Die Nordströmsche Gravitationstheorie hatte ihre Qualitäten. Sie postulierte die völlige Unabhängigkeit von Gravitation und elektromagnetischoptischen Vorgängen, sie ergab Newtons Gesetz als eine Näherung für ruhende Körper und ergab, ebenfalls als eine völlig ausreichende Näherung, jene wundersame Gleichheit von träger und schwerer Masse, die empirisch längst anerkannt, aber in der Mechanik ein Anhängsel, kein organisch eingebauter Bestandteil war. Mit alledem war sie in bester Übereinstimmung mit der damaligen Erfahrung. In einem Punkte freilich wich sie von der Beobachtung ab, nämlich bei der Perihelbewegung des Merkur. Aber welcher Physiker hätte wegen dieser einen, durch wenig durchsichtige Störungsrechnung gefundenen, in der Astronomie selbst noch umstrittenen Zahl eine sonst befriedigende, umfassende Theorie verworfen?

Für Einstein aber war das Gesetz der Gleichheit beider Massen mehr wie ein Näherung; das zeigte schon eine Veröffentlichung von 1907. Es war für ihn etwas Fundamentales, etwas so Fundamentales, dass er ihm eine andere, seit jeher allgemein acceptierte und als selbstverständlich angesehene Idee opferte: Die euklidische Massbestimmung im Raume der Physik, und, was damit zusammenhängt, in der Minkowskischen "Welt." Wieder war es ein genialer Einblick in das Wesen von Raum- und Zeit-Bestimmungen, was ihm diese ungeheuerlich scheinende Neuerung ermöglichte. Sie zeitigte aber bald unerwartete, tatsächlich zutreffende Ergebnisse. Nicht nur ergab die "allgemeine" Relativitätstheorie in ihrer allmählichen Entwicklung zwangsläufig den astronomischen Wert für die Perihelbewegnung des Merkur, vielmehr fand die Sonnenfinsternis-Expedition unter Eddington 1919 in der Tat jene Ablenkung des Lichts durch die Sonne, welche diese Theorie als einen Einfluss der Gravitation auf die Fortpflanzung des Lichts forderte. Das war ein Triumph, wie er in der Wissenschaft nur ganz selten vorkommt. Er festigte Einsteins Ruhm für alle Zeiten. Und schliesslich, nach langen Mühen, fanden die Astronomen auch die dritte der von Einstein als beobachtbar erklärten Folgerungen, die Rotverschiebung der Spektrallinien an einer besonderen Klasse von Fixsternen.

Trotzdem ist die allgemeine Relativitätstheorie Einsteins Sorgenkind geblieben; er arbeitet heute noch an ihr. Wir wissen nicht, wie sie sich weiter entwickeln wird; spätere Finsternis-Beobachtungen haben anscheinend die Lichtablenkung nicht ganz in Einklang mit der Berechnung ergeben. Aber die grundlegende Idee, die Einführung nicht-euklidischer Geometrie zur Wahrung des Gesetzes von der Gleichheit beider Massen, dürfte zum gesicherten Bestande der Physik gehören.

Was verehren wir nun bei Einstein am Höchsten? Ich möchte meinen, nicht die gewiss nicht zu unterschätzende mathematische Befähigung, mit der er insbesondere die allgemeine Relativitätstheorie meisterte, nicht die Vielseitigkeit seiner Begabung, nicht einmal die Unbefangenheit gegenüber allen bestehenden Theorieen. Vielmehr steht über dem die schlechthin geniale, unmittelbare, und, wenn sie einmal ausgesprochen ist, so einfache Einsicht in das, was in der Natur wesentlich ist. Sie hat sich in den beiden erwähnten Zweigen gleichmässig bewährt. Aber, um sie wirksam zu machen, musste noch eine Charaktereigenschaft hinzukommen, nämlich eine absolute Ehrlichkeit und ungewöhnlicher Mut der Überzeugung, um gegen uralte, eingefleischte, mächtige Vorstellungen anzukämpfen—zunächst ganz allein. Und diesen Mut, den er auch in dem wohl noch unentschiedenen Kampfe um die Auffassung der Quantenmechanik zeigt, hat er nicht weniger in seinem Verhalten zu den Mächten der Umwelt bewährt. Das werden auch die ihm zugestehen, die ihm in dieser Hinsicht nicht durchweg zu folgen vermögen. Natürlich hat er auch den dafür üblichen Preis bezahlen müssen mit einem unruhigen, manchmal stürmisch bewegten Leben.

