THE LENIN DOCTRINE ON KNOWLEDGE AND PHYSICS

S. G. Suvorov

Lenin was not only the organizer and leader of the world's first socialist state, but also the great thinker and philosopher of our time. The combination in Lenin of a revolutionary and philosopher-theorist is natural: this is because he was able to find the true path of transformation of a society and to determine the methods of constructing socialism which he, like Marx, understood profoundly and for which he developed the theory that lies as the basis of knowledge of mobile forces in nature and society, i.e., philosophy.

In philosophy, Lenin was the direct pupil of Marx and Engels, i.e., he was a dialectic materialist. He not only succeeded Marx but he also developed and intensified, under new conditions of knowledge, the different aspects of Marxist philosophy. Below, we shall consider briefly the new knowledge that Lenin introduced into theory and which, in our opinion, is important to physicists.

1. The fundamental complete philosophical work of Lenin, "Materialism and Empiriocriticsm" was written in 1908. Despite the fact that after the havoc of the revolution of 1905 many pointed practical and theoretical problems associated directly with the revolutionary movement arose, Lenin was able to turn to philosophical problems. Important circumstances prompted him to this, which he associated directly with the work of the Party.

At the beginning of the 20th century, there was an increase in philosophical and natural science circles of the influence of positivism (empiriocriticism) – of idealistic philosophy stemming originally from Berkley and which contradicted the existence of an objective world as the source of knowledge and did not acknowledge the objectivity of the laws of nature.

The effect of positivism increased, because in physics at this time there occurred a turbulent undetermining of ideas due to new discoveries and the development of new theories. It was established that the atom, which had been assumed to be the starting material basis of the outside world, after all was not "the last brick of universal knowledge." The radioactive source of energy was discovered; it was found to be inexhaustible and that it refuted the law of conservation of energy. The representation of the absoluteness of space and time was destroyed. The entire system of absolute representations and concepts built up in physics was shaken. Metaphysical materialism, on which physics rested, could not be handled with this breakdown of ideas. Some physicists – including for example Poincaré – began talking about a general breakdown of physical laws, about the "physics crisis," the "disappearance of matter." This confusion of mind was used by positivism, having suggested a philosophy allegedly concurrent with the results of the most recent natural science. It is true that in nature there is nothing absolute, positivism asserted, but this is because outside of us there is nothing objective and our knowledge is related only to sensations and science is a system of ordering of sensations.

Positivism came into fashion. Certain writers from a number of the Party intelligentsia were absorbed by it; they attempted further to unite positivism with Marxism, i.e., with the revolutionary doctrine concerning the laws of development and transformation of Society. This "infection" was not only a Russian occurrence, it ailed the ruling social-democratic circles in the West and the social-democratic press also supported it. Lenin had the insight to discern in this attempt to unite Marxism and positivistic philosophy, an undetermining of the theoretical foundations of Marxism and, in fact, recent history has shown that withdrawal from the basis of dialectic-materialistic philosophy was not accidental – it was the beginning of the

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departure of the social-democratic leaders from Marxism and by their change, the lot of the working class was improved.

In "Materialism and Empiriocriticism" Lenin recalled the essence of positivistic philosophy and showed its historical roots, its relation to double-dyed idealism, its incompatibility with the scientific revolutionary theories of the development and transformation of Society and the groundlessness of its pretences to emerge as a philosophy of modern natural science.

Having shown the unscientific nature of positivism and having grounded himself on the works of Marx and Engels, Lenin developed a theory of representation of the outside world in the consciousness of mankind. He analyzed the processes taking place in physics and showed that a vigorous revolution was taking place, which was natural for the advancing course of knowledge and the breakdown of ideas, and the increased noise in certain circles concerning the "physics crisis" is of a gnosiological nature. Gnosiological hesitations give rise themselves to the development of science with the special features of modern physics. Lenin noted two reasons for physical idealism – mathematization of physics, beyond which some scientists cease to regard material processes, and relativism which in the case of ignorance of dialectic logic leads to negation of objectivity. Therefore, in order to avoid slipping down into idealism, Lenin called upon naturalists to seize hold of materialistic dialectics. As is well known, Hegel developed dialectic logic; but for Hegel it "stopped at the head," as he regarded the basis of everything real in some kind of absolute spirit but not in nature and he expounded it in an extremely mystical form. Just as in the time of Marx, Lenin posed himself the problem of "writing Logic with a capital letter," i.e., to expound and develop a materialistic dialectic in a special acceptable book. Just like Marx, Lenin did not succeed in writing Logic, as a consequence of the fact that before him stood urgent theoretical and practical problems of the revolutionary movement. But he left to our generation the "Phiolosophical Tetrads" in which he expressed many profound ideas by logic. Moreover, he skilfully used dialectic materialistic logic in his numerous writings on the theory and practice of transforming Society and particularly in papers on Marxism; a study of these is essential for the purpose of mastering the philosophical ideas applied in them.

Thus, in order to master the philosophical opinions of Lenin and his contribution to the development of materialistic dialectics, it is necessary to study from this angle the views of all his literary heritage.

2. The idealogical struggle at the beginning of the 20th century posed the question: how do perturbations in the natural sciences and, in particular, in physics affect the solution of the fundamental problem of philosophy concerning the source of knowledge, the precedence of nature and the repeatability of thinking, and how does it affect the conclusion about the understanding of the world and the paths and criteria of knowledge? The opponents of materialism set the solution of these problems in direct dependence on the results of physics, which they interpreted as a denial of the conclusions of materialistic philosophy. Lenin showed that such interpretation of the results of physics is unscientific: they not only do not refute materialistic philosophy but they cannot refute its fundamental theorems. The problem as posed is itself incorrect: the justification for the conclusions of materialistic philosophy does not rest on the interpretation of results, even in the case of such an important science as physics. It rests on a much broader basis – on the entire activity of mankind. The fact that the feelings and ideas of man have an objective intension is shown by the results of practical suitably directed activity. Mankind has preserved his species and has achieved all the new stages of individualism only because at every previous stage, even prior to the genesis of modern science, he has correctly learned to understand the outside world in a number of generations, each time within the limits of a defined circle linked with him. This fact is of enormous gnosiological importance and it is impossible to refute it with any sophisticated interpretations of some or other unique result in physics. The results of physics are concerned only with knowledge of the concrete structure of the material world, with the specific form of interrelations in it and not with philosophical problems about the source and criterion of the knowledge.

On the other hand, even philosophy does not dictate the physics of any a priori representations about the structure and form of the interrelations of objects studied and, moreover, of the general conclusion that all nature is one and is in a state of motion, or more precisely in a state of development (because only this can explain the fundamental philosophical fact that thinking does not stand above nature but is a property of highly-organized organic systems developing in nature). Lenin stipulates directly that "in discussing the problem concerning the link between one school of the most modern physics and the reactivation of philosophical idealism, we are far from thoughts regarding special studies of physics. We are interested exclusively in the gnosiological conclusions from certain defined theorems and universally known discoveries."* In reality, consideration of all problems is transferred to the gnosiological plane. It is said:

*V. I. Lenin, Poln. Sobr. Soch, Vol. 18, p. 266.

"matter is vanishing," therefore materialism is coming to an end. But what, in fact, vanished as a result of the development of physics and what was this "matter"? The defined, historically bounded representation of the structure of molecules and atoms vanished – and this, naturally, also is the movement of science ahead. And the material? Material is a philosophical category for denoting the source of objective moments in our consciousness and existing outside of it. But this truth is not refuted – it is confirmed by the entire history of mankind and will be verified by any new step in our knowledge, however cardinal it may be. Lenin successively draws this line when discussing all other problems – space and time, causality, etc. He does not consider the question of the specific physical representations of these categories – this is the competence of physics – but he considers the question of their objectivity which is the competence of philosophy.

Thus, Lenin sharply divides the subject of philosophy and the subject of physics. Having shown that the fundamental philosophies of a problem are not solved in physics, he reveals by the unscientific position of certain scientists following from the results of physics at the dawn of the 20th century, the inadmissible philosophical conclusions. Even in our time, certain eminent scientists as much as stated unacceptably that philosophical problems are allegedly solved in physics. Thus, E. Wigner writes that he cannot suggest any scientific philosophy until the entire chain of microphysical measurements relating the object of the measurement with understanding is traced; he repudiates materialistic philosophy because in his opinion it has been supported by a system of laws of classical physics and not by the disclosure of the entire microphysical chain, including also the process in the brain.*

However, the refinement by Lenin of the competence of the natural sciences and philosophy sometimes is used for the conclusion that physics and philosophy must be demarcated. Philosophers, in talking to us, may demand from naturalists only recognition of the objective world but in other respects they should not interfere in the development of natural science because their interference would always be incompetent and would impede the development of science.

