

## Appendix: A Personal Philosophy of Science

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If we contemplate the interpretations of science that have been given by the various philosophical “schools,” we can see clearly that the “school” to which an individual scientist adheres is not determined, to any great extent, by the result of his research as a scientist, but rather by his religious or political predilections, which he attempts to support by a certain philosophical interpretation of science. Perhaps it would be instructive to clarify this situation by presenting the philosophical interpretation which has been given to physical laws [not] by “schools” but by individual scientists. We shall use as an example one of the greatest physicists of our time, Albert Einstein. Although the cleavage between positivistic and metaphysical concepts has often been called the fundamental rift among the philosophical interpretations of science in our period, Einstein has been claimed as an adherent on both sides of the gap. When we read his obituary on Ernst Mach, [note 1] we gain the impression that Einstein had been a clear-cut positivist. He writes:

Science is nothing else but the comparing and ordering of our observations according to the methods and angles which we learn particularly by trial and error.... As results of this ordering abstract concepts and the rules of their connection appear.... Concepts have meaning only if we can point to objects to which they refer and to the rules by which they are assigned to these objects.

Einstein refused absolutely to interpret Mach as an idealist or solipsist, as had been done by both Thomists and Dialectical Materialists. Einstein himself has stressed the influence of Hume and Mach upon his thinking. In his presentation of the theory of relativity, [note 2] given in 1921, Einstein writes:

The object of all science, whether natural science or psychology, is to coördinate our experiences and to bring them into a logical system.... The only justification of our concepts is that they serve to represent the complex of our experiences; beyond this they have no legitimacy. I am convinced that the philosophers have had a harmful effect upon the progress of scientific thinking in removing certain fundamental concepts from the domain of empiricism, where they are under control, to the intangible heights of a priori.

All these passages could have been written by positivist in the old sense, like August Comte, Ernst Mach, or Ernst Stallo. [note 3] Occasionally Einstein called a system of propositions from which no statement about sense experience can be deduced “metaphysics” or “empty talk.” [note 4] In this passage he uses the language of the “Logical Positivists” like Rudol[f] Carnap, who have declared metaphysics to be “meaningless.” [note 5] There was, however, one point in the “positivism” of Comte and Mach with which Einstein did not agree. This positivism was often characterized by the claim that science is a registration of “sense observations.” If we accept these words in their common-sense meaning, they seem to imply that science describes our sense

observations in the same way as a reporter describes some event (a fire, a meeting, etc.) for the “record.” Einstein has always emphasized the active, the creative work of the scientist. He does not “record” sense observations, he “produces a theory.” As a matter of fact, the “new positivism” of Poincaré and the “logical positivism” of Carnap have always stressed the point that scientific theories are products of the human mind. [note 6] According to this doctrine, the general concepts and propositions of science can certainly not be “deduced” from sense observations.

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Einstein disagrees with “positivists” who require that “all those concepts and propositions which cannot be deduced from the sensory raw material are[‘?], on account of their “metaphysical” character, to be removed from thinking [note 7] The principles of the general theory of relativity are obviously not “deduced” from sense observations; neither are the principles of quantum theory. If we are clearly aware of these facts, it is easy to find, by careful analysis, that the same thing holds for the principles of Euclidean geometry and Newtonian mechanics. The new Twentieth-century physics, particularly the theories of Albert Einstein and Niels Bohr, have led scientists and philosophers to the general view that all science is a produc[t] of human imagination; it is to be “checked” by sense observations, but cannot be “deduced” from sense observations.

In his “Herbert Spencer Lecture” Einstein says [note 8] clearly that the philosophers of science of the eighteenth and nineteenth century

were, most of them, possessed with the idea that the fundamental concepts and postulates of physics were not in the logical sense free inventions of the human mind, but could be deduced from experience by “abstraction”—that is to say, by logical means. A clear recognition of the erroneousness of this notion really only came with the general theory of relativity. [note 9?]

Einstein called the systems of axioms on which science is based “metaphysical” principles, because they are neither statements about experiences nor statements that have been logically “deduced” from experiences. If we understand “metaphysical” in this negative sense, Einstein’s opinion is not really different from the opinion of the logical positivists about the logical structure of physical theories. However, if we give what we have called [note 10?] “philosophical interpretations of science,” Einstein’s interpretation is clearly different from the interpretations given by the logical positivists, the pragmatists, and the operationalists. This means that Einstein’s proposed common-sense interpretation of this “science of science” seemed to support a more desirable behavior of the scientist than the positivistic interpretation did. Every scientific theory “invents” a set of “simple” principles from which the immense complexity of observable phenomena can be logical derived. The possibility of such “inventions” is the fact that makes science possible.