Seit einer Reihe von Jahren konnte er nun sein Lebens-Schiff in einen ruhigen Hafen lenken, und die Physiker der ganzen Erde richten am 14 März ihre Gedanken nach Princeton. In dankbarer Verehrung wünschen sie dem Jubilar noch viele Jahre der alten geistigen Klarheit und der alten Freude an der Wissenschaft.

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Einstein's Philosophy of Science

Philipp Frank
Department of Physics, Harvard University, Cambridge, Massachusetts
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ABOUT ten years ago I spoke with Einstein about the astonishing fact that so many ministers of various denominations are strongly interested in the theory of relativity. Einstein said that according to his estimation there are more clergymen interested in relativity than physicists. A little puzzled I asked him how he would explain this strange fact. He answered, a little smiling, "Because clergymen are interested in the general laws of nature and physicists, very often, are not."

Another day we spoke about a certain physicist who had very little success in his research work. Mostly he attacked problems which offered tremendous difficulties. He applied penetrating analysis and succeeded only in discovering more and more difficulties. By most of his colleagues he was not rated very highly. Einstein, however, said about him, "I admire this type of man. I have little patience with scientists who take a board of wood, look for its thinnest part and drill a great number of holes where drilling is easy."

Through all his life as a physicist Einstein has regarded his own work as a search for the general laws of nature and as closely related to the work of the philosopher. In his obituary to Ernst Mach (1916) Einstein wrote

"When I remember the ablest students whom I met as a teacher, I can say with certainty that they were strongly interested in the theory of knowledge. I mean by 'ablest students' those who excelled by independence of judgment, not only by quickness. They liked to start discussions about the aims and the methods of science and proved by their obstinacy in the defense of their opinions that this issue seemed to them to be an important one. This is not astonishing, indeed."

As a matter of fact, Einstein's physical theories have played a great part in the history of contemporary philosophy, a very great part, indeed. We can venture on good grounds the statement that no "professional philosopher" of the 20th century was quoted so frequently by other philosophers as Einstein was. He was measured by professional standards, an "amateur" in philosophy, but a "philosopher" in the literal sense of the word that means a "lover of wisdom."

In order to understand Einstein's place in the evolution of philosophical thought we have to cast a glance upon the period in which Einstein started his work, the turn of the century, the period around 1900. In these years not only a great many new facts were discovered in physics, but also new theories were advanced by which the "classical physics" of the 17th, 18th and 19th century was rapidly transformed. Along with these changes a new "philosophy of science" had developed at the end of the 19th century, one would say, necessarily. The traditional philosophy of that "classical period" had been, more or less, a petrification of classical physics. Thence the breakdown of those physical theories brought about the breakdown of a philosophy which had "demonstrated" the eternal validity of the same theories which were abandoned by the scientists later. The appearance of the new philosophy of science preceded to a certain degree the theory of relativity and the quantum theory. Men with great insight into the logical structure of science noticed already in the last quarter of the 19th century that "classical physics" and its "traditional philosophy" was doomed. The electromagnetic theory of matter, the first glimpses of electronics, the new conception of fluctuation, etc., were sufficient to demonstrate the necessity of a radical change in the traditional philosophy of science.

Towards the end of the 19th century two great men advanced with great strength the need for a new approach to the philosophy of science, Ernst Mach and Henri Poincaré. Both men played a prominent part in Einstein's intellectual evolution and both have left their imprint on the way Einstein formulated his physical theories.

At the first glance, Mach's and Poincaré's views on the principles of science seem to be antagonistic and even contradictory to each other. In Einstein's philosophy of science these two views appear as two aspects of one integrated view.

According to Mach the principles of science offer an "economic" (practical) description of a great diversity of sense observations. According to Poincaré, however, these principles are free creations of the human mind which are neither true nor false but may be convenient or inconvenient.