A tendency toward "demarcation" cannot be assumed to be correct. It can be understood only as a reaction to a fact from the recent past, when individual scientists and schools in the name of philosophy, which are dominant in our society, advocated one trend to the detriment of another. Such was the case, for example, in relation to the theory of relativity, genetics, and cybernetics. However, although individual philosophers also occupied an unattractive position in this problem, there was no materialistic philosophy in it. The natural philosophical dictate over natural science for the new period was rejected even by Engels, although he also pointed out that in its time natural philosophy played a positive role. But in the struggle against definitive theories in natural science it was frequently not the philosophers who led, but the naturalists themselves; against genetics, the agrobiologist Lysenko came out – against the fundamental theorems of quantum mechanics, the "transformer of natural science" (according to Lenin's definition), the great physicist Einstein came out, he himself having given a stimulus to the development of quantum concepts and the statistical representation of quantum processes.

It can be seen already from this example that the problem to be freed from the struggle against the "new" is not solved completely by the removal of "incompetent philosophers" from interfering in the affairs of the physicist. History shows that the struggle against the "new" also is led by naturalists themselves, when they do not understand by what paths a knowledge of the "new" is accomplished. The problem of the correct relation to the new trends in science is solved not by demarcation but, on the contrary, by the close interaction of philosophy and natural science.

And here, Lenin gives us a splendid lesson for the correct understanding of the relationship between the two sciences – philosophy and natural science. He is not entirely self-removed from an investigation of by what means thinking arrives at a knowledge of the truth in any of the sciences, because philosophy teaches this, the theory of knowledge. With the opening of these paths, dialectic materialistic philosophy – in particular the works of Lenin – rendered considerable assistance to the physicists. In fact, when it seemed to many physicists that their science suddenly came before the "ruins of the laws," it was the voice of Lenin that sounded encouragement: a revolution is taking place in natural science; it is demolishing the antiquated representations about nature and the paths for understanding it; this is the natural process of development. And, further, Lenin pointed out: this process is pregnant with the dangers of the departure of

* However, in contradiction to what has been said, Wigner in the same paper supported one philosophy, positivistic philosophy, having expressed views on the concept of reality as well as on the synonym of usefulness of this concept in information, and on the world – as well as on the structure of our sensations, perceptions and recollections.

thinking from nature, from the objective world, if the dialectics are not known; the naturalist must study dialectic logic and the art of working with understanding. This is why Lenin spoke not about demarcation but about the union of philosopher-materialists with the naturalists accepting materialism.

3. The history of the development of modern physics shows that the movement of thinking toward the truth is a complex process, requiring special investigations of the development especially of science. Even prominent foreign naturalists, whose contribution to science we value highly, do not always present this process clearly. At first sight, this statement appears to be paradoxical, but the next account shows that this is not so.

Actually, we know in the 20th century two physical theories which are basic for the entire future development of physics – the theory of relativity and quantum mechanics. Both theories have changed in a radical way our views on the structure of the material world, the properties of solids, space and time and the absoluteness of concepts on which classical physics operated. It will be correct to say that both theories have produced a radical cataclysm in the thinking of physicists. They have caused them to muse over how similar cataclysms are being effected, how a scientist who in experiments relies only on classical concepts which are certainly inadequate in the microworld, even so arrives at his knowledge by whatever means knowledge of the "new" is revealed. What are the answers to these problems and where are they found?

Let us consider the views of two eminent physicists – Einstein and Born – who have made a significant contribution to the development of these theories. Both Einstein and Born valued highly the importance of the theory of knowledge, without which science "becomes primitive and confused" (Einstein). But they both proposed that the existing philosophical systems are themselves certain schemes into which the actual process of knowledge cannot be fitted. Such schemes, in their opinion, can be constructed only abstractly, but the naturalist is forced to take account also of experimental results which explode these schemes. Therefore, he cannot confine himself to a single philosophical system: he constructs his system by choosing from one philosophy one useful idea or method, and from another philosophy another idea or method, etc.; in view of this, his opinion by necessity appears like an eclectic mixture. Born says directly that when physicists encountered difficulties in understanding events on the atomic scale, when having explained the inapplicability of the methods of classical physics and the inadequacy of its ideas, not a single existing gnosiologist could help him. It was necessary to work out new gnosiological principles by his own efforts and these were generated in the form of Born's principle of additivity, Heinsenberg's principle of observability, and a number of others. As concerns Marxist philosophy, physicists would be unable to follow it because its foundations were laid down by Marx 100 years ago, long in advance of the point when problems appeared in physics which led to the development of the theory of relativity and quantum mechanics. Heisenberg wrote: "From the point of view of common sense it cannot be expected that the thinkers, having created dialectic materialism more than 100 years ago, could forsee the development of the quantum theory. Their representations of matter and reality cannot be adapted to the results of our present-day refined experimental technology."

The problem concerning by what means knowledge of the new is revealed is considered by physicists also in the logical plane.

De Broglie, in the report "Along the Path of Physics" (1955), expresses his views "on methods of reasoning and discovery in physics." He says that our understanding results by two different routes – deduction and induction. Deduction gives the rules of transition from premises to conclusions. It follows strictly logical rules but it does not lead to knowledge of the new, as in the conclusions from deduction there is nothing that should not be contained in the premises. According to De Broglie, only the method of induction leads to the new. But how? Here, there is no logical necessity in the reasonings: it is guess, intuition, creativity, and fantasy (imagination) that function; and risk – but "risk is a necessary condition for any exploit." Thus guess, creativity, and risk are exposed to logic.

Einstein repeatedly expressed himself in the sense that ideas and theory are the essence of the product of the free (from logic) creativity of thought and that "there is no path from experiment to the construction of a theory." Even in the decline of life, in a letter to Solovin (1952) he outlined the gnosiological cycle as he understood it. Knowledge commences with perceptions E ("direct sensitive experiment") and from these perceptions conversion to axioms A is effected; from the latter conclusions S are logically drawn (theory, obviously, is also included here; this can be seen from others of Einstein's papers) and the conclusions are compared with the perceptions E (verification of experiment). In this gnosiological

cycle Einstein sees two logical gaps – "there is no logical path leading from E to A" he comments on his scheme; between them "there is only an intuitive (psychological) link." The other logical gap he sees in the transition from S to E. Logical gaps in a gnosiological cycle become obscure, as the conclusions obtained may coincide with experiment. Long before the letter quoted, even in 1936 Einstein was pondering over this problem but could not find an answer; he wrote then: "The very fact that the combination of our sensitive perceptions by means of thought (. . .) can be ordered, in my opinion is astonishing, but we can never have it. We can say that 'the perpetual puzzle of the world is its cognizability.'"

The stated views of eminent scientists force us to consider the following questions: 1) whether philosophy, whose principles were developed more than 100 years ago, can exert an influence on modern science; did it solve problems which are of considerable importance to modern science, as a former stage; 2) do logical gaps actually exist in the gnosiological cycle and does knowledge of the new truth proceed regardless of free invention, change, risk, and intuition; how is Marxist philosophy the process of reflection of nature in understanding the entire gnosiological cycle?

4. One of the problems of philosophy consists in that it should reveal the most common relationships of the objective world, the logic of interrelations in it and it should trace the "mechanism" of their reflection in the awareness of man. These common relationships are revealed when investigating specific material objects, so that one and the same logical relation can be important for objects of a different nature. A parallel can be drawn here which will assist in explaining the meaning of what has been said and which is similar to physics. It is well known that the Hamilton equations were derived for investigating mechanical phenomena and that they were reduced to a high degree of generality. This was done long in advance of the appearance of quantum problems, more than 100 years ago. Nevertheless, in the generalized form of the Hamiltonian equations general relations between variables were also included, which are also important for quantum mechanics, but the variables here are of another and more complex nature. If this does not give rise to astonishment, then no astonishment should be caused by the fact that the logic of certain interactions which also are acting in quantum topics, may also be revealed when investigating other nonquantum topics.

