Publ. Astron. Obs. Belgrade No. 85 (2008), 35 - 43 *Invited lecture*

THE OLD AND NEW PHILOSOPHY OF SCIENCE

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Abstract. The aim of this paper is to point out the *essential* differences in the understanding of character of scientific knowledge within the old and new philosophy of science. The old philosophy of science is founded on doctrines of *observationalism* and *inductivism* and centered on the *cumulative* image of the growth of scientific knowledge. More or less, *scientific theories are conceived as true descriptions of relevant experience.* This image is completely changed under the influence of the methodological analysis of scientific revolutions. It appeared that: it is impossible to derive theories from experience in an inductive way; that *pure* experience does not exist -namely, facts (experience) are always interpreted (organized) by some (partly *conventional* or *a priori*) referential framework; that possibility of proof in empirical sciences is *illusory* just as the *conclusive* falsification of scientific statements; that same facts can be explained by *different* (mutually inconsistent or incommensurable) theories; that scientific change often is of a *revolutionary* character, and so on. These methodological facts are the main points of the new philosophy of science, and every approach (among different ones) within that philosophy explains these facts in its own way. However, perceived globally, *today scientific theories are conceived much more as constructions of human reason* (although strictly dictated by demand for their predictive success) *than truths about the world, images of experience (or reality), true descriptions of relevant facts, etc.*

My main intention in this contribution is to analyze and explain the drastic change in the image of science that happened in the transition from the old (empiricist and positivistic) philosophy of science to the new (post positivistic) philosophy of science.

To do this, I will

(1) present the image of science developed as part of the old philosophy of science,
(2) try to point out the basic reasons for the rise of the new philosophy of science; namely, try to explain why the image of science is changed so radically,
(3) describe the main points of the new image of science, or better yet, new *images* of science – because these main points are, in fact, only a common core of several different contemporary conceptions of science; and
(4) give a general description of two basic concept of science within the new philosophy of science.

I

The old philosophy of science[1] depends on two *doctrines* (doctrines, because these beliefs, as we will see later, have no means of justification).

(a) The first one is *observationalism* – the belief that it is always possible to formulate a number of *purely* observational statements presenting an *empirical* basis of the given scientific theory. These statements represent a kind of *description* or even a *image* of pure (autonomous) facts. They are *true* and *infallible* by nature.

(b) The second doctrine is *inductivism* – the belief that it is always possible to derive universal theoretical statements from a relevant set of singular (observational) statements by inductive generalization. This procedure has a *logical* power. Therefore, scientific theories are not only derived directly from experience, but they are also automatically proved to be true.

The basic consequences of these doctrines are as follows:

(1) Scientific knowledge is always a *unique true description* of the relevant field of experience (or even of the relevant segment of reality)[2]. If a theory is *scientific*, it cannot be *false*.

(2) Development of science is strictly *cumulative* by its character. Science is constantly discovering new truths and adding them to old ones (previously discovered). New theories are only extended and may be slightly modified old theories. In this regard, old theories can be *reduced* to new ones. A radical scientific change (revolution) is not possible at all.[3]

(3) Basic scientific terms *do not change its meaning* in the historical perspective.

It is important to see that, within the old philosophy of science, scientific knowledge is conceived in an entirely *passive* manner – as discovery of something already given (but hidden up to now). A *categorial apparatus* or *conceptual framework* used in the process of scientific cognition (investigation) is considered to be consisted of *natural* and *objective* categories or concepts. This means that scientific concepts are not seen as *arbitrary*, *conventional*, and *artificial* even in a minimal sense. Just the opposite, they completely correspond to natural and objective entities. Therefore, in the old philosophy of science, scientific concepts (such as space, time, mass. . . .etc.) are not taken to be something problematic. In that context, *framework* is not even a frequently mentioned term.

[1]By the *old philosophy of science*, I mean the philosophy of science developed in the empiricist tradition that had its peak in logical positivism. This traditional philosophy of science is mostly influenced by Hume and the other British empiricists, Russell and early Wittgenstein (from the period of logical atomism), Mach and other scientists-philosopher from the nineteenth centaury, and of course, Karnap, Reichenbach and other logical positivists.

