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GNOSEOLOGICAL STATUS OF THEORIES IN ASTRONOMY AND PHYSICS

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Abstract. In this paper one considers the gnoseological status of theories in astronomy and physics, or, more precisely, whether theories are to be viewed as true or false predicaments, and if yes, in what sense. The basic characteristics and shortcomings of the descriptivistic, instrumentalistic, conventionalistic and realistic concepts of theory are examined. In the framework of the realistic concept of theory the special attention is paid to the metaphysical realism.

1. INTRODUCTION

The gnoseological status of theories in astronomy and physics has been subject of long debates, not finished yet, where very complicated problems appear. The complexity does not concern technical problems of logic and scientific facts only, but also requires essential philosophical considserations involving the nature of semantics and knowledge. In dealing with the gnoseological status of theories in astronomy and physics the main question is, whether theories are to be viewed as true or false predicaments and, if yes, in what sense. The history of science knows various attempts of looking for the answer. In principle, the answers have been incomplete and one-sided. As an example we can mention the descriptivist point of view where it is claimed that theories never give an explanation, but only describe, in a simple or economic way. The basic objects of knowledge are direct impressions or sensual contents of a sensual or introspective experience. Also, the instrumentalist point of view in which theories appear as a means suitable in sumarizing and systematizing a given set of observable data from which one deduces consequences usable to the human practical activity. The process of the most adequate determination of the gnoseological status of theories has been realized in the realist point of view which assumes the reality of theories and entities postulated by them. The present paper is aimed at a detailed presentation of the advantages and basic shortcomings of the given concepts.

1. 1. THEORY AS VIEWED BY DESCRIPTIVISTS

The descriptivists say that theories never give explanations, instead they give simple and economic desriptions. The most radical form of their point of view is the consistent extension of phenomenalistic knowledge theory to sciences. This knowledge theory claims that basic objects to be known are straightforward impressions or sensual contents of introspective or sensual experience. A less radical form of the descriptivist point of view usually introduces "crude experience" as the starting point in analyses, though admits that judgements based on such an experience can often be erroneous so that their correction through rationalism is necessary. The main standpoint in this doctrine is that all predicaments of theory can be, in principle, translated into those concerning observable events, items, properties and relationships met in the commonsense crude experience without any change of the original meaning. According to this theories are suitable, concise descriptions. Their theoretical predicaments can be translated into the familiar language having as the subject facts of the verifiable experience though the predicaments of any theory cannot be described as true or false in the real sense of its meaning. A theory is, nevertheless, either true or false if it can (cannot) be translated into predicaments concerning the facts established observationally. This standpoint was tenaciously advocated by many scientists of the XIX century who opposed the development of the atomistic theories in physics and chemistry. They rejected the assumptions of classical rationalism and tried to release the science of "metaphysical" assertions. In their opinion the descriptivist point of view explains correctly the nature of physics and serves as a weapon in the struggle against the philosophical doctrines believed to prevent the development of science.

In order to justify the desriptivist concept Rankine (Nagel 1961 - ch. 6) claimed that in physics, there were two methods in formation of a theory. Theories formed by using the "abstractive" method present the relationship among the properties common to a class of objects or phenomena observable by our senses. In them, nothing hypothetical or in probable is postulated. Theories belonging to this group are referred to as abstractive, phenomenological or macroscopic. As examples we can mention Newton's mechanics and gravitation theory, Fourier's theory of heat transfer and classical thermodynamics. Theories formed by using the "hypothetical" method claim that hypothetical entities not given by senses are related. Their empirical correctness is indirectly evaluated, on the basis of the agreement of their consequences with the results of observations and experiments. They are referred to as hypothetical, transcendent or microscopic. This group of theories comprises the molecular gas theory, various atomistic theories, etc. The development of physics and the exceptional successes of atomistic theories of matter in predicting new phenomena and systematic unification of large parts of physics resulted in a conviction of many scientists that the abstractive theories and a further development of microscopic theories should be abandoned. The descriptivists reject these facts since they view the abstractive theories as an ideal form of a scientific theory. In their opinion the abstractive theories can be translated, perhaps even the microscopic ones. However, both the abstractive and microscopic theories possess properties which distinguish them from experimental laws. An example may be the case of the Newtonian mechanics where the basic notions are not experimental, though they are formed on the basis of experimental notions and correspond to such notions. This concerns, above all, the absolute space and absolute time, both substantially different from the experimental notions