In Einstein's work we can easily notice the influence of both these philosophies. In his "Special Theory of Relativity" Einstein started from the question: If we say that two events at different places occur at one and the same time, what does the expression "at the same time" mean if we formulate it as a statement about possible sense observations? In a similar way we find in Einstein's general theory of relativity at the beginning the question: If we say that a fluid mass rotates and is flattened by the centrifugal force, what does the expression "rotating" mean if we express it by statements about possible sense observations?

However, we can also construe Einstein's theory of relativity as an example of Poincaré's "conventionalism." Einstein defined the time distance between two events in such a way that the principle of relativity becomes true. We can say that, in a certain sense, the principle of relativity is not a statement about physical facts but a definition of the expression "length of time." It is therefore, merely a convention about how to use the expression "equal time distances." Similarly, Einstein's famous definition of "simultaneity" was an arbitrary convention about the use of this word. It was not supposed to be "true" but convenient to formulate the laws of physics in a simple and "economic" way.

Einstein's Special Theory of Relativity (1905) was formulated in such words that it could serve as a brilliant example for the general views of Mach and Poincaré about the logical status of scientific principles. This theory established in a conspicuous way the characteristics of scientific principles which were stressed by both of these "rival philosophies." The validity of both characteristics within one and the same physical theory was a clear demonstration of the compatibility of Mach's and Poincaré's views if they were correctly understood. In a much higher degree Einstein's General Theory of Relativity had its philosophical basis greatly in the writings of both philosophers and one could hardly imagine that a theory of this type could have appeared except in the intellectual atmosphere which was determined in an essential way, by the writings cf Mach and Poincaré. Einstein's General Theory of Relativity contains implicitly a "philosophy of time and space" which, probably the first time in the history of philosophy and science, gave a clear account of what is meant by expressions like "the nature of space and time," "the validity of Euclidean geometry," etc.

Einstein formulated this underlying philosophy of space and time explicitly in his lecture "Experience and Geometry" which he gave in 1921 to the Prussian Academy of Science in Berlin.[1]

This lecture is a historic landmark in the long and tortuous approach to philosophical clarity. The relation between experience and logic in geometry, and in science altogether, was presented, the first time, in a satisfactory way. Einstein did it with great simplicity and directness leaving no dark angle where remnants of obscurity could take a hiding. Certainly, the earlier writings of men like the mathematicians Hilbert and Poincaré had clarified this issue a great deal. Hilbert had presented geometry as a formal system in which the significance of terms like "straight line" or "point" or "intersect" were not used in the drawing of conclusions. He contributed in this way much to the understanding of the part of reasoning in geometry. But his argument on the physical meaning of geometry was rather vague. Poincaré characterized geometrical axioms as "conventions" about the use of words like "straight line." In this respect he agreed with men like Hilbert. He recognized also that these conventions can be practical or not practical. It depends whether conventions or definitions can be applied to the physical reality or not. But Poincaré did not show clearly by concrete examples what a geometry would look like which is different from the Euclidean geometry and is a picture of reality. This could not be done until one was in the possession of a physical theory which contained the interaction between the physical field of force and the departures from the Euclidean geometry.

Einstein's General Theory of Relativity was the first physical theory in which, what one called formerly "geometry" was completely integrated into the frame of physics in general. Only within such a frame the relation between reasoning and experience in geometry can be clearly stated. The axioms of geometry by themselves are, as Hilbert and Poincaré pointed out, purely formal systems from which we can draw results without knowing the significance of the words "straight line" etc. But by interpreting a straight line as a light ray or as a rigid rod, the axioms become physical hypotheses; they become statements within mechanics or optics. All conclusions which are drawn from them can be checked with the same precision and with the same uncertainty as all statements of physics. Einstein characterized this situation by the famous dictum that, as far as geometry is precise, it does not tell us anything about the world (it is a formal system); if, however, it tells us something about the world, it is not precise (it has the same status as a statement of physics).