Let us take the problem of the relation between the parts and whole of a system. Classical physics considered a system as a mechanical conglomerate of component parts. Therefore, the problem of studying a system reduces to a study of the properties of the component parts. This approach, whilst it was characteristic for all sciences, was a definite system of thinking. When vulgar economists (Düring) attempted to explain the laws of capitalistic society, they reverted to an investigation of the nature of man and in it they searched for the rudiments of properties which were characteristic of a developing society. Thus, the "theory" of the "original cell of society" appeared: Robinson was the exploiter and Pyatnits exploited the fact that the working relations lie in the nature of the individual. Marx refuted this method, by showing through a specific analysis of the economic relationships of capitalism that the laws which are characteristic of it originate in the system whatever the conditions; and these specific laws which originate in the system and which characterize it cannot be reduced to laws of the component parts. Under the action of internal relations new associations originate in the system, i.e., development of the system takes place – this is the most general conclusion at which the founders of scientific materialism had already arrived in the past century and even then there was sufficient material for this conclusion.

The physicist remained at the Robinson position for a further long time, and only the development of quantum mechanics persistently suggested the idea that specific laws are characteristic for a system and are not a characteristic of the component parts. The system emerges as a certain entirety in which a particle loses its lines of individuality to a known degree and which therefore must be defined by another nonclassical concept of state. In fact, new relations originate in it. The presence of system laws in quantum physics is specified by the introduction of the wave function as the new characteristic of state, by the establishment of Pauli's principle, the appearance in the system of quasiparticles, etc. It is very good that ideas concerning the specific relations in systems, even if with some delay, also finally penetrate into physics. It should not be otherwise: they dictate the dialectic nature of objective reality and demonstrate the universal nature of a series of logical relations.*

* However, what has been said does not imply that the gnosiological meaning of these physical discoveries has been explained. Certain physicists think, for example, that the regularity of biological systems reduces entirely to the movement in them of elementary particles (see discussion on the report by Weisskopf, published in Ukrainsk. Fiz. Nauk, 95, No. 2, 1968) and they even assume that this reduction is a unique weapon against vitalism.

Further, let us take the problem concerning the nature of natural relations. Physicists, right up to the emergence of quantum mechanics, have assumed that in nature there exists a unique fatally developing link between one event and another ("Laplace determinism"). But although in the kinetic theory of gases, even in the 19th century, statistical methods had been developed (Clausius, Maxwell, Boltzmann, et al.) they were considered only as an additional roundabout method applicable by virtue of the fact that it is in practice impossible to establish dynamic relations and the initial conditions for an enormous number of molecules; it was assumed, however, that in principle the problem can be solved by the methods of investigation of single-valued dynamic relations.

Marx studied the economics of capitalistic society in which an enormous multiplicity of "elementary events" was also present – exchange of commodities: he analyzed this process. Exchange is conditioned by social distribution of labor; on the average it is effected as exchange-equivalent, for which identical amounts of socially essential labor are compared to the commodities being exchanged. In events of individual exchange, there are always deviations from equality. But so long as they are caused by individual reasons, such as greater skill of the commodity manufacturer or accumulation at a given market and in a given time relative to the demand and supply, these deviations do not affect the exchange process as a whole – they are accidental for it. But deviations from equivalent exchange may become (at least over a more or less long time) normal, if an individual commodity manufacturer reduces the production costs of his commodity in comparison with the average needs of society, owing to the introduction of a technical improvement. In this case, he reaps an additional benefit which will also stimulate further improvement in his technology. Thus, in the complete economic organism a definite tendency is created which illustrates the fact of a transformation of fortuitousness into a definite law. Our problem is not to trace other tendencies arising in this society as a result of this (overflow of capital from one branch of production into another, reduction of the profit norm, etc.); this is all substantiated in the economic world of Marx. It is important to show here that Marx revealed in the economic system of a capitalistic society the role and importance of chance, the condition for conversion to a tendency and to a law. Marxist philosophy, therefore, recognizes the objective meaning of the category of chance and rejects Laplace determinism, even in the past century long in advance of the development of quantum mechanics. The utter sarcasm of Engels' comments is well known in the address of the determinists of Laplacian meaning, reducing determinism to fatalism. But in contrast from certain modern physicists, Marxist philosophy did not oppose the fortuitousness of a regular relation and did not draw false conclusions about the disappearance of a causal relation in its philosophical significance only on the basis that a unique relation between certain physical categories (impulse and coordinate) was lost, and reflected in the mathematical formalism of classical physics. Marxist philosophy showed that the boundaries between chance and necessity are related and that they both are only moments of an objective link in a complete process.

Or, we may consider such a problem as the succession of accomplishments produced by different generations of people. In summarizing Hegel's "Science of Logic," Lenin wrote excerpts in which the idea is expressed that knowledge of mankind is developing and, beginning with simple definitions, it is becoming everywhere richer and more specific and nothing is being lost in its dialectic forward movement; "it implies that everything is acquired and is enriched and consolidated within itself." Lenin thus commented on this situation: "This excerpt rather aptly sums up in its way what is dialectics."*

Thus, the idea concerning a succession of accomplishments, their development and enrichment was formulated more than 150 years ago in the philosophy of Hegel. Subsequently it penetrated also into other sciences. Later, dialectic materialism defined it in the doctrine concerning the movement of knowledge toward absolute truth through true comparatives. Later still, under the pressure of the necessity for finding some kind of ground for the solution of specific physical problems in the quantum field, in essence the same gnosiological idea was formulated by Bohr in the form of the physical principles of conformity.

However, physicists were far from understanding – and not everyone – at once the gnosiological significance of the ideal of a succession of accomplishments and the movement of knowledge to the truly absolute through the truly relative. At the time when Lenin wrote "Materialism and Empiriocriticism," welcoming the revolution in natural science, many quite eminent physicists assumed that physics was approaching a crisis and that before us were the "ruins of the laws," etc. Only much later did they realize that this was not so, that with all the abruptness of transition to new ideas the succession of knowledge still existed.

* V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 212.

In connection with the problem being discussed, one cannot but remember Lenin's famous statement that "the electron is also inexhaustible, just like the atom."* This was said soon after the discovery of the electron and during the time when physicists were assuming that they had reached (at last!) the "last bricks of the universe," the final properties of which can be described completely. Such an understanding was reflected also in the so-called "elementary particles." Many have realized now how naive these concepts were. But Lenin was not a physicist and his prediction cannot be considered as physical. He himself implies the inexhaustibility of the electron only as an example, illustrating the infinity of knowledge of nature deep down in view of the singularity of its interrelations and development. Because of this Lenin raised the profound question concerning the relativity of this category as the essentialness: The "essentialness" of an object or the "substance" likewise are relative; they express only the depth of human knowledge of the objects and if this depth did not go further than the atom yesterday, further than the electron today, then dialectic materialism insists on a temporary, relative, approximate nature of all these boundary marks of knowledge of nature progressing by the science of mankind.* Knowledge is a perpetual infinite approximation of thinking toward an object, in which essentialness emerges not as a metaphysical, absolute and final substance but as a boundary mark of knowledge of nature. "The concept of man," writes Lenin having returned to this problem in his "Philosophical Tetrads," "is deepened infinitely from an event to an essentialness of the second order, etc., ad infinitum. In the characteristic sense, dialectics is the study of a contradiction in the essentialness itself of the subjects: only the events are transient, moving and fluctuating and they differ only in conditional limits but the essentialness of the object is the same."†

The transition from classical physics to the physics of the atomic scale, and from the latter to the physics of elementary particles (of which in Lenin's time there was no inkling) is the richest illustration of this statement of Marxist philosophy. In its entire depth, this idea even today has not reached the consciousness of all scientists; this is attested by expressions concerning the fact that physics is nearing the exhaustion of its subject matter (see, for example, the report by Weisskopf mentioned above and the discussion on it).

The examples considered show that Marxist philosophy reveals the general laws of the objective world – its objective logic, hidden from the nonspecialists – and the laws of representation of this world in the knowledge of man, investigating the results of development of individual sciences and frequently, long before these problems are raised completely and indeed in obvious and pointed form before the naturalists. Furthermore, this is achieved in the light of consideration of the whole history of knowledge and therefore with a greater justification and competence. It is precisely this, that permitted Marxist philosophy to assess correctly the replacement of classical representations in physics on the edge of the 20th century as a revolution in natural science and not as a crisis of physics, to explain the inevitability of the breakdown of ideas (this has now become clear to all), to warn physicists of the errors associated with the special features of the new stage of development of science – with the abstractness and relativity of its representations.