[2]Logical positivists were inclined to discuss only the description of *experience* because of their *anti-metaphysical* views. Other traditional philosophers of science were mostly realists and asserted correspondence between scientific theory and *reality*. A theory is some kind of image of Reality.

[3]For logical positivists, scientific changes are always cumulativistic episodes. If some great change from the past is obviously not cumulativistic, it must be, it their opinion, the transition from quasi-scientific beliefs to scientific theory. It can be by no means *scientific* theory.

II

It might be said that the reason for radical change in the understanding of scientific knowledge was the methodological analysis of great scientific revolutions.

Namely,

- If the old image of science is correct, scientific revolutions arenot possible.[4]
- Scientific revolutions occur from time to time.
- Hence, the old image of science is not correct.

However, this would not be the whole truth. The methodological analysis was not being so easy, simple and schematic. In fact, there were a number of such analyses going in two directions. One of these directions was to defend the old philosophy of science at any cost.[5] The other was orientated toward a new and more adequate explanation of radical scientific change. Only the latter led to the new philosophy of science.

Nonetheless, the starting point of the crisis of old philosophy of science used to be the same one as the starting point of the crisis of Newtonian physics and Newtonian worldview altogether. This crisis was the consequence of numerous partly scientific and partly philosophical discussions among physicists concerning the *anomalous* character of Maxwell's equations in relation to Newtonian physics, i.e. the consequence of recognizing these equations as an anomaly.[6] This happened at the second half of the nineteenth centaury.

Roughly speaking, it was not possible to reconcile electrodynamics with Newtonian physics and experience. Namely, if electromagnetic radiation moves with the equal velocity in all directions from its source, which also moves itself through *ether* – then something in physical theory is very, very wrong. (Later experiments by Michelson and Morley yielded the same result.)

And really, analyses of this problem showed that there is something wrong with some physical concepts, especially with concepts of *space* and *time*. During that period many valuable contributions were made towards the consideration of the problem, primarily by Lorenz, Fitzgerald, Mach, Poincare. (At that time, a significant conventionalist withdrawal was made from empiricist tradition.)

Einstein solved the problem, partly on this foundation.

But, how did he do it?

[4]This is because a scientific revolution is a change in which the continuity between two theories about the same domain of experience is interrupted. In this case, the principle of cumulativity does no longer holds. Furthemore, meanings of theoretical terms of new theory are changed in relation to the old one.

[5]There were two approaches: (1) to attempt to preserve reductionism. If old theory is not contained in the new one in the full sense, it is still contained in a narrow limit and only approximately. Later, Kuhn convincingly argued that the argument is weak because of the radical change in the meaning of theoretical terms in the new theory. (2) To assert that the Newtonian theory is not *completely* scientific (i.e. that is *partly* mistaken) because it operates with inadequate concepts of time and space. Therefore, the theory of relativity would be its correction. (Hans Reihenbach, *The Philosophy of Space and Time*, Dover, 1957). However, Newtonian theory even now holds as a paradigmatic case of correct scientific theory in a *methodological* sense.

[6]Or, better to say, of recognizing the *fact* these equations *states*, as an anomaly.

It was not an experimental result or empirical discovery. It was in a way a *philosophical*, or even a *semantic* solution. To solve the problem, Einstein *changed the conceptual framework which constitutes experience.*

Later, on the basis of a detailed analysis of scientific revolutions, all assumptions of the old philosophy of science were falsified. They were shown to be absolutely inadequate. However, the process of their criticism was long and difficult. The old image of science was deeply rooted in people's minds. Even today, only this old philosophy of science presents a commonly accepted image of science.

Now, I will consider the main points of the old philosophy of science in light of scientific revolutions, or more precisely, in light of instructions provided by the analysis of the structure of scientific revolutions.