Einstein's work contains the definite settlement of the problem, how it is possible that geometry makes definite and final statements about the external world which are not based on sense experience. It is now clear that geometry is not different from any empirical science. In any empirical science there is a part which is purely logical. It tells us what follows from certain axioms without bothering whether these axioms are true. This part contains statements which are very exact and the truth of which cannot be challenged by any future advance of empirical science. But these statements do not say anything about the external world. In physics we have large books written about what logical deduction we can make from Newton's laws of motion or Maxwell's equations of the electromagnetic field without bothering whether these laws of motion or of field laws are true or even what is their physical significance. The books remain valid whatever we may later say about their fundamental assumptions.

The same thing is true even in biology or economics. In genetics we have analytical genetics which derives results about "genes" from Mendel's laws. These deductions do not even depend upon what the word "gene" means as an object in the physical world. If we know the "semantical rule" by which statements about "genes" can be translated into statements about the frequency with which some properties of organisms occur in the hereditary process, we can make use of analytical genetics in empirical biology. In economics one starts often from the conception of the "economic man" who acts only for his profit. We know exactly the properties of this man because they are arbitrarily ascribed to him. Then we can derive logically how this economic man behaves as a part of society, we can derive laws of prizes which would be empirically valid —if mankind consisted exclusively of economic men. The conditional statement, "the prices would change in a certain way if men behaved as economic men do" is true whether an economic man exists in the real world or not. Here again we note that a part of the argument in economics is exact, but does not say anything about the external world. The question from the viewpoint of empirical biology and economics is merely whether these assumptions can be applied to circumstances which really occur in the world of organisms or human societies.

This analysis of geometry was a major event in the history of philosophy and could be extended to any empirical science. The axioms of geometry were the most brilliant and the most "scientific" example of statements which were valid *"a priori"* and therefore

[1] An English version of this lecture was published in the book *A. Einstein, Sidelights on Relativity* (Methuen and Company, Ltd., London, 1922).

of an eternal validity which could never be shaken by any advance in science. Einstein's theory was a clear example which showed that the axioms of geometry are either purely analytical and do not say anything about reality or are not different from the statements of physics, biology or economics. The scientific basis of a great many philosophical doctrines was destroyed radically. There was no longer any scientific foundation for the contention that the human mind can make valid statements by other than the scientific method. This method consists obviously in a cooperation of logic and experience as exemplified by Einstein's analysis of geometry.

The belief that there is any "philosophical method" besides the empirical-logical method had lost its most scientific foundation.

In order to appreciate correctly the place of Einstein's *Special and General Theory of Relativity* in the history of philosophy we have to consider the reaction of the "professional" philosophers to these new physical theories.

It is only fair to say that even prominent men among the followers and rebuilders of traditional philosophy were at a loss to tell correctly the changes which had to be made in order to integrate Einstein's work into the traditional pattern. Men of high intellectual and imaginative caliber like Henri Bergson, Ernst Cassierer, or N. A. Whitehead tried in vain to make contributions towards a better understanding and assimilating of Einstein's new theories. I omit to mention those philosophers who just asserted in a perfunctory way that Einstein theory bolsters their pet philosophy. According to some interpretations, Einstein's theory shows, for example, that physics has to do with mind and not with matter or, in the opposite that space and time conceptions do not refer to some abstract entities but to material bodies. I shall rather give a glimpse of the main lines of philosophical thought in the 20th century. What had been left of traditional metaphysics belonged, roughly speaking, either to the Aristotelean (Thomistic) tradition or to the Kantian tradition. Both groups were based on the conviction that the fundamental axioms of Euclidean geometry are self-evident and cannot be altered by any future advance of empirical science.

When these opinions were shaken by Einstein's theories, the representatives of those currents of thought behaved in two different ways which we may characterize by using a parlance of theology, the "fundamentalist" and the "modernist" approach.