5. The theory of reflection of the objective world and of nature in the consciousness of man, developed by Lenin, is of considerable importance for natural science. Lenin shows in "Materialism and Empiriocriticism" that the objective nature of the elements of understanding is demonstrated by the results of all human activity, including the development of science and technology based on it. These elements of understanding – sensation, perception, conception, theory and science as a whole – Lenin called reflections or images of the outside world. The concept of "image" is conceived in the logical sense, i.e., in the sense that the movement of an element of understanding even if it concerns sensation, follows the same logic whatever the movement of the object being reflected, so that there is no incompatibility between them.

In "Materialism and Empiriocriticism," Lenin paid the most attention to revealing the objectivity of sensations, representations and perceptions and this is natural: even at this stage of understanding, positivism was stumbling and declared again in the face of Berkley that a feeling can only be like a feeling, and not like any other thing outside the subject. On the one hand it would be necessary to show the unscientific character of the subjectivistic interpretation of sensations and perceptions. Such images as conception and theory are discussed by Lenin in Chapter 5, which is devoted to the revolution in natural science, and in even more detail in the "Philosophical Tetrads."

*V. I. Lenin, Poln. Sobr. Soch., Vol. 18, p. 277.
†V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 227.

Theory is a more profound image; according to Lenin's expression it reflects the "life" of an object, its development from origin to transformation into an object of another type. The difference is at once explained in the approach to the assessment of the role of theory by positivists and materialists. Positivists, who consider theory only subjectively as a system of ordering of sensitive perceptions, assume that this ordering can be accomplished in many ways. In this spirit Mach gave his opinion, his pupil Kleinpeter and, in our time, Professor G. Reichenbach of the University of California, and others.

But if theory is a thing of objective reality and not an arbitrary ordering of an amount of perception, then it is natural that the essentialness of a given order can reproduce only a single image. It is obvious that the image is unique in the logical sense, because the reflecting theory can be expressed in a different form; but in such a case, theories which are different in form will be logically equivalent to one another and between them there should be unambiguous transformation relations, as occurs for example between the matrix and wave forms of quantum mechanics.

Lenin concerns himself with the question of the uniqueness of the image-theory in a debate with Bogdanov, in which he advances the fact that he had overlooked the idealistic substance of Kleinpeter's conception. And in demonstration of its ideality, Lenin cites a quotation from Kleinpeter's work: "Why is it possible to give many theories about one and the same domain of facts . . . this fact is so well known to the physicist, how incompatible with premise is any absolute theory of knowledge. And this fact is linked with the volitional nature of our thinking; in it is also expressed the incoherence of our volition with outside circumstances."* Here, for the sake of this positivistic idea about the independence of thought on the outside world, Kleinpeter turns his hand to the conception about the multiplicity of theories by means of which the set of data from events can be "ordered."

It is well known that Einstein assumed that if the perceptions of man to some kind of degree are compulsory for him, then concepts and theories should be free inventions of his thinking. There are also other physicists who assume that theories are "children of free fantasy." Such concepts, however, give rise to objections from the side of the physicists themselves. In 1955, the semicentenary from the time of publication of the fundamental works of Einstein was observed in the Berlin Physical Society (this was during the months before his death). A close friend of Einstein, Max Born, in his address expressed disagreement with Einstein's opinions on theory; he said: "The value of theory is the higher and our confidence in it is the greater, the less the freedom of choice in it and the greater its logical compulsion."

The idea of logical compulsion and uniqueness of theory coincides with the materialistic understanding of theory as the image of objective reality.

But let us return to problem of theory, as Lenin put it. In the fifth chapter, Lenin speaks about concepts as images (again in the same logical sense). But concepts are more mobile than theory. Lenin pointed out that in order to represent objective reality, concepts should be flexible and mobile to achieve identity of contrast. This mobility, flexibility of concepts, mutual transformations of concepts one into another, in short their dialectic nature, was emphasized by Lenin with special force in the "Philosophical Tetrads." At the same time he warned that this flexibility is not arbitrary and not subjective. "Flexibility, applied subjectively = eclectic and sophistry," he wrote.†

But the question is, what is the guarantee that concepts are flexible just to the extent that they adequately but completely express the outside world in all its dialectic relations and, moreover, that flexibility is used not subjectively but objectively?

Lenin at once gives an answer to this question: "Flexibility, used objectively, i.e., reflecting the comprehensiveness of a material process and its uniqueness, is dialectic and is the true reflection of the external development of the world."† Here, Lenin points to the condition for which flexibility of concepts preserves its objectivity. This condition consists in that flexible concepts must reflect "the comprehensiveness of a material process and its uniqueness," i.e., concepts must be considered not in their distinctness but in their mutual relation and in their completeness. Here, Lenin does not call theory by name, but it is not difficult to see that completeness of concepts and the reflection of the comprehensiveness of a material process in its uniqueness is indeed theory.

*See, V. I. Lenin, Poln. Sobr. Soch., Vol. 18, pp. 232-233.
†V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 99.

And, in fact, the guarantee that concepts are used flexibly but not arbitrarily, and precisely to the extent that they are not detached from the objective world, is their verification through theory. Theory in this aspect plays a special role. It takes its starting material from the objective world of events, which it reflects in the form of certain inflexible relations – postulates – and it then leads on to practice and to certain new inflexible relations, which are verified by comparison with the result of controlled experiments. This capability of verification is the distinctive feature of theory, which also advances it as a measure of the adequacy of reflection of the outside world. As regards the concepts used in theory, then within the limits of theory (defined by its mathematical formalism) they are mobile and flexible and, moreover, their intension is determined by that function by which they perform in theory as an entirety.

Thus, union of the requirements of dialectic logic and materialism takes place through theory as a specific image of the outside world, the adequacy of which is easily verified.

But, emerging as an entirety of concepts theory still performs one important function. It is well known that the critical moment in the development of any science is the problem of knowledge of a new and related transfer to a new system of concepts. The difficulty of knowing the new, consists in that the researcher has at his disposal ideas which, in the new circle of events, are necessarily inadequate for him. Bohr, Heinsenberg, Born, and others pointed out this situation repeatedly in the construction of quantum mechanics, and the physicist will always encounter the same problem in new fields.

But whence can ideas be taken, which are adequate in the new field of facts, if the physicist experimenting by means of classical instruments has in his arsenal only classical concepts?

And besides, it is theory that performs an important function in knowledge, which consists in the regulation of the transfer to the new system of concepts, which reflect adequately the new circle of objective phenomena. This function is revealed in analysis of the process of its establishment and of its genetic relation with experiments.

This simple problem, it would appear, in fact has not produced an unambiguous answer by the physicists. We remember the opinions of eminent representatives of classical physics at the end of the 19th century, having studied the problems of electrodynamics. It had been assumed that the electromagnetic oscillation discovered by Maxwell and Hertz was a process taking place in a global highly-penetrating medium – the ether. The technical application of electrodynamics required physicists to solve the problem of whether moving bodies entrain this medium? What kind of answer do experiments give? The phenomena of the annual aberration of stars can be interpreted as a demonstration of the immobility of the ether. Experiments to determine the velocity of light in moving transparent media led to the well-known Fresnel formula and gave an unexpected and even nonunderstandable answer: the ether is "partially entrained." It is true that Lorentz attempted to explain Fresnel's strange formula on the basis of the electron theory and the conservation of the hypothesis of stationarity of the ether. All physicists were hoping to find an "experimentum cruxis" – "a decisive experiment" – which would solve the problem "finally": is the ether stationary or not? Hopes were laid on Michelson's experiment, in which the property of two coherent beams was used, traversing different optical paths but meeting at the point of origin to interfere with one another. In this experiment, one of the beams travelled along the direction of motion of the earth and the other travelled across it. If the ether is stationary, the beams should return to the point of origin with a phase difference and an interference pattern should be observed. But it was not found to be so! This was inexplicable, this contradicted the phenomenon of star aberration. But here Lorentz introduced a new hypothesis: the ether is stationary but there is no phase shift and no interference is observed because all bodies in the direction of motion are contracted always in the ratio $1:\sqrt{1-v^2/c^2}$ (independently of the nature of the body).

Thus, by the introduction of the new hypothesis the previous hypothesis concerning the stationarity of the ether was conserved.

In this example an attempt is cited by physicists to construct a theory by treating each newly discovered phenomenon in the light of existing ideas, and if it is contradictory then a special hypothesis is formulated for the cause of the deviation of the effect from that expected.