I will start in reverse order – from the last consequence of observationalism and inductivism:

(1) The last consequence of observationalism and inductivism was a point (3) that states that basic scientific terms do not change their meaning in the historical development of science. We have already seen that this statement is completely mistaken. Albert Einstein explained this error or delusion which has the central place in the old philosophy of science with the following words: "Concepts that have proven useful in ordering things easily achieve such an authority over us that we forget their earthly origin and accept them as unalterable givens. .... The path of scientific advance is often made impassible for a long time through such errors. For this reason, it is by no means an idle game if we become practiced in analyzing the long commonplace concepts ... [On the basis of this analysis] [they will be removed...., corrected...... [or] replaced by others, if new system can be established that we prefer for whatever reason."[7]

These Einstein's words, written in 1916, present an unusual anticipation of significant ideas which will occurred later in the new philosophy of science, and especially anticipation of some of Kuhn's important views about the essential role of the variance of meaning of theoretical terms in the growth of scientific knowledge, and many other things, precisely during of the *absolute* domination of the old philosophy of science. This shows that he not only accomplished scientific revolution on the basis of his scientific intuition, but that he also *understood* the basic mechanisms of the development of science far before they were formulated by philosophers of science. He understood them far before other scientists and philosophers of science of that period understood them.

(2) I denoted (2) *cumulativism* as the second consequence of the two doctrines of the old philosophy of science. This consequence failed because of the extremely different structure of theories divided by scientific revolution. As a result of their different conceptual frameworks, reduction between such theories is not possible. They are mutually inconsistent and in many cases even incommensurable (namely, the categories they operate with are disparate and cannot be reconciled by any means).[8]

[7]Albert Einstein, "Ernst Mach", *Physikalische Zeitschrift* 17 (1916)., 101-104. Cited from Don A. Howard, "Einstein's Philosophy of Science" (Stanford Encyclopedia of Philosophy), http://plato.stanford.edu/entries/einstein.philscience/. Written in 2004.

[8]Tomas Kuhn convincingly argued in favor of incommensurability in *The Structure of Scientific*

(3) From reasons listed above, scientific knowledge cannot be considered to be a true description of experience or reality (in terms of correspondence or some kind of image).

Therefore, observationalism and inductivism must be mistaken, since their consequences are mistaken.

However, there is a lot of *independent* evidence supporting this conclusion.

Concerning induction, it is completely clear that a universal statement cannot be derived from a *finite* set of singular statements in any logically valid way.[9]

Concerning observationalism, it is clear that different frameworks must give different interpretations of the same *raw* experience. So-called observational statements are not neither true nor infallible. Strictly speaking, they do not exist at all. They are rather statements that are the result of an interaction between the conceptual framework we used, and a raw experience given to us by environmental stimuli. If the conceptual framework is changed, the "observational" statement will also change its character. In this sense, we can perceive the conceptual framework as a kind of *a priori* theory that *organizes* a raw experience in one way or another.[10]

III

The new philosophy of science is a result of the above considered insights. However, it is not *monolithic*. It consists of a number of conceptions concentrated around several statements that can be conceived as a *common core* of the new philosophy of science. *But different philosophers interpret these statements in different ways.* Again, this means that the statements do not present *one* consistent philosophical theory of science, but that to a greater or lesser degree they represent only the core of all contemporary conceptions - however, a core that is differently interpreted within each of them. Therefore, in fact, there are *several different philosophies of science*

Revolutions, Chicago, The Chicago University Press, 1970 (The first edition from 1962). Meanings of theoretical terms in some successive theories divided by revolutions are so different that they cannot be reconciled by any means.

[9] Undoubtedly, the most prominent critic of induction was Karl Popper. He strongly criticized induction already in his first book *Logik der Forschung*, Wien: Julius Springer, 1934. (The first English revised edition: *Logic of Scientific Discovery*, London: Hutchinson, 1959.). In his opinion, induction is neither logically valid (as Hume showed long before), nor is used in science at all. Instead of it, the *hypothetico-deductive* method is used.

[10] For insance, Popper writes: "Our observational experiences are never beyond being tested; and they are impregnated with theories....Even a 'phenomenal' language permitting statements like 'now here red' would be impregnated with theories about time, space, and color." (*The Logic of Scientific Discovery*, London: Hutchinson, 1972., p.111.) and "... sense-data, untheoretical items of information, simply do not exist. For we *always* operate with theories, some of which are eve incorporated in our physiology. And a sense-organ is akin to a theory: According to evolutionist views, a semse-organ is developed in an attempt to adjust ourselves to a real external world, to help us to find way through the world. A scientific theory is an organ we develop outside our skin, while an organ is a theory we develop inside our skin. This is one of the many reasons why the idea of completely untheoretical, and hence incorrigible, sense data is mistaken. We can never free observation from the theoretical elements of interpretation. We always interpret; that is we theorize, on a conscious, on an unconscious, and on a physiological level." (Imre Lakatos and Alan Musgrave (eds.), *Problems in the philosophy of Science*, Amsterdam: North-Holland 1968., pp. 163-164.)

today, and several different images of science.

