behavior that has an essential identity and epistemological function for each realization. Mathematics is the most sensitive domain of this realizing behavior. However, axiomatic thinking also manifests itself in this field. The desire for a mathematical procedure modeled on Euclidean geometry is widespread. However, every mathematician knows that this is not the case (Bachelard, 2008: 37). This desire for generalization manifests itself as a desire for completeness. Only in this way does objectification have the possibility of completion and coherence. For Bachelard, the function of completion can eliminate the ambiguity of physical and rational reality and lead to the finalization of propositions. Rational reality, which is in design, realizes this design by forming groups. The existence of groups eliminates the ambiguities produced by independent and tolerated self-consistent consensuses. The physical invariances in the structure of groups give permanence to physical phenomena, and this principle of permanence gives them a rational rather than a realistic value (Bachelard, 2008: 39).

> The physicist realizes that there are permanences in reality, which is constantly in motion, while phenomena flow like a flood; to describe them, the physicist's spirit constructs geometries, kinematics, and mechanical models, the axiomatization of which has as its purpose to make precise what we will call, for lack of a better term, the useful implication of the experiments or observations of various concepts that suggest the foundation in question. (Bachelard, 2008: 39).

Physical realities, which are the findings of experiments, are given an integrated and organized meaning by mathematical physics. The realization of scientific knowledge thus finds itself in mathematical expression. The experiment itself is based on previous intellectual experience as well as on existing objective possibilities. It is only in abstraction that this structure of experimentation can lose its coherence. This table of experimental possibilities is a table of axioms (Bachelard, 2008: 44). This reveals the necessity of bringing physical mathematics to life. In spite of the double function of integration and regularization of physical mathematics, this qualitative feature is ignored, and it is thought to be a separate abstract phenomenon detached from its object. But every formal thought has an incomplete simplicity and, as such, is a limited thought (Bachelard, 2008: 44). It is an epistemological error to ignore this aspect of physical mathematics, which acts as a purifier. One of the reasons for this erroneous approach is the successive boxing up of spiritual generations.

> In moving from non-Newtonian to Newtonian thinking, there is not a contradiction, but a contraction. It is this contraction that allows us to find the limited phenomenon in the noumenon that surrounds it, to find the particular situation in the general situation (although the particular never resembles the general). Henceforth, the study of the phenomenon is the result of a purely noumenal activity; mathematics opens up new avenues for experiment. (Bachelard, 2008: 62).

Bachelard says there is no progress based on the falsification or negation of old scientific thought by new scientific thought but rather on the enveloping of old thought by new thought.

Considering that mathematics and scientific thought have a function that is not separated from its object and that envelops its object, the problem of the theoretical relationship between physics and mathematics seems to be solved in a way. In the field of experimental physics, the problem still remains. In the perception of the object moving in time, there are bound to

be time- and space-dependent changes due to the motion. Similarly, the superposition of the object and its trace within the scientific possibilities based on observation also poses problems. Although Euclidean geometry ignored these movements of time and space, these problems continued to exist. With the development of microphysics, our ability to master the knowledge of particularity has increased. The new information obtained led scientists to develop new theories to express the existing observations. The attempt of the Newtonian understanding of the universe to explain the universe within certain limits at the macro level has also led to the development of new theories. These advances in experimental physics led to the questioning of the Newtonian and Euclidean understanding of science. As a result of this questioning, a scientific epistemology has developed that generally falsifies the old sciences. However, the interpretation of the new knowledge revealed by new scientific facts as the completion of the missing points of old knowledge requires a new epistemological understanding. The universe of objects has a complex and malleable integrity (Bachelard, 2008: 95). Every measurement and observation based on objects has tried to be analyzed within a reduction that belongs to a moment and certain possibilities. However, an object in motion and oscillation is not only in linear motion. Objects also have oscillations in the form of waves (Mlodinow, 2018: 303-314). For this reason, an observation and measurement reduced to a point is insufficient to give us information about the object. Since the bidirectional uncertain motion of the object is mentioned here, an epistemological approach should be realized by considering its linear and wavelength motion together (Bachelard, 2008: 96). Such an approach to our study of the object will allow us to realize the richness of its possibilities.