of relative space and relative time. The same is true for the notions of point mass, instantaneous velocity, instantaneous acceleration and force. All the basic terms of microscopic theories are not related to the experimental notions through the rules of correspondence, whereas each of the postulatively defined terms of an abstractive theory is related to an experimental notion by means of such rules. Due to this abstractive theories seem like simple experimental laws and to find a visual model for them becomes relatively easy. In the past abstractive theories were formed following a strict analogy with empirical laws which had been previously established within a limited field. The experimental study of heat transfer preceded Fourier's analytical theory of heat. No conclusion of their identity follows from the strict analogy between abstractive theories and empirical laws. Abstractive and hypothetical theories belong to the same group of theories when the possibility of their translating into the language of observations is borne in mind.

The theory concept developed by desriptivists is not free of some weak points. The radical version involves the standpoint that the theoretical predicaments can be translated into the "language" of data coming from our senses. However, there exist no autonomous language originated in our senses, nor the possibility of forming such a language. The fact that elementary data coming from our senses are not basic facts of exeperinece, through which every notion can be constructed, is well known. The exeprience of our senses appears only as a response to complicated, though not decomposed, systems of qualities and relations. This response usually assumes the habits of interpretations and recognitions based on taciturn beliefs and conclusions which can be confirmed by no individual instantaneous experiences. The language normally used for the purpose of describing straightforward experiences is the language of social communication containing differences and assumptions based on a large collective experience. Since the language of data coming from our senses is not autonomous and any version of it is still missing, then, in principle, any translation of all theoretical predicaments into a language composed of data purely originated in our senses becomes impossible. The same is true also for the less rigorous position concerning the translation of predicaments. According to it, in the case of any theoretical predicament, there is a class of predicaments concerning observations logically equivalent to the given predicament. This class of predicaments can be finite or infinite. Though a given class of predicaments is, per definitionem, logically equivalent to a scientific theory, their diversity and quantity can never be completely determined.

1. 2. THEORY AS VIEWED BY INSTRUMENTALISTS

According to instrumentalists a theory is a rule or principle of decomposing and symbolical presentation of some facts originated in the crude experience and also an instrument in the technique of deriving some predicaments concerning what can be observed from other predicaments. A theory is neither a concise description, nor a generalized predicament concerning the relationship among observables. A theory functionates as the leading principle or rule of concluding according to which conclusions concerning observable facts are reached on the basis of given fact premises, not as a premise from which such conclusions follow.

The concept of scientific theories developed by instrumentalists removes the problem of whether these theories are true. Any hypothesis or theory is correct if it is able to "save the phenomena", to offer an explanation for a given set of phenomena

which will be utilized as an instrument of prediction and practical use. Any theory that is, not meaningless nor unusable, is equally good. The instrumentalism admits a simultaneous existence of a number of hypothetical explanations for the same set of phenomena where no priority is specified. Theory is viewed as utensils only suitable for summarizing and systematization of a given set of observable facts from which consequences useful in human practical activity are deduced. In a given situation, the theory seeming most suitable to an individual or scientific community is used. The instrumentalism tolerates a simultaneous existence and use of several different theories that treat the same set of facts. The advantage may be given to a theory which is "more simple to be used", follows more general theoretical schemes and which does not contradict the adopted knowledge system in physics. It is interesting to say that some theories in the initial phase of their development were accepted from the point of view of instrumentalists, were accepted also by realists (Novaković 1984) later on, as a result of a real convincing process. This was the case of the atomistic theory, which had had a long development from an untrustworthy metaphysical theory towards a scientific theory liable to theoretical criticism and empirical verification (Gardner 1979). The same is true with the theory of Copernicus (Duhem 1969). Though Copernicus had a realistic position, his theory was understood over a long time only in the framework of instrumentalism.