The following statements can be considered as constituents of the core of the new philosophy of science:

(1) *Universal scientific statements cannot be derived from experience.*

Rather, they are imposed on experience. The reason is clear: pure observational statements are illusions, and induction is a myth. On the other hand, we organize experience according to conceptual frameworks, which are changeable.

(2) *Universal scientific statement cannot be proved by experience in a non-inductive way.*

In principle, all scientific theories are false. The development of science shows that false theories are always being changed by other false theories – at least up to now (negative induction).

Even if some of them were true, we could not know that.

Why?

If induction is not a logically valid method, then reasoning in science can be in the shape of *affirmation of consequent.*

$T \Rightarrow O_1, O_2, O_3, \ldots\ldots\ldots O_n$ observational consequences of T

$\underline{O_1, O_2, O_3, \ldots\ldots\ldots O_n}$ real evidence

Then T

But affirmation of consequent is a *logical fallacy.* We keep theories only in so far as they have good predictions – later; we abandon them, and try to formulate others.

(3) *Scientific statement or hypothesis cannot be even refuted conclusively.*

The famous Duhem, or Duhem-Quine thesis, may be expressed as follows: conclusive refutation of single scientific hypothesis is never possible in spite of available empirical counter-evidence because, due to the essential interdependence of hypotheses within a theoretical system, it is always possible to save the given hypothesis by some adequate modification elsewhere in the system.[11]

$H \Rightarrow O_1$.. Hypothesis H implies observational consequence O_1

$\underline{\quad \neg O_1}$.. We have observational evidence non- O_1

$\neg H$ We refute hypothesis H

This is a poor simplification, because the essential interdependence of hypotheses within a theoretical system is ignored. There is always a set of other hypotheses without which it is not possible to derive the observation consequence O_1.

$(H \ \& \ A) \Rightarrow O_1$.. A is a set of other (auxiliary) hypotheses

$\underline{\qquad\quad \neg O_1}$

[11] *Cf.* Pierre Duhem, *The Aim and Structure of Physical Theory*, New York: Atheneum 1974. ch. 10 (the first french edition is form 1905.).

$\neg$(H & A) it is realistic situation
and in this case it is always possible to formulate a set A* (a modified set of auxiliary hypotheses) so that

(H & A*) $\Rightarrow \neg O_1$ and in this way to save H, because

(H & A*) $\Rightarrow \neg O_1$

$\underline{\qquad\qquad\quad \neg O_1}$

(H & A*) hence, H holds

(Of course, the other possibility is to refute H and retain A.)

(4) *The underdetermination of theory by data.*

This thesis consists in the following: If we have theory T, we can always construct alternative theory T* which will be empirically equivalent to T (having the same observational consequences) and will be logically incompatible with T in the non-trivial sense (i.e., it is not only a different formulation of T apparently incompatible with it). This thesis is in close connection with Duhem-Quine thesis. In Quine's words: "We may expect this because of how scientists work. For they do not rest with mere inductive generalizations of their observations: mere extrapolations to observable events from similar observed events. Scientists invent hypotheses that talk of things beyond the reach of observation. The hypotheses are related to observation only by a kind of one-way implication; namely, the events we observe are what a belief in the hypotheses would have led us to expect. These observable consequences of the hypotheses do not, conversely, imply the hypotheses. Surely there are alternative hypothetical substructures that would surface in the same observable ways."[12]

(5) *The role of the conceptual framework is of paramount importance to knowledge.*

There is no knowledge without it; or reasoning, perception, formulation of facts, etc. A framework orders our experience in accordance with its schemes - - by *segmentation* and *classification* of the given raw material, and by *organization* of the so obtained elements into perception and other cognitive structures. A framework is *a priori* to experience. Also, it is *arbitrary* in a sense. However, changes of frameworks always have to be orientated toward solutions of cognitive problems. Different frameworks may be equally successful in organization of experience, but it does not mean that all possible frameworks are equally successful.