Lenin saw other ways of constructing a theory. He rapidly assessed the understanding of the relation between experiments and theory found by him in Hegel's "Science of Logic." Hegel criticizes the method of understanding by which contradiction of the new experiment "disposes of the fact that he understands and instigates the experiment, not in its specific entirety but as an example and, moreover, from the side

favorable for hypotheses and theories. In this subordination of a specific experiment prefaced with definitions of the basis of theory, it is obscured and appears only from the side confirmed by theory."* Consequently, Hegel contrasted two methods: one of these consists in the systematic interpretation of new experiments in the light of existing hypotheses and ideas (additional hypotheses are required to explain "anomalies") and the other considers every experiment in its entirety.

Lenin's comments on this statement of Hegel, which he calls "clever," are very instructive. He writes: "It is remarkably accurate and deep (relative to political economical bourgeoisie compared to subjectivism and unilateralism."* He not only highly rates Hegel's statement but he also emphasizes that it is directed against subjectivism and unilateralism and straight away he directs himself toward an attempt to develop a science similar to it. It is not difficult to see that political economical bourgeoisie he called an example of development by the first of these methods. It cannot be questioned that in Logic he should also have quoted an example of the development of a theory in accordance with the second method, in which subjectiveness and unilateralism were first overcome – the political economics of Marx. An economical experiment was investigated and interpreted "in its specific entirety," objectively and comprehensively.

In many of his works† Lenin remarked that an objective study of reality requires an approach to it precisely like the approach to entirety and only such an approach will reveal the objective relations of reality and will eliminate any subjectivity in the interpretation.

This establishment of the logical union of theory with experiment and with experience is very important for the theory of knowledge. It shows what is the logical path from experiment to theory (despite what Einstein said) and it consists in the discovery and formulation of the conditions of logical compatibility of contradictory (from the point of view of existing ideas) experimental results.

The factual history of physics confirms exactly the effectiveness of this path. Actually, as is well known, the knot of inconsistencies accumulated in electrodynamics toward the beginning of the 20th century was cut by the young Einstein. He proceeded along a new path and never attempted to explain each of the well-known experiments by means of hypotheses concerning the mechanism of the electromagnetic process, supplemented by hypotheses explaining the causes of the "anomalous" cases, nor did he look for a new experimentum cruxis. He set himself another problem – to explain under what conditions the equations of electrodynamics remain covariant for all inertial systems. The requirement for covariancy, the correctness of which was demonstrated at least for quantities of the first order, was designated by Einstein the principle of relativity of physical laws in inertial systems. To this proposition he added the theory of the invariability of the velocity of light in these same systems (in essence, the law of summation of velocities with the velocity of light). Such were the starting postulates of Einstein. The result of formulating the conditions for their logical compatibility was a formula for the transformation of coordinates into times. The basic historical problem standing before the physicist – to find the conditions of covariancy of Maxwell's equations – was solved by the common transformation of coordinates, times and field strengths. The system of transformations and all the set of consequences and ideas originating from it, is the special theory of relativity. The theory created by this method brought fruitful results. It not only substantiated the logical set of all the experiments, which previously seemed to be incompatible (phenomenon of aberration, Fresnel's formula, the negative results of Michelson's experiment, etc.), but also led to the discovery of phenomena which were unknown before this theory (for example, Doppler's lateral effect). It revealed a series of new and unexpected relations – for example, the proportionality of mass and energy of a body, the dependence of the linear dimensions of a body and the duration of processes in them on the relative velocity of the body. The interrelations established by the theory of relativity lay as the basis of calculations in modern nuclear physics. In the light of the new ideas, the physicist must now consider all phenomena taking place at relativistic velocities which are comparable with the velocity of light and he must take them into account in all physical theories.

From the logical aspect, the most important result of the new method of constructing a theory was the conversion to a new system of concepts. In the theory of relativity, the relative nature of these concepts was revealed as length, duration, mass, and others, the concept of unit four-dimensional continuum for "space–time," the idea of absolute simultaneity no longer arose and the idea of the ether as some absolute medium – the carrier of electromagnetic processes – passed as useless. To sum up – a new system of concepts originated.

*V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 192.

†See, for example, the Paper "Once again about the Trade Unions," V. I. Lenin, Poln. Sobr. Soch., Vol. 42.

The new method of constructing a physical theory proved to be fruitful. Its meaning, however, was not explained by the physicists. First and foremost, it was not explained even by Einstein. Factually, it has become the decisive revolution in the method of construction of a physical theory, in essence having followed the road of the same discussion of experience in its entirety, about which Hegel wrote and which Lenin also rated very highly. But in discussing the theory of knowledge, he maintained that there is no logical path from experiment to theory and that in the gnosiological chain there are logical breaks. Why did he arrive at this contradiction? Because the new stage of development of physics required new methods; a new method matured objectively but it was burst open by a talented researcher. But subjectively Einstein had only a very narrow understanding of logic and he saw it only formally – the standard rules of inference. This, however, was characteristic not only of Einstein.

6. Marxist philosophy deepened the understanding of logic in a number of aspects. First of all, Marx in the celebrated "Theses of Feirbach" included the practical activity of man in the system of logical categories; this is important in principle for knowledge. In criticizing "inductivists," Engels showed that the wealth of all forms of inference cannot be squeezed into the framework of deduction and induction and, moreover, opposed to one another; such attempts transform these forms "into the purest absurdity." They both understood logic not only as a system of rules of thought but also as an expression of the general objective laws of nature. Engels wrote: "Over all our theoretical thinking, there prevails with absolute force the fact that our subjective thinking and the objective world are computed by one and the same laws and therefore they cannot contradict one another in their results, but they must agree between themselves. This fact is an involuntary and unconditional premise for our theoretical thinking."* Nevertheless, the objective nature of logic is emphasized. Both Marx and Engels showed that an adequate nature can only be dialectic thinking.

In preparing the data for the creation of Logic with a capital letter, Lenin also connected logic with the internal intension of the laws of development themselves of the world and its knowledge. He wrote: "Logic is the study not of the external forms of thought but of the laws of development of all material, natural and spiritual objects, i.e., of the development of the entire specific content of the world and its knowledge, i.e., the sum total of deduction of the history of the world's knowledge."† Such an understanding of logic actually reveals the wealth of forms of the conclusions about which Engels wrote.‡ It brought Lenin to the formulation of a proposition about the unity of logic, dialectics and the theory of knowledge. In "Das Kapital," logic, dialectics, and the theory of knowledge [three words are not necessary: they are one and the same] of materialism are applied to one science, having taken everything valuable from Hegel and moved its value forward.**

These condensed formulations give a deep understanding of the essence of logic. Logic is a doctrine not only about the external forms of thinking but also about the laws of development of the objective world; it does not express any normative rules of thought, but the very laws of development of the specific intension of the world and its knowledge, i.e., included in its total is the history of knowledge. As this total shows that nature itself is developing in contradictory forms and that adequate knowledge of the world is not possible through frozen forms of thinking, then logic coincides with dialectics. Subjective logic emerges as the science of complex dialectic laws of the movement of thought toward the truth. The entire theory of knowledge, treated by Marxist philosophy, is a doctrine about the source of knowledge, about the forms of reflection of the objective world in consciousness (of sensation, ideas, theory, etc.), about the criteria of knowledge (practical purposeful activity), about the process of deepening knowledge by conversion to the essentialness of a deeper order with conservation of the former knowledge in a "skimmed" form, about the development of ideas, etc. – all this is the expression of complex dialectic laws of the movement of thinking toward the truth and, consequently, it is logic. The theorem about the unity of logic, dialectics, and the theory of knowledge is a deeper formulation of the Marxist theory of knowledge, and we can only regret that Lenin himself was unable to write Logic with a capital letter and to work out this problem in detail.

In the light of understanding of the unity of logic, dialectics and the theory of knowledge it is becoming clear that intelligent knowledge of the new is possible only through logic, but logic which coincides

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* K. Marx and F. Engels, Sochineniya (2nd Ed.), Vol. 20, p. 581.

† V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 84.

‡ Engel's Manuscript, under the title "The Dialectics of Nature," first published in 1925 after the death of Lenin.

** V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 301.

with dialectics. If, in the light of this unity, a real dialectic process of knowledge, a gnosiological cycle is analyzed then it can be seen that the enigmas of knowledge formulated by Einstein are reduced.