The theory concept developed by instrumentalists has some limitations. The main shortcoming is contained in the point of view that once established instrumentalist role of theories eliminates the possibility of deciding whether they are true or false. This point of view is incorrect because there is no necessary contradiction between the statement that a theory is correct and the statement that it has important functions in the research process. The best confirmation for this we find in the example of Copernicus' heliocentric system. Also instrumentalists have no single explanation for some objects postulated in microscopic theories, like electrons and photons. If theory is viewed as a leading principle or technique in reaching conclusions based on the method of phenomena describing, then the terms electron and photon probably functionate just as notional connections in the rules of describing and concluding. In this case the meaning of such terms is exhausted through directing the research and systematization of observational data.

1. 3. THEORY AS VIEWED BY CONVENTIONALISTS

The conventionalism is a standpoint concerning the methodology of natural philosophy, methods and meaning of scientific predicaments, in physics especially. It was formulated by French physicists and mathematicians who were also active in philosophy, above all Poincaré and Duhem (Kolakovski 1972).

The basic idea of conventionalism assumes that certain predicaments of exact sciences are creations established artificially, not imposed by experience, but due to other reasons, especially suitability, intelectual benefit or esthetical reasons, as said by Kolakovski (1972).

To the conventionalists the object of special criticism is the notion of "facts" as something by which "laws of science" are confirmed. According to them a pure experience in general, i. e. a fact containing no theoretical assumptions a priori, taken directly from nature, does not exist. Even the most simple measuring device involves some laws so that any "fact" established by its use is given together with these

laws only. Experience, as a prerequisite to verification of scientific laws, also involves already known laws. Thus there is no one-way verification and there are no "original facts", "basic predicaments" or similar constructions, because in the mere description of facts theories already formed are contained. There is a cyclical verification only. Duhem's point of view is that predicaments of physics are not true and false, but suitable and unsuitable. The system of a theory, as a whole, may also contain, if suitable, contradictory hypotheses.

The part of convention in creating science was also emphasized by Poincaré (Kolakovski 1972). A rejected hypothesis can be always saved, if desirable, by adopting new ones. Different hypotheses reflect different languages describing facts. Their choice is, above all, a consequence of suitability and pragmatism.

Thus, according to the point of view of conventionalists, scientific laws and theories are developed or accepted in the dependence on conventions. As admissible creations of imagination scientific theories are above experience. In this way, a theory is deprived of all their factual or empirical contents. A theory is correct by convention and predicaments of science cannot be viewed as true or false independently of what scientists decide in this matter. The conventionalists proved the non-existence of "pure facts" in the scientific experience and the presence of logical or semantic conventions within the system of theoretical knowledge. They undermined the confidence in objective power and absolute significance of scientific results. They proved the non-existence of any scientific knowledge that is absolutely free of "assumptions".

1. 4. THEORY AS VIEWED BY REALISTS

The basic standpoint in the scientific realism is that a long-term success of a sientific theory offers the reason to believe that the entities and structures postulated by this theory do exist. It is clear that this standpoint requires a theory to be successful over a sufficiently long time interval. The success of the theory in explaining offers a reason, though not a decisive one to believe in it, to accept that the structures contained in the theory are something resembling the structures of the real world and that no privileged position for the entities postulated in the theory is required.

The scientific realism involves the realism of theories and that of entities. In the case of theories, it is important to establish whether they are correct or incorrect, or perhaps candidates to be true. In the case of entities, it is important whether they exist. Philosophers are mostly concerned by theory and truth. The idea is that if a theory is correct, then the entities must exist. In the opinion of the realists the entities do exist (also including those not liable to a direct observation) and the relations among them also exist. Hence, to give a description of the world means to describe the entities (or sorts of entities) in it and indicate their relationship.