Solving the problem of determining the object with multiple possibilities arising from the subject and the object itself, which is experienced in the experimental physics of the object, is one of the most important problems before us. With the progress of science, this problem is becoming more and more apparent. Although the old mistaken habit of ignoring the irregular motion of these objects still seems to persist, it seems that the old knowledge at the micro and macro levels is insufficient to explain the current situation.

> In the science of the past centuries, the unity of the concept of mass..., its unmediated and self-evident identity..., the concrete apprehension of nature by the intellect, was believed to be such that Newton's definitions were considered to be the finalization of an idea which, though grounded, remained vague. (Bachelard, 2008: 51).

Bachelard states that the Newtonian understanding of mechanics and its mathematical trace were firmly convinced that the understanding of the object was one-to-one in the design of the universe, but even if Newtonian mathematics carried this degree of concreteness within it, this was due to the fact that empirical physics was ignored and direct mathematical generalizations were made. Thanks to Heisenberg and Einstein, who came after Newton, Newton's activity of understanding particulars gained a possibility of completion. With the development of microphysics, the attitude of ignoring the particular in the Newtonian understanding of the space-universe began to produce problems. With the descent of experimental physics to the micro level in the knowledge of the particular, the idea developed that "a thing cannot be imagined without accepting some action of that thing" (Bachelard, 2008: 67). In the old sciences, the potentiality of matter was taken into account, while its kinetics was ignored. With the development of microphysics, a dual-structured system of thought involving matter and energy developed. Due to the inadequacy of the previous knowledge of microphysics, this gap was filled with the help of intuition. While the knowledge of the role of static matter in possible experiences had an intuitive approach to Newtonian physics, it is now made meaningful by the diffusion of energy and mobility through time (Bachelard, 2008: 71-72).

Refining knowledge of the particular, the current epistemological approach will further strengthen the relationship between object and mind. However insurmountable the metaphysical gap between mind and world may be for an unmediated intuitive metaphysics, it would be easier for a metaphysics that follows scientific developments. Such an approach implies the quantification of the object. The physical-chemical substance is only a shadow of a number (Bachelard, 2008: 85).

Mathematical physics, through its functions of integrating and ordering the multiplicity in the universe, moves objects onto a numerical plane. All our knowledge of the linear or fluctuating motion of matter lives within a problem of certainty. Mechanistic-materialist thought forms groups by ignoring the linear and fluctuating motion of matter in order to arrive at knowledge that has the possibility of certainty and reality. In this way, mechanistic-materialistic thinking is likely to lead to the formation of a set of theories whose body is one thing and whose foundation is another. The knowledge of the particular, which the sciences ignored for the sake of determinism and certainty, has begun to carry a content integrity that cannot be ignored with the development of modern sciences (Bachelard, 2008: 105).

One of the most important principles of modern science is the principle of causality.

Causality contains a pre-thought. The aforementioned pre-thoughts can bring a measure to the determination of phenomena by listing what is necessary for a phenomenon to appear to be determined, and by finalizing the elements of description valid for prediction (Bachelard, 2008: 115).

> More generally, we shall say that the principle of causality submits to what is required by objective thought, and, therefore, can be said to be the fundamental category of objective thought. (Bachelard, 2008: 115).

The idea of causality is based on objectivity. It seeks to objectify any proposition with which it is associated. Although it is thought to contain loops or metaphysical relations, it imprisons the proposition in a closed system completely dominated by the laws of physics. It necessarily relates all propositions to objects in such a way that the laws of physics are the criterion. The scientist builds his knowledge of phenomena on the basis of prior knowledge. Qualitative determinism has always prevailed over quantitative determinism. In the relationship between sign and sign, which is a deterministic assertion, experimentation and observation are undertaken on the assumption of prior knowledge. However, this preference for quality over quantity is flawed on a scientific level. Scientists consider the predicted behavior of objects rather than their unpredictable behavior (Bachelard, 2008: 117). In the classical Newtonian-Euclidean understanding of science, the scientist who deals with determinate behavior ignores the unpredictable (indeterminate) behavior. The indeterminate, of course, is not the determinate. After proving that a phenomenon is undetermined, the scientific spirit considers that phenomenon to be undetermined because of the method it uses (Bachelard, 2008: 118). This is how probability calculations come into play in scientific reality to solve scientific problems. One of the reasons why probability theories are widely used in modern science is that the mathematics of Newton-Euclides was complemented by scientists such as Lobachevski-Heisenberg-Einstein. With probability theories, even the simplest laws had to be reconsidered (Bachelard, 2008: 122). The measurement or evaluation of certain effects that were ignored in experimental physics were, of course, ignored and formulas were derived because they were impossible in terms of current science. In the calculations that we try to create as a result of the desire for certainty and perfection, we include the factors that are not taken into account in the process with the concept of probability. The effects that belong to the particular, which are ignored in a

deterministic epistemology, can lose their negative characteristics in a new epistemology by including probability.