We say that by introducing the term “comprehensible” from our common-sense language, a domain of observational facts is “comprehensible,” if we succeed in deriving them from a few simple principles. Now the question is quite natural, how does it happen that the physical universe, or the world in general, is “comprehensible.” [note

11] This question can scarcely be answered by a scientific theory. Einstein said, "The most incomprehensible thing about the world is that it is comprehensible." For the Thomistic philosophy the answer was very simple. The laws of nature were regarded as genuine laws given by a law giver who was a "rational being." He had a mind similar to, although superior to the human mind. Then, of course, the phenomena of nature must obey laws that are "comprehensible" to the human mind, although Einstein does not, as Thomistic philosophy has done, assume a "personal lawgiver." He would like to say that the "universe is rational" or, in other words, the laws of nature can be formulated by the mathematics which the human mind has been able to construct. "I am convinced," writes Einstein, "that we can discover by means of purely mathematical constructions the concepts and the laws connecting them with each other which furnish the key to the understanding of natural phenomena." He would not say that the validity of a physical theory can be proved by mathematics; he would say rather that it helps us to find a theory, which must be confirmed by experience.

"Experience," writes Einstein, "remains, of course, the sole criterion of the physical utility of a mathematical construction. But the creative principle resides in mathematics." Occasionally, he even expresses himself in a way that is close to the language of ancient and mediaeval metaphysics. "In a certain sense," he writes "I hold it to be true that pure thought can grasp reality as the ancients dreamed." This "dream of the ancients" was, of course, what we have described earlier as "seeing with the intellect," or "metaphysical insight." But the qualifications "in a certain sense" bring us back to the "positivistic doctrine" that the mathematical construction is an instrument for the invention of a physical theory but not a criterion of its validity. The belief in this heuristic role of theoretical construction does not necessarily lead to metaphysical interpretations, according to which the physical world would be in agreement with our mathematical constructions or, as some philosophers and scientists (for example James Jeans) expressed it, the creator of the world would be a pure mathematician. One can certainly interpret the helpfulness of mathematical constructions in physics by common-sense analysis, which leaves us with the "positivistic" view of nature. We may quote as an example, what Percy W. Bridgman writes about the role of simple mathematical laws in physical science. He distinguishes between two attitudes: [note 11] "One is that there are probably simple general laws still undiscovered; the other is that nature has a predilection for simple laws." Bridgman rightly emphasizes that simple means only "simple in terms of our human concepts." However, "Our concepts are hazy and do not fit nature easily." Hence there is little presumption in assuming that nature has a "predisposition to simplicity as formulated in terms of our concepts.... The know[n] laws of nature are 'simple' if we consider only a limited range of facts.... It does not seem so very surprising that over a limited domain, in which the most important phenomena are of a restricted type, the conduct of nature should follow comparatively simple rules." The laws of nature seem to be simple because they are first approximations. The higher approximations are unknown to us, and may be far from simple. However, this presentation of the "simple" laws and their role in science was not satisfactory to Einstein. It does not provide sufficient mental stimulation for the search after general laws of nature.

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We can also give philosophical interpretations, however that make use of common sense analogies that are different from Bridgman's "positivistic formulations," but are nonetheless compatible with the results of all experiments that have been recommended and recorded by physicists. Einstein, in contrast to Bridgman, prefers the analogy of physical theories with the blueprints which reasonable beings have made of the physical world. He prefers it because of its higher emotional value. It gives strength to the physicist in his efforts to invent theories, and to the student in his efforts to comprehend them. The use of this analogy supports the belief that the "world is comprehensible," which is, for the physicist, identical with the belief that simple mathematical laws are to be found for the sequence of natural phenomena. Einstein writes explicitly that "the faith in the possibility that the regulations valid for the world of existence are rational," or, in other words, the belief that the world is "comprehensible to reason" belongs to the sphere of religion. "I cannot conceive," he writes, "a genuine scientist without this profound faith." He even maintains that the faith in the comprehensibility of nature is the center of true religiousness. "in this sense, and in this sense only, I belong to the ranks of devoutly religious men."

We see that Einstein speaks of a religious interpretation of science. If one formulates the most general principle in this "science of science," the "theory of theories," as the belief in the existence of a system of simple mathematical propositions which man can find, from which he can derive the immense complexity of observable facts, one formulates the chief tenet of "cosmic religion." By using this analogy, we cannot add anything to our knowledge about nature. Religion, according to Einstein, cannot give us any insight, but it can give us strength. Einstein formulated his opinion about science and religion in the brief and strong sentence: "Science without religion is lame, religion with science is blind."

##### [F's "finis"?)