These reasons and many others have done that most of scientists and philosophers are inclined to accept the realism admitting the explanations of laws in observable phenomena. Only the realism is capable of explaining the pragmatism of scientific theories and indicate the distinction between correct and only usable, but incorrect, scientific theories. In this connection it also becomes important to determine the conditions for accepting a theory interpreting it in the terms of realism (as a real truth) or in the terms of instrumentalism (as suitable for concising, systematizing, deducing from a given set of informations). A physical theory will have a realistic interpretation if it satisfies the laws of physics, if it is consistent with other knowledge

generally recognised and all observational data, if it contains certain quantities only and is capable to predict new facts, if it has a central hypothesis supported by a wide variety of empirical facts, if it is within the domain of possible human knowledge and explains facts postulated by rival theories, and if it agrees with some non-observational requirements of some preceding theories aimed at explaining the same observations.

To the concept of realism also important are the conditions under which it is reasonable to accept the entities postulated by a theory (processes, states, fields, etc). The entities are treated not as hypothetical, but as if they did exist. The most important conditions are the following:

1. The best known condition states that an item is physically real if this item or event is noticeable when it can be observed.

2. Every non-logical term in a law (empirical or theoretical) indicates something physically real provided that this law has been confirmed by empirical evidence and accepted by the scientific community as probably correct. According to this criterion the physical existence is attributed not only to the entities which can be determined empirically (for instance, electrical resistance of a conductor), but also to theoretical objects such as probability waves.

3. A term concerning something physically real must be present in several empirical laws provided that these laws are logically independent one of another and none of them is logically equivalent to a set of two or more laws. The criterion can be intensified if the existence of more such empirical laws is required. According to this requirement the items identifiable in a different way from and independently of the procedures serving for the purpose of their defining can be described as physically real. For instance in the free-fall law $\vec{g}$ is the acceleration of the Earth's gravity. If this were the only law where $\vec{g}$ appears, then, according to the given criterion, the term gravitational force would indicate nothing physically real. However, since $\vec{g}$ also appears in the formula for the period of pendulum oscillations, physical existence may be attributed to the force of terrestrial gravity.

4. A term indicates something physically real if it appears in a causal law (theoretical or empirical) already confirmed.

5. Anything invariable in a set of transformations, variations, projections or way of observing, given a priori, is real.

When the view of a theory advocated by the realists is concerned, the position of metaphysical realism is of special interest. According to this position there is a reality independent of mind which may be accessible in some way. Real items (objects, events, processes, etc), do exist independent of mind. In other words the entities postulated within any good or acceptable theory do exist. Therefore, physical objects exist though their properties and existence do not depend on whether they are understood, measured, conceived or not. Any physical object corresponds to a set of laws of physics, i. e. stable and objective structures. Laws of physics and some of the properties of individual physical objects are knowable.

The general concepts presented here characterise physical theories and reflect metaphysical assumptions of the research in physics. By means of them one expresses the existence of the world beyond us, its laws and knowability. They cannot be denied either theoretically or empirically but can be only confirmed to some degree (Merril 1980). The research in astronomy and physics should be focused on convincible, clear and fruitful metaphysical systems avoiding the metaphysics of the speculative way of

thinking.

The entities and objective structures postulated in physical theories usually follow from the application of the fundamental laws of physics, corresponding logical and mathematical transformations, principles of philosophy of science. In this process the entities and their properties are often postulated with a high degree of reliability though non-observable directly. Such possibilities are especially due to mathematical physics. The methods and conditions of registering these entities are extended afterwards in the theory of physical experiment, i. e. astronomical observation.

The history of both astronomy and physics offers many examples of this kind. In the middle of the XIX century Adams and Le Verrier, concluded independently of each other, that the perturbations in the motion of Uranus might be successfully explained by the presence of a new planet unknown by that time. The physical basis was Newton's gravitation law. On Le Verrier's insistence the new planet (Neptune) was soon discovered observationally. On the other hand, in 1930 W. Pauli using the law of energy conservation introduced a new particle - neutrino. More precisely, according to the hypothesis during the process of β^+ decay a neutrino leaves the nucleus together with an electron. Neutrino (antineutrino) existed as a hypothetical particle over a long time. The belief that its existence was real was based on the application of energy-conservation law. Later this hypothesis met its experimental confirmation.

1. 5. CONCLUSION

Though it is not deprived of weak points, the concept of scientific theories advocated by realists has met the widest support by scientists and philosophers of science. According to this viewpoint both the theories and entities postulated in them are real.

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