This cycle begins with the determination of the starting elements of knowledge. Then, what Einstein calls a "set of first-hand data from a sensitive experiment" is still very indefinite. But the point is not only that information about the objective source of the sensitive experiment is absent here. In the pure form "the first-hand sensitive experiment in question" (even understood objectively) is encountered only with animals and with man at a lower stage of development. A thinking man is found to be at some kind of nonelementary loop of a gradual spiral-shaped movement of knowledge; he is concerned with perceptions illuminated by the light of thought. Not only the elements of logic are reflected in them, which are accessible also to an animal (identity, difference, comparison), but also a system of ideas and practice attained at a given level as criteria of the truth, i.e., the sum total of the former cognitive process is included to some extent.* According to this, the starting elements on which the gnosiological cycle of thinking man functions, can be defined more advantageously as "the initial experimentally established relations."†

The fact that the starting relations reflect in themselves the operation of thinking, dialectically includes in itself both positive and negative moments. In fact, if the gnosiological cycle began every time with "pure" sensations, every person must have accomplished anew the entire path of accumulation of knowledge. There would be no noticeable progress of knowledge from generation to generation. On the other hand, however, this same circumstance leads to a danger; it consists in that common sense can be introduced into the starting relations in excess of that due to observation, and the history of physics gives many examples of this. Control of thinking is essential.

Usually, a multiplicity of experimental relations is established in a new sphere of knowledge (probing experiments). For the further movement of knowledge it is necessary to make a choice of "a system of postulates." Indeed, thought creatively chooses a system of starting postulates, but it chooses not regardless of logic but on the basis of logic in the same way as an inventor who has created a new machine uses creative fantasy, not regardless of the physical laws but on the basis of them, and that is why it is hopeless to create perpetuum mobile.

When choosing a system of postulates, thought must take into account the requirement of the dialectic theory of knowledge, i.e., logic. These requirements are not arbitrary. They arise from the necessity of ensuring adequacy of the future theory-image of objective reality. Without pretending completeness here, we shall name the principal ones.

The first requirement is that the postulates themselves must be adequate by nature, i.e., they must be relationships whose truth can be established experimentally at the existing level of knowledge. The second requirement is that of the logical full value of each of the postulates. It consists in that of all the adequate postulates, those which are able to introduce a special contribution to future theory are chosen (those which possess an inherent "logical intension"). It is clear that in a set of postulates there should be two postulates with identical logical intension. Finally, the third requirement – the choice of postulates must be complete, i.e., all (or all existing) postulates with a specific logical intension must be included in the choice. Without these requirements on the starting postulates, theory would not accomplish its problem – to the reflection of the essence of new diverse events. It is clear that the choice of a system of postulates corresponding to the requirements of adequacy, the full value of the postulates and the completeness of their choice, is found wholly within the sphere of the theory of knowledge or of dialectic logic.

For dialectic logic it is important that the correctness of the choice of postulates, as well as any component in the process of knowledge, is controlled by the subsequent verification of the adequacy of the theory created. This test can be made to either accept or reject the choice of postulates made, or even to correct it in relation to any of the requirements. Thus, in the process of knowledge there is a reverse relation which is absent in the interpretations of formal logic. This reverse relation is a form of logical bond, i.e., a sphere of logic, but the logic of dialectics. It should be recalled that in dialectic

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* This fact is admitted in essence also by physicists. De Broglie writes: "Data of our feelings can serve for the construction of a scientific theory only when they will be interpreted in the appropriate manner, and in this interpretation certain ideas of our mind, i.e., theoretical ideas, will necessarily interfere." Born also expressed similar ideas.

† It is convenient to call them "probing experiments," bearing in mind that they are like a probe feeling the unknown and deeper nature – in contrast from controlled experiments which verify the adequacy of the theory created.

logic the category of practice emerging as a criterion of truth is included in the gnosiological cycle; practice is a logical category and Lenin emphasized this with great force in his theoretical works, following Marx.

The source of the starting postulates is the practical activity of man and his interaction with nature; it is constantly enriched and expanded on the basis of knowledge already acquired. This constantly expanding practical activity of man is one of the sources of new knowledge, although at this stage it is not yet revealed to the end, until a new theory-image of objective reality has been created on its basis.

The next stage of the process of knowledge is the construction of a theory on the basis of the set of postulates. Dialectic logic requires a joint consideration of the starting postulates; of two possible routes, Lenin counted this as the first and the history of the development of physics also confirmed the correctness of this route at the most critical moment, independently of whether or not the gnosiological significance of this route was achieved by the physicists. Joint consideration of the starting postulates – this is the same as we formulated in the words: the establishment of theory is a process of searching for and formulating the conditions of logical compatibility of the starting postulates (experimental relations).

The process of constructing a theory from a set of postulates is not a simple deduction, in the findings of which there is nothing that was not in the premises. First of all, the theoretician is concerned here with a set of postulates and, moreover, postulates which in the light of existing theory are contradictory to one another. The problem is posed therefore, of finding and formulating the condition for their logical compatibility, i.e., formulating a new theory. Consequently, the construction of a theory is a complex logical process and dialectic by nature. Theory, in relation to postulative relations and to the concepts in which they are formulated, plays the same role as played by any complete system relative to its components.

This is precisely because, from the set of postulates to the theory, a cognizable logical process is involved; theory is not an identical set of postulates. It is natural, therefore, that this logical process leads to a knowledge of the new, which is revealed in various aspects.

In the first place, new interrelationships are revealed of categories which did not lie on the surface in the set of starting postulates itself (for example, the relation between mass and energy in the theory of relativity, the relation of the indeterminacy of noncommuting quantities in quantum mechanics, etc.). Secondly, the generalized meaning of the categories is revealed. The categories used in probing experiments are related of necessity to an existing system of concepts; in resultative theory they receive a new intension, or the function is changed by which they achieve complete compatibility. This change of concepts as a result of transition to a new theory is of considerable importance; it is the key to the understanding of unusual relations in a new field and with a starting point for the further development of knowledge, which will always proceed from what is already achieved to the last stage of knowledge.

It is inevitable that later the problem will arise concerning the relation of theories reflecting the substance of the various orders about which Lenin wrote.

The initial probing experiments and the postulates selected from them are formulated in the concepts of existing theory. This path is inevitable. But only by rational thinking, which "grasps the difference and inconsistence, but not transition from one to the other" (Lenin), this inevitability is portrayed as an obstacle to the movement of knowledge to a substance of higher order. Actually, this movement is achieved through the entire gnosiological cycle. Probing experiments considered in the light of this new substance emerge as limiting cases in which the categories – mobile, relative, transient in their contrast in the new substance – acquire a rigidly fixed precision and become accessible to measurement by classical methods. However, the substance of the higher order is associated with the former substance, not by way of individual concepts but through their dialectic unity, i.e., through theory: generalized theory with limiting values of the characteristic parameter assumes the form of the previous theory, which is a form of substance of a less high order. In physics, this connection with theory is shaped in the form of the correspondence principle. In Marxist philosophy this character of the movement of knowledge through truth which are relative to truth of the absolute, i.e., to an even more precise image of the objective world, without leading however to absolute knowledge and to cessation of its movement. Lenin wrote in his "Philosophical Tetrads": "The coincidence of an idea with an object is a process: the idea (= man) should not represent the truth in the shape of a dead spot in the form of a simple picture (image), pale (dull), without trend, without motion, like a genius, like a number, like an abstract idea. . . . Knowledge is a perpetual infinite approximation of thought to an object. The reflection of nature in the thinking of man must be understood not

as "dead," not as "abstract," not without movement, not without contrast, but in a perpetual process of movement and of the genesis of their contrasts and resolutions."*

Finally, in the transition to the image of a substance of deeper order, not just a single concept is changed but the entire set. Individual concepts pass away. Transition to a new system of concepts is accomplished. This movement of knowledge deepens the link between man and the objective world, expounds the possibility of his active influence on nature and thereby accelerates further movement of knowledge which we also observe in the history of all the sciences. The genesis of a new system of ideas exerts a reverse effect on the entire perception of man. The new generation does not begin knowledge from the same origin, repeating the figures of logic at the same qualitative level. Nevertheless, in revealing the "mechanism" of transition to new concepts by the example of the genesis of modern theories, dialectic logic gives the key to an understanding of the development of the process of knowledge in the past, and its transition from the lowest to the highest forms of thought. Again, Marx wrote that the anatomy of man is the key to the anatomy of the monkey. Such is the common complete process of knowledge, the gnosiological cycle, which has no logical gaps and in which every component is linked with the others by a mutual logical chain.

Let us compare two cycles. The gnosiological cycle of Einstein with its logical gaps inevitably led to a result which he himself acknowledged as astonishing: the conclusions of the randomly devised theory unexpectedly can coincide with sensual perceptions (with experiment).