With the introduction of probability formulas into scientific reality, the Descartesian concept of science, the roots of modern science, has been shaken. Of course, this new epistemology is not based on a non-Cartesian science. Bachelard says that the new philosophy of science is integrated with a covering over, a completion of the old (Bachelard, 2008: 149). The basic Descartesian methods must be modified by the movements of complex and indeterministic matter. The relationship of the spirit to mathematics and physics must be established by taking these new theories into account.

> In reality, there is no simple phenomenon; a phenomenon is a web of relations. There is no simple nature, no simple substance; substance is a web of predicates. There is no simple thought because, as Dugrēel saw quite clearly, a simple thought, in order to be understood, must be embedded in a complex system of thought and experiment. The practice is complexification. (Bachelard, 2008: 151).

The simplification of knowledge of the classical philosophy of science has been demolished by today's physical-mathematical theories. This new epistemology is one of completion, of making complete. To understand this new epistemology, the study of atoms, their structures and motions will provide sufficient examples. Although it appears to be holistic, one can see endless epistemological paradoxes within it (Bachelard, 2008: 151).

In the light of new information, one might think that scientific developments are destroying the old. However, what is essentially happening is a rectification of the scientific spirit, of knowledge, of our methods of knowledge. It is a broadening of the framework of science and knowledge. The new non-Euclidean, non-Cartesian scientific spirit is essentially a new boundary. It is a redrawing of the existing old boundaries (Kaplan, 1972: 13). The new scientific can, which is an act of completion, has broken the taboos of rationalism that were considered intimate from the past to the present (Bachelard 2008: 174). Our interest in objects and our desire to understand their movements at the macro and micro levels necessarily leads us to know the entire universe, from the simplest to the most complex things. This is an orientation. In this understanding, it is fundamental not to falsify old concepts but to set new limits to old concepts. Einsteinian mechanics does not destroy Newtonian mechanics but adds the concepts of Newtonian mechanics to its understanding. This understanding is

to carry Descartes into the present by setting new limits. This new epistemology stems from the development of experimental and mathematical physics and the fact that the particular cannot be ignored. So much so that the theorists who laid the foundations of this new scientific epistemology still maintain the idea that the physical laws of nature can be reduced to a single fundamental formula by saying, *"God does not throw dice."* (Mlodinov, 2018: 118).

The serious progress of scientific discoveries at the subatomic level has led to the formation of various new approaches both to the mystery of the universe and to the metaphysical orientation of human beings. In this direction, the reflection of the human search for the "new" in the field of contemporary physics-mathematics turns into an image in which the object acquires a design meaning and ceases to have a phenomenological meaning. In this context, poststructuralism is replaced by a microstructural and design universe in the context of quantum theories, and the knowledge-object relationship of the human subject acquires a fluid meaning. Bachelard locates the subject, which is missing in the Newtonian, Euclidean, axiomatic, mechanistic understanding of modern science, by starting from the nature of mathematics and emphasizing that its rational special possibility has a physical context rather than a metaphysical meaning. As a result of this orientation, the subject's connection to the existent is not only preserved, but its importance for the developments in microphysics and science of the period is also revealed. From this point of view, Bachelard tries to develop a subject-centered theory of mathematical physics on a philosophical basis, in line with Einstein's and Hawking's understanding of the universe. This theory has neither a purely abstract mathematical meaning nor a purely physical meaning. On the contrary, he thinks that science has a poetic spirituality, and in this context, he thinks that it is a human production that is creative and full of human action (Ehrmann, 1966: 572-578). Given Einstein's attitude toward this new scientific spirit, Bachelard's epistemology of science has a coherence that gives the impression of being an acceptable theory given the history of the epistemology of science and the sciences of the mind.

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