The "fundamentalists" asserted boldly that Einstein was just wrong. The non-Euclidean geometry, for example, according to their opinion, existed only as an artificial system of thought but not in the real world. The "modernists" again are represented by the groups which one calls mostly Neo-Kantians and Neo-Thomists. They attempted to integrate Einstein's physics in a certain way into their systems by drawing a sharp separation line between science and philosophy. They admitted that within science Einstein's rejection of the Euclidean geometry and Newtonian mechanics is legitimate. But then, the problems of the "nature of time and space" still remain unsolved. Their solution can only be found by a way of approach which is not the scientific one and which they called the "philosophical" or "metaphysical" one. In this way Einstein's new reconstruction of physics contributed to the disintegration of traditional philosophy. The only remnant of the old doctrines was a type of discourse which did no longer affect science at all. It restricted itself to produce a certain "background" to science. It was supposed to contain a more profound insight into time and space but contained, actually, attempts to reconcile our old common sense approach to time and space with the principles of modern physics. It was an attempt to formulate our modern experiences in the physics of swiftly moving bodies by using the Aristotelian or Kantian concepts which had been generalizations corresponding to a much older stage of human experience.

I shall not dwell here upon these historical connections but I shall rather try to describe what are the permanent vestiges which Einstein's work has left upon the philosophical thought of our 20th century.

As far as we discussed it by now, we can summarize Einstein's contribution by stressing that he gave the last and decisive touch to the program of physics that was outlined by men like Mach and Poincaré. What these scientists had in mind as a mere program and what they were not able to formulate in full precision Einstein achieved and presented as a full-fledged scientific theory. It assigned its correct and satisfactory place to non-Euclidean geometry and defined precisely the mutual relation between convention and facts in science.

According to Mach and Poincaré and to a certain degree also according to Einstein's earlier papers, the abstract concepts which are the building stones of physics must have an interpretation in the realm of observable facts. Concepts like "mass and force," "position and velocity," "distances in space and time," etc., can only be used in the principles of physics if accompanied by a recipe how they can be measured in the physics laboratory. Einstein added to these concepts also expressions like "simultaneity" and emphasized even more than Mach and Poincaré the necessity to anchor all abstract concepts firmly in the ground of observable facts.

The general belief was, at that time, that the chain which connected the abstract terms with the observational facts was to be fairly short. Some authors even liked to express themselves in a way as if the principles would speak directly about observable facts.

The General Theory of Relativity was the death knell for this "optimistic" belief. It became now clear that this belief had been an oversimplification. In his Herbert Spencer Lecture given at Oxford on June 10, 1933, Einstein describes the structure of science in agreement with what I called his integration of Mach and Poincaré. But he stresses a point which had been rather minimized in the period when one believed that the principles of physics contain only concepts which are fairly near to observable phenomena. Poincaré had said already that the fundamental principles themselves are "free creations" of the human mind, and that they are connected by physical interpretations with the realm of observations. Einstein says in this lecture: "The conception here outlined of the purely fictitious character of the basic principles of physical theory was in the eighteenth and nineteenth centuries still far from being the prevailing one. But it continues to gain more and more ground because of the ever widening logical gap between the basic concepts and laws on the one side and the consequences to be correlated with our experience on the other, a gap which widens progressively with the developing unification of the logical structure, that is, with the reduction in the number of the logically independent conceptual elements required for the basis of the whole system. . . .

The scientists of those times were for the most part convinced that the basic concepts and laws of physics were not in a logical sense free inventions of the human mind, but rather they were derivable by abstraction, i.e., by a logical process, from experiments. It was the General Theory of Relativity which showed in a convincing manner the incorrectness of this view. . . ." Einstein stresses strongly the point that the principles of a physical theory do not "describe" the facts of experience but are inventions of the human mind from which the facts can be "derived." The principles of Newtonian mechanics and of general relativity theory are very different from each other. One cannot envisage how they could be both "derived" from the same stock of experience. But none the less, within a wide range, they describe the same experimental facts! "This indicates," says Einstein, "that any attempt logically to derive the basic concepts and laws of mechanics from experience is doomed to failure."

This analysis of the logical structure of actual physics, particularly 20th-century physics, became the germ of new developments in the philosophy of science. The traditional systems of philosophy of the Kantian, Aristotelian, Neo-Kantian and Neo-Aristotelian (Neo-Thomistic) type had failed to draw any fruitful conclusions from Einstein's theories. But a new type of philosophy arose which was directly influenced by Einstein's General Theory of Relativity.

The new men did no longer attempt to stretch the traditional philosophical systems artificially, in order to bring the new physics into the fold of the old philosophy. They followed the word of the Bible: "No man puts new wine into old bottles; else the new wine will burst the bottles, and be spilled, and the bottles shall perish. But new wine must be put into new bottles and both are preserved."