In the gnosiological cycle of Marxist philosophy none of the unexpected arises; here there is a logical connection in the whole cycle, a dialectic connection which includes also the reverse connection; there is no place in it for gaps or for incomprehensible unexpectedness. The fact that in every element of knowledge, beginning with sensation, there is an objective intension provides its integral verification in precisely this gnosiological cycle: the whole sophistry of the positivists becomes clear in its light, defining rhetorical problems such as: but what can a sensation resemble if not a sensation? Or, where in a single act of perception (measurement) does the boundary lie between the subjective and the objective? In the light of this gnosiological cycle, which, after explaining the "mechanism" of the establishment of theory, acquired total completeness, all the problems of knowledge can and should be considered – even the system of concepts used and the significance of objective reality in whatever abstract forms of thinking it has been reflected, and many others.

All this confirms the fact that logic (subjective), having been elevated to a higher dialectic level, emerges like a science, learning the process of movement of thought toward truth. The wealth of Lenin's understanding of the process of knowledge is inexhaustible, expressed in the formula: logic, dialectics, and theory of knowledge – these are one and the same.

7. Ways have been shown above for establishing the theory of relativity. In the history of the appearance and in the future destiny of this theory, the realization of the entire gnosiological cycle of Marxist philosophy is traced quite clearly – probing experiments and the selection from them of the starting postulates – formulation of the theory as a search for the conditions of their logical compatibility – and the criteria of practice, confirming the theory. And all this has led to a change of the system of concepts, to an explanation of the interrelation between the new and previous theories, i.e., to an explanation of the overall progressive development of knowledge.

If we analyze the process for establishing another fundamental theory of modern physics – quantum mechanics – we can see that in it, a gnosiological cycle of Marxist philosophy was also realized in the final count. If otherwise, physicists would not have arrived at such positive results.

But the path to this theory was not straight: there were deviations and regressions to the right path in it; there were also attempts to work to "new gnosiological principles," although it should be remembered that no new gnosiology had been created.

In his atomic model, Bohr used quantum concepts successfully for the structure of the atom and he related, although superficially, the quantum states of the atom with its discrete spectra. However, this still did not provide the theory of events on the atomic scale. Physicists knew what was essential to them in order to produce a physical theory: it was necessary that stationary energy states of the atom followed

*V. I. Lenin, Poln. Sobr. Soch., Vol. 29, pp. 176-177.

as solutions of the general equations describing atomic phenomena, that these equations should simultaneously determine also the intensity of the radiations and it was necessary that the theory describe also complex atomic systems. However, the path for constructing this theory was not clear; an attempt was made to find the theory by means of the Bohr planetary model of the atom – it had the advantage of visualizability. Around the nucleus are rotating classical particle-electrons along an orbit of finite radius in accordance with the laws of classical mechanics. Quantum conditions were introduced in the form of requirements, so that the constants of integration of this motion were nonderivative; it was attempted to identify the frequency of the quantum with the frequency of rotation of the electron along its orbit, which was found to be possible only in the limit for large quantum numbers. The latter led to the idea that in the region of large numbers, the quantum problem merged into the classical problem. This bounded transition was formulated in view of the correspondence principle by means of which an attempt was made to probe the approach to the solution of more general cases. Of course, the discovery of this principle was a step in the right direction but in itself it still did not give the path to a theory; on the contrary, the whole of its deep significance was explained only after the theory was created and it became clear that it expresses not only coincidence of the problem in the limiting case, but first and foremost the union of two theories which reflect the essence of different procedures.

Despite partial success, after 10 years of searching it became clear that the "semiclassical method" does not reveal the mechanism of quantum events. The picture on the whole had not been clarified.

The merit of Heisenberg consists in that he renounced himself from the "semiclassical method," from electron orbits, and he attempted to formulate quantum conditions on the basis of the laws of classical mechanics. There were no electron orbits and in principle they could not be observed; any attempt at observing them led to destruction of the atom. This gave Heisenberg cause to justify his new approach by the existence of a special gnosiological principle – the principle of observability.

The introduction of this principle led to controversies of idealogical procedure. The positivists used it as the natural science "basis" of a thesis, to exist, to mean to be perceptible. Meanwhile, materialistic philosophy considers abstract concepts, providing they are inseparable elements of an adequate theory, not less but even more real than the categories, "directly observable." Lenin wrote: "Value is a category which deprives a substance of sensitivity,* but it is more real than the law of demand and supply."† It is inadmissible to demand that if all categories possessed a "substance of sensitivity" they should be observable.

In the materialistic theory of knowledge there is no necessity to resort to such extravagent methods as the announcement of a new gnosiological principle. In it, each step is based logically and naturally. In fact, having posed the problem of constructing a theory for a new range of phenomena and having selected the starting set of postulates, the researcher naturally should require that the postulates themselves be adequate by nature. This is an essential but trivial requirement. It does not always coincide with the requirement for "observability": as, for example, the postulate concerning the relativity of physical phenomena in inertial systems (in the special cases of covariance of Maxwell's equations) is not an identical "observability." Representations of the classical trajectories of electrons in the atom, moving according to the laws of classical mechanics, should be excluded from the premises of theory but not on account of the special principle of observability, but because there was no proof (and we know now, that this could not be) that these representations are adequate by nature. The requirement for adequacy is more strict. If it is not adequate by nature, then obviously it will not be observable.

However, independently of the methods of demonstration, the practical steps of Heisenberg in a specific situation were completely rational: they brought him naturally right to the choice of certain starting, experimentally justified postulates, on the basis of which it was only possible to construct a new theory (jointly with Born and Jordan) by finding the conditions for their logical compatibility.

The entire collection of experimentally verified facts known at that time (1925), led to the conclusion that the atom is a complex integral system. This is shown by the fact that the spectra of the atom are subject to a defined systematization; each spectral series consists of an infinite series of spectral lines gradually approaching and merging at the edge of the series. This is also indicated by the fact, established by Einstein, that although in the language of quantum representations a single act of emission of a quantum represents a probable process in which the magnitude and direction of the individual quantum is random,

* Translation from German: "Entbehrt des Stoffes der Sinnlichkeit."

† V. I. Lenin, Poln. Sobr. Soch., Vol. 29, p. 154.

the entire aggregate of radiations from the atom (for the equilibrium case) is subject to a definite law – Planck's distribution of energy density throughout the spectrum.

As the purely mechanical characteristics (motion of the electrons along an orbit) for the atom decay, it should be necessary to look for some other defined state of the atom or, as Heisenberg formulated, some other kinematics. It was prompted by the fact that in order to change the atom, it is essentially a change of its energy levels, associated with the emission of defined frequencies. But as atoms are complex systems which give a stable emission spectrum, then their kinematics naturally are determined not by any unique transition, but by the aggregate of all possible transitions, for which a certain "matrix" of transitions can be depicted with components E_{nm}. Such matrices should represent all physical "quantities" – "coordinates," "momenta," their derivatives and squares, "energy," which are encountered in Hamilton's canonical equations.* It should be necessary to take account of one further fact – the wave properties of atomic processes. The investigations undertaken in 1921-1925 on the dispersion of light showed that every transition of the atom is associated with a finite oscillation amplitude. Consequently, the atom can be considered as some kind of oscillator with amplitude $q_{nm} = e^{2\pi i \nu_{nm} t}$. This determined the form of the starting matrix of the coordinate from which it should not be difficult to convert to all other matrixes.

The use of matrixes in Hamilton's equations leads immediately to an encouraging result: the energy matrix (for the case of a harmonic oscillator) is found to be diagonal, but its elements are time-independent, i.e., the use of a matrix calculation discriminates a number of energy states of the atom which corresponds to the results of experiments and to Bohr's atomic model, and is found to coincide with the law of conservation of energy. The value itself of the energy levels is found from the quantum condition, according to which the "commutation relation" – which is characteristic for the matrix – should be proportional to h, or more precisely it is equal to $h/2\pi i$. Calculation shows that for elements of the energy matrix, a value of $W_{nm} = E_n = h\nu(n + 1/2)$ is obtained, which coincides with the results of experiments.

Of course, the theory developed should also take account of the internal degrees of freedom of the elementary particles (spin, magnetic moment) and the singularities of their bonds in complex systems (Pauli's principle). But we are not writing the history of quantum mechanics. For our purposes it is important to show, even if only in general form, that the structure of quantum mechanics has been accomplished in complete accordance with the materialistic theory of knowledge and that the theory was revealed as the formulation of the logical compatibility of a defined set of experimentally verified relations. The difficulties consisted in determining this set and in finding the conditions for their logical compatibility, and not in the absence of any new gnosiological principles.