It means that categories, our framework works with, are not *natural* and *objective*, as in traditional view. Just the opposite, they are *conventional* and *subjective*. They are *conventional* in a sense that we create them in a way that we consider they provide the best organization of experience in accordance with our (scientific) needs. They are *subjective* in a sense that they are created by some individual subject of knowledge, or group of them.

[12] W. V. O. Quine, "On Empirically Equivalent Systems of the World", *Ertkenntnis*, 9 (1975), p. 313.

This approach resembles to Kantian position - but only resembles it. There are also essential differences between them. For Kant, categories are *natural* and *subjective*. However, they are *natural*, not because they are taken from reality, but because they are *inborn*. Furthermore, they are *subjective* because they belong to the human race as a collective subject of knowledge. In this way, these categories are *unchangeable* and *a priori*. On the other hand, within the new philosophy of science, categories are *changeable* and also *a priori* - but a priori in a slightly limited sense - they have to be tuned to ensure operational accordance between theories and experience.

(6) *Scientific knowing is very active process in the new image of science.*

It is not the relatively *passive* description of experience (reality). It is the organization and construction of experience (or a model of reality). So, scientific activity is free to a *great extent*, but *not completely* free: such constructions must be in operational accordance with the *given* (with raw experience).

(7) *Scientific revolutions are, and must be, one of the essential characteristics of the development of science.*

They are episodes in which conceptual frameworks (or paradigms, categorical apparatuses, etc) of comprehensive theories usually are radically changed. In that sense Kuhn sees the development of science though the following scheme:
Normal science ⇒ crisis ⇒ revolution (new paradigm) ⇒ new normal science ⇒ new crisis....

IV

Philosophers who work today within the new philosophy of science may be roughly divided into two groups: Rationalists and Relativists.

Relativists assert that because of disparate frameworks, theories separated by radical scientific revolutions (for example, Newtonian and relativistic) are *incommensurable*. They *cannot* be compared. We may feel (have intuition) that newer is better, but there is no operative method to show that.

The development of science consists simply in achieving plenty of particular comprehensive theories. Each of them is adequate for its own experience. However, human experience has the tendency to expand. When experience becomes too expanded and starts to show anomalies, the old framework must be changed - and we give a new comprehensive theory. Such a theory is not better then the old one, not truer - it is only adequate for its own experience. That is all.

On the other hand, rationalists claim that usually it is possible to determine a better theory from the set of rival theories (irrespective of their different frameworks).

They admit that contemporary theories are not derived from experience, are not true, are not description of reality, and may be changed with different (incompatible), but equally good theories (underdetermination), and so on.

However, they also asserts that frameworks are constantly improving, and theories are getting increasingly truer - in terms that *over time* concepts correspond increasingly more to objective and natural entities.

Therefore, in a hypothetical future, the image of science from the old philosophy of science will be achieved.

However, this rationalists approach appears like an ideological dream. It has great problems concerning commensurability of theories, possibility of their appraisal and estimation, and especially, concerning the nature of truth (What does it mean, what does true description of reality mean at all, what is reality, what kind of a relationship exists between reality and the subject of knowledge, etc).[13]

[13]It would be said that the new philosophy of science starts - in a systematic way - with Popper's *Logik der Forschung* (cited edition). Of course, even before this book there were texts that had strong influence on this philosophy (as, for instance, already mentioned Duhem's book). Among the texts that determined the course of new philosophy of science the following are certainly very significant: already mentioned books by Karl Popper (The Logic of Scientific Discovery), and Thomas Kuhn (The Structure of Scientific Revolutions), then, Imre Lakatos, *The Methodology of Scientific Research Programmes*, Cambridge, Cambridge University Press, 1978. (Especially, "Falsification and the Methodology of Scientific Research Programmes"). Paul Feyerabend, *Against Method*, London: Humanities Press, 1975., P. Feyerabend, "Explanation, Reduction, and Empiricism", in H. Feigl & J. Maxwell (eds.), *Minnesota Studies in the Philosophy of Science*, vol. III, Minneapolis: University of Minnesota Press, 1962., Larry Laudan, *Progress and its Problems*, London: Rutledge and Kegan Paul, 1977. and Barry Barnes, David Bloor & John Henry, *Scientific Knowledge*, Chicago: The University of Chicago Press, 1996.