M. Schlick in his book "Space and Time in Contemporary Physics" which was published in Germany in 1917, immediately under the impact of Einstein's General Theory of Relativity, recognized clearly that this theory was a turning point in the philosophy of science. The new philosophy was based on the ideas of Mach and Poincaré but tried to integrate the new ideas with which science was confronted by Einstein's new physics. Schlick stressed the point that the principles of physics or, for that matter, of any science, do not consist of "descriptions" of observable facts. They are, rather, statements about symbols and their connections from which statements about observable facts can be derived. Schlick suggests, therefore, to regard all the concepts which occur in the principles of science as elements of our physical reality and not only those to which sense observations can be directly assigned. All concepts belong to the real world from which statements about possible sense observations can be derived. We can describe this shift in attitude also as follows:

According to the older form of positivism and empiricism, as represented by Mach, the principles of science were direct statements about sense observations. Schlick developed Einstein's method into a new approach to the philosophy of science and proposed to regard the principles of physics as statements which deal "indirectly" or "by implication" with sense observations. But we can just as well say that these principles are statements about the physical reality, as far as sense observations reveal physical reality.

The movement started by Schlick has been called later "logical empiricism," it regarded the principles of science not as simply empirical, but as "empirical by logical implication." Schlick says in his quoted book "There is no argument whatsoever to force us to state that only intuitional elements, colors, tones, etc., exist in the world. We might just as well assume that elements or qualities which cannot be directly experienced also exist. . . . For example, electric forces can just as well signify elements of reality as colors or tones. They are measurable and there is no reason why epistemology should reject the criterion for reality which is used in physics."

The development of logical empiricism has demonstrated strongly the great bearing of Einstein's analysis of science upon the philosophical attitude towards science. R. Carnap, for example, says in his book "The Logical Syntax of Language" (1934) about Maxwell's equations of the electromagnetic field

"There is no sentence which contains only symbols of observational statements and is equivalent to such an equation. But, of course, sentences of an observational form can be deduced from Maxwell's equations (in conjunction with other sentences of physics)."

The doctrine of logical empiricism which was the result of this integration of Mach, Poincaré and Einstein developed during the twenties and thirties of the 20th century into a strong movement among the scientists and all other groups who wanted to carry on their work according the example of science. If we investigate the role of this doctrine as a motive for human action or, more exactly speaking, as a weapon in the battle of religious and political ideologies, we notice easely that there have been two main types of interpreting logical epiricism as a "philosophy of life."

If we regard a scientific theory like Einstein's theory of gravitation as a free construction of the human mind invented for the purpose to predict and produce phenomena of nature we can look at it from two different angles. We can either say: since the theory is a "free construction of our mind," we can certainly construct again and again new theories which may become more and more helpful in their application, but there is no reason to believe that we approximate a perfect theory. To expect a "perfect theory" would be a similar thing to expecting a "perfect automobile" which will keep its form and construction for the eternity. This aspect has been the prevailing one for great many logical empiricists and was particularly stressed by P. W. Bridgman.

But we can also direct our attention to the form of the fundamental differential equations themselves and imagine that these equations will, of course, be changed again and again but will eventually converge toward a final system of equations which will be the "true" theory of the physical field. Einstein has been more and more attracted towards this second aspect. In his Herbert Spencer Lecture, which we quoted already, he says:

"If the basis of theoretical physics cannot be an inference from experience, but must be free invention, have we any right to hope that we shall find the correct way? Still more—does this correct approach exist at all, save in our imagination? To this I answer with complete assurance, that in my opinion there is the correct path moreover, that it is in our power to find it."

When Einstein started in the search for the equations of the gravitational field, he was guided by the mathematical theory of invariants and covariants. He had noticed before, that his special theory of relativity could be presented as the theory of invariants of a certain mathematical group. This was his starting point in the search for his theory of the gravitational field and he has strongly believed that by this method one can find also the laws for the "unified field" which will embrace the gravitational the electromagnetic and the nuclear field.