8. The principle of complementarity is frequently introduced as another and perhaps even more fundamental gnosiological principle which supposedly has played a basic role in the creation of quantum mechanics. Born writes about it as "the highest achievement of the present day form of the philosophy of science." However, this principle has not played a leading role in the establishment of quantum mechanics. In the well-known review "Discussions with Einstein. . ." Bohr himself tells of the reason for the appearance of the idea of complementarity in the fall of 1927. At this time, the formalism of quantum mechanics had already been created by the efforts of Heisenberg, Born, and Jordan (matrix form), Schrödinger (wave form), and also Dirac; the theory had been found and proved. Bohr wrote: "Quantitative scope of the great empirical material did not leave any large doubt in the satisfaction and usefulness of the equipment of quantum mechanics; however, the abstract nature of this equipment created a widespread feeling of dissatisfaction." Whence, from 1927 according to Bohr's statement, the second phase of development began with the purpose of overcoming the feeling of dissatisfaction which had arisen because of the abstractness of the mathematical equipment. The principle of complementarity thus appeared to be the result of a tendency toward visualizability and toward a clear interpretation of the already created theory.

Having striven to achieve this visualizability, Bohr assigned different formulations to the idea of complementarity. One of these, the earliest and most frequently encountered, states that in nature there exist two mutually complementary types of instruments; the use of one of them for the accurate measurement of a single correlated (conjugate) quantity gives lesser accuracy than the other. The tendency toward great visualizability led him also to another formulation in which the noncommutativity of quantum values was because in any interaction, exchange with the action can be achieved only with a whole number of

* The fact of using these equations – but with matrixes in place of the usual quantities – shows the unity of classical and quantum physics and at the same time of their specific properties.

quanta and therefore within the limits of the quantum the process becomes uncontrollable. This formulation has an agnostic tint; it was subjected to criticism (in particular by V. A. Fokke) and in one of the recent papers specially reproduced in the journal "Advances in Physical Sciences," Bohr makes the reservation: ". . . we, obviously are concerned here not with limited measurement accuracies but with limited applicability of space–time concepts and the dynamic laws of conservation. . ." (Uspekhi Fizicheskikh Nauk, 67, No. 1, 1959). Supporters, just like opponents, of the principle of complementarity remarked on the vagueness of the formulation of this principle. Einstein remarked that despite all his efforts, he had not succeeded in understanding the meaning of this principle. Born even assumed that the incorrect uses of the concept of complementarity frequently encountered in the literature to a certain extent are not exactly explained by Bohr's precise formulations.

It is important here for us to note the following. First of all the idea of complementarity appeared, according to Bohr himself, after quantum mechanics was created and its adequacy proved. Secondly, its formulation was changed and refined by its author over a period of many decades. Such an idea could not be a new gnosiological principle, which supposedly could be derived only by modern physics, by the correct route in the counterbalance of the materialistic theory of knowledge.

The rationale that is in this principle consists not in that it formulates new paths of knowledge, not in that it makes obvious the mathematical formalism of quantum mechanics, but in that Bohr in this form emerged against attempts to reduce the physical presentations either to a wave pattern or to a discrete pattern; such attempts were encountered at this time by other physicists also. It is obvious that the inadmissibility of these tests of knowledge ensues directly from the correct use of the gnosiological cycle of materialistic philosophy. The latter requires flexibility of ideas, unity of contrary definition, which are dictated by an objective nature and Lenin persistently emphasized this special characteristic of nature and knowledge of it. But the fact that this is the inevitable result of the use of a gnosiological cycle and that this is the basic argument in favor of the use of a new system of concepts, was not acknowledged either by supporters of quantum ideas or by their opponents. Therefore, the statement against reduction of objective reality to any one of the patterns had a positive meaning even if this was achieved in the form of complementarity, although it was not found to be convincing for all physicists.

9. The application of the gnosiological cycle to materialistic philosophy leads to the establishment of a new system of concepts. If the whole cycle is achieved correctly in each of its links, the new system of concepts reflects the objective reality and is imposed upon consciousness with compelling force, however "strange" (Lenin) it may be.

In physics, many discussions have taken place which have been associated with lack of understanding of the process of knowledge itself (of the gnosiological cycle) and the commitments of its conclusions. Many pseudoproblems arise which lead to useless debates and sometimes to incorrect ideological conclusions which the opponents of materialism use. Up to the present times, demands have increased to show through what crack in the lattice the electron passes; attempts have been made to regenerate a contraction hypothesis (Janossy) or by means of "hidden parameters" to get rid of the statistical relationships in quantum mechanics.

Einstein even made repeated attempts to construct, although mentally, an experimental device by means of which it would be possible to verify the most important conclusion of quantum mechanics – the uncertainty relation. Each time, Bohr showed the fallacy of the next device and Einstein constructed yet another mental experiment, even more subtle. Over the period of many years the disputing sides failed to convince one another. Neither took account of the fundamental argument: the assumption of the feasibility of such a mental experiment, which would verify the uncertainty relation, is incompatible with many real experiments which had been reliably substantiated (including all spectral analyses, Planck's distribution, energy levels of the atom, diffraction of electrons, etc.). To the extent that the entire system of quantum mechanics is constructed correctly in relation to the gnosiological cycle (validated probing experiments – theory, as well as the formulation of conditions for their logical compatibility – controlled experiments, practice), acceptance of the uncertainty relation is inevitable. And, in fact, the correctness of the structure of quantum mechanics was not disputed by Einstein.

All these and similar pseudoproblems are associated with the well-known conservation of rational thinking: a correctly used process of knowledge leads to a new system of concepts, but reason still tries to use the old categories in the new field of events, which no longer reflect the new relations.

The process of development of a new system of concepts and procedures for their use, naturally is a philosophical problem although the many discussions arising do not appear to fall outside the scope of physics. But lack of understanding of the whole process of knowledge sometimes leads also to direct philosophical conclusions. Let us cite an example. In events on the atomic scale, there has been a very clear dependence of the result of observation on the conditions of observation. This has been interpreted as if a new theorem had appeared in the atomic field: it is possible, in an effect, to distinguish the boundary between that which is being observed and the conditions of observation; it follows from this that the physicist is concerned not with objective reality but with an effect in an instrument, which also is a unique "physical reality" and about which the experimenter can talk. This "physical reality" was opposed to objective reality; the latter concept was considered to be obsolete and its use was considered to be a return to classical physics.

Meanwhile, the formulation of this problem is unacceptable. Of course, a unique happening is the result of interaction of two partners and in the special case it represents an inseparable completeness of objective and subjective moments. But man arrives at the concept of an object not because he has succeeded in drawing the boundary between the objective and the subjective in any unique events. Lenin asserted that in our feelings there is an objective insertion which is not entirely reference to the presence of such a boundary but to the criterion of objectivity. Man arrives at the concept of the objective as a result of achieving the entire process of knowledge (gnosiological cycle). He observes the results not of a single unique event but of a set of events; this leads him to search for the conditions of their logical compatibility and he creates a theory and then proves it in practice. If it is substantiated, it emerges as the image of an objective reality and there is no question of the presence in it of any boundary in a unique event, and the conditions of interaction (observation) exist in it only in a "stripped" form, implicitly.

We can see that materialistic gnosiology is an adequate theory of knowledge of a real world, applicable for knowledge of any regions of nature whatsoever – both the macro- and microworld. Lenin made a significant contribution to this theory. By emphasizing the importance of logic first of all as an expression of the most general laws of interrelations in nature, he showed logic subjective as a reflection in the knowledge of man of logic objective, as a complex regular process of the movement of thought toward the truth. This movement does not lead to the normative rules of thinking; it encompasses logic, dialectics and the theory of knowledge in a single gnosiological cycle. In this cycle, each link is joined with another; in particular, theory emerges as the formulation of the conditions of the logical compatibility of experiments, and this generalization of experiments in their singularity leads to new knowledge, to a new system of concepts and dialectics developing on the basis of the previous ones.

Science is moving ahead only to the extent that scientists realize finally the generalized gnosiological cycle of materialistic philosophy, independently of the fact that they do or do not acknowledge this. With many, and frequently leading, scientists this realization goes by complex zig-zag paths, with a sequence and with attempts to formulate characteristic gnosiological principles. Soviet scientists must show that science gains much from the conscious application of Lenin's theory of knowledge with all its representatives.

Lenin attached enormous importance to the conscious application of materialistic gnosiology. It was precisely for the sake of these aims that he recommended the achievement of union between philosopher-materialists and naturalists using materialism.