He continues in his Spencer Lecture, "It is my conviction that pure mathematical construction enables us to discover the concepts and the laws connecting them which gives us the key to the understanding of the phenomena of nature."

Einstein did not believe, of course, that by any mathematical argument one could "demonstrate" the truth of a physical theory. This can only be done by experiment. But on the other hand, the *discovery* of a theory is according to Einstein, not based directly on experiments but on mathematics. Einstein says that the "truly creative principle resides in mathematics." By this emphasis of the heuristic value of mathematics, Einstein, who had always discouraged all *a priori* conceptions of natural laws, arrived at the result that mathematical thought could lead to the discovery, but not the "proof" of the true laws of nature. Einstein says, "In a certain sense, therefore, I hold it true that pure thought is competent to comprehend the real, as the ancients dreamed."

The belief that there will be eventually a perfect system of physical laws of great simplicity and beauty that will allow a mathematical deduction of all phenomena of the physical world, is sometimes called the "belief in the rationality of nature."

This belief which amounts to an optimistic attitude towards research in the natural sciences is according to Einstein, of a religious nature. Einstein calls it occasionally his "cosmic religion." In this sense, Einstein stressed repeatedly he can be called a devoutly religious man.

Among theologians, philosophers and even politicians there has been a trend to claim that the Theory of Relativity has reconciled the old conflict between science and religion. According to this school of thought the Theory of Relativity has overthrown Newton's mechanics and, therefore, the mechanistic world view, according to which the universe is a large machine. This "materialistic" view has been regarded as incompatible with all kinds of religion. The failure of Newton's mechanics, so the argument goes, has also refuted the "machine theory" of the universe and, therefore, given a chance to a recognition of science and religion. A similar argument has been also used in the case of quantum theory. It has been claimed by a great many authors that the physics of the 20th century is strongly opposed to the machine theory of the universe, that it is propitious to the world picture of the traditional religions.

These views have been supported also by several prominent physicists among which the name of J. Jeans and A. Eddington are the best known. It is important to understand that these views have by no means been supported by Einstein. While he has held that the possibility of theoretical physics and cosmology suggests a belief in the "rationality of nature" and "cosmic religion" Einstein has never believed that 20th-century physics is in this respect different from classical physics. Who is willing to interpret the laws of theoretical physics in this way is supported by Newton's mechanistic physics not less then by Einstein's Theory of Relativity and Heisenberg's Principle of Indeterminacy.

That incorrect interpretation of Einstein's opinions about the bearing of his theory upon religion is based upon a much wider misunderstanding of Einstein's theories. I stressed in this paper, what I believe to be the actual bearing of Einstein's physics upon our modern philosophy of science. We must, however, not ignore the fact that the interest of adherents of the traditional philosophical systems was not so much occupied by the real advances in philosophy that are due to Einstein but rather by "philosophical implications" of Einstein's theory which were due to gross misunderstandings of physical theories in general and Einstein's theories in particular. As a matter of fact, as Bertrand Russell once remarked very aptly, the majority of adherents of the traditional systems in philosophy have interpreted Einstein's new physics as a support of those metaphysical doctrines which they had held for ages. This holds for idealistic philosophies as well as for materialistic ones.

These misinterpretations of Einstein's theories by philosophers and theologians are, certainly, of a psychological and sociological interest.

They can serve as a good example of a general phenomenon. Since the "philosophical implications" are not justifiable by scientific methods their origin is rather in the eternal attempts of men to find a basis for their social and religious aspirations in the laws of the physical universe.

As I have discussed these problems in several books and papers, I shall here only outline briefly the most frequent types of misunderstanding without discussing them in detail.

Great many philosophers started from the role of the observer in the Theory of Relativity. They concluded from it that the Theory of Relativity cannot be stated as classical physics was, a description of objective facts. Einstein's physics is concerned only with subjective sense impressions of human beings. This would mean, in the language of traditional philosophy, that Einstein's theory supports the philosophy of subjective idealism. Furthermore, as no objective truth about the physical world can be stated and the world looks different for different observers. Einstein supports a "sceptical" philosophy. Since every observer is equally right, truth can never be found and the "agnostic" can prove his case. By applying this "relativistic" attitude also to the realm of ethics the theory of relativity was even accused of being hostile to morality and of being a subversive doctrine.

These misinterpretations have played their part in the attitude of political groups towards Einstein's theories. During the Nazi regime in Germany and under the Soviet regime in Russia the ruling parties and even spokesmen of the governments subjected Einstein's theories to severe criticism. There have been everywhere also serious attempts to achieve a "negotiated peace" in this ideological war. For, whatever may be the form of government, the experiential results of Einstein's theories cannot be ignored in the application of physics to industry and warfare. A compromise had to be found under which the practical implications could be exploited without having to face the philosophical implications.

Instead of an elaborate discussion of all these points I shall restrict myself to quoting those sections of my previous books where such a discussion is done carefully.*

I shall not discuss in this paper Einstein's attitude towards Bohr's philosophical basis of the Quantum Theory. This attitude is closely connected with Einstein's position towards the positivistic and metaphysical conception of science. According to Einstein the Quantum Theory in Bohr's formulation does not describe the physical reality but only the reaction of the observing and measuring physicist to this reality. Bohr's interpretation of Quantum Theory is the most radical conclusion drawn from positivism and applied to a concrete situation in physics. I refer for this point to my book *Einstein, His Life and Times*, Chapter IX, Section 5, where Einstein's philosophical position with respect to Bohr's principles is described and analyzed. N. Bohr presented the philosophical issue between himself and Einstein in his paper "Conversations with Einstein on Epistemology" which is published in the book "Albert Einstein: Philosopher-Scientist" quoted above.

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* *Foundations of Physics* (University of Chicago Press, 1946). Chapter V discusses the Theory of Relativity. The philosophical interpretations, particularly the question of subjectivity and relativity is taken up in Sections 26 and 27.

Between Physics and Philosophy (Harvard Press, 1941). In Chapter VIII (What "length" means to the physicist) the "relativity of length" is logically analyzed.

Einstein, his life and times (New York, 1947). Einstein's Philosophy of Science is discussed in Chapter IX, his attitude towards religion in Chapter XII. The interpretations of Einstein's Relativity Theory from the viewpoint of political ideologies is elaborately described in Chapter XI.

Modern Science and its Philosophy (Harvard Press, 1949). In Sections 9 and 10 of the Introduction, Einstein's impact on the rise of a new philosophy is described. In Chapter 5 "Is there a trend towards idealism in physics?" the subjectivistic and idealistic interpretations of Einstein's physics are discussed. In Chapter 7, "Modern Physics and Common Sense," the question is discussed whether the Theory of Relativity is contrary to common sense and whether it is abstract or pictural. In Chapter 10 "How idealists and materialists view modern physics" the idealistic and materialistic interpretations of modern physics are historically and logically analyzed. In Chapter 13, "The Philosophical Meaning of the Copernican Revolution" the question is analyzed whether Einstein's Theory of General Relativity has confirmed or refuted the philosophy which has been the basis of the Copernican Heliocontric world system. In Chapter 16 "The place of Logic and Metaphysics in the Advancement of Modern Science" a more thorough investigation is devoted to some philosophical misinterpretations of Einstein's theories, in particular to the alleged lowering of the role of reasoning and rationality in modern science.

The interpretations of Einstein's theories as "philosophical relativism," as supporting the "relativity of truth and values" is discussed in my paper: "The relativity of truth and the advance of knowledge" in the Italian journal "Analisi," (1946). A much more elaborate presentation will appear soon in a book *"Relativity —a richer Truth,"* (Beacon Press, Boston, 1949).

There has been much discussion and a great diversity of opinion whether Einstein's theories can be used and are intended to be used by their author as a support of a positivistic anti-metaphysical philosophy or, in the opposite, as a basis for a metaphysical world conception. This question is certainly of great interest if one wants to understand the climate of thought in our time and the interrelation between scientific theories and philosophical world views in particular. I have discussed this question and its solution at length in my paper: "Einstein, Mach and Logical Positivism" which is published in the book: *Albert Einstein: Philosopher-Scientist*" (Volume VII of the Library of Living Philosophers, ed. by P. A. Schilpp, Evanston, 1949).