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LANGUAGE AND UNDERSTANDING IN SCIENTIFIC KNOWLEDGE

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Abstract. Since the birth of non-classical science starting with quantum theory in 1927, the language of contemporary physics and cosmology has been "beautified" by a nosegay of pure theoretical constructs. Besides, the quantum phenomena display incompatible properties. An interpretation of the quantum theory to provide an understanding of its subject matter proved to be necessary. Thus the Copenhagen interpretation appeared together with quantum mechanics, which was prevalent till the end of the 80ies of the past century. Alternative interpretations have also appeared, the suggestions of which have been due to philosophical reasons, spreading among different versions of realism and subjectivism. It was Richard Feynman who declared: "I think I can safely say that nobody understands quantum mechanics." The problem emerges then which of the following two cases must be preferred: that of a lack of interpretation, without which no understanding is possible, or that of several alternative interpretations – a case which also impedes understanding, since it is in need of only one of them. This "interpretational" problem is standing today not only in front of the quantum theory, but in front of alternative views of the evolutionary mechanism in biology, and in front of cosmology, as well.

Keywords: understanding, interpretation, pure theoretical constructs

1. That language is, or could be used as means of communication is a trivial fact. And communication is void of content without the act of understanding. The language of any discourse is thus assumed to be understandable for the communicators.

2. Everyday language has greater communicative scope than specialized languages used in the contemporary scientific enterprise. This is true to the effect that theoretical languages in science are used for the explanation and prediction of facts that belong to special domains displaying strict ontological boundaries. Such boundaries are practically absent, or rather very flexible, for the world of the man on the street. Nevertheless, until the beginning of the 20th century, theoretical concepts in science have not been severed from the conceptual base of the common everyday language despite their special usage, which is subordinated to strict definitions. The mathematical garments of some such concepts are not a counterexample, since they represent in a

formal manner concepts like force, energy, velocity, trajectory, etc., which are often and readily used in everyday life too, and evoke no embarrassment among communicators.

3. Since the formulation of the general theory of relativity in 1916, and especially since the birth of non-classical science in 1927 when quantum mechanics was put forward as the first theory about the micro-world, the scientific language is being permanently enriched by what is dubbed "*pure theoretical constructs*" in an epistemological jargon. Unlike "ordinary" theoretical concepts, which have links with empirical concepts, and thus with experience, pure theoretical constructs are said to have no direct referents. Such are for instance terms like 'charm' and 'colour', expressing specific properties attributed to some quantum objects, but which have nothing to do with the everyday meaning and usage of these terms.

4. The founders of quantum physics Niels Bohr and Werner Heisenberg maintain that we are facing a strange situation: we express all experimental results by using classical concepts only, while the formal mathematical descriptions go beyond the linguistic expressiveness of a unique theoretical vocabulary. The so called *principle of complementarity* was suggested to account for the contradictory behavior of atomic objects. It states that we must rely on two different vocabularies of usual (classical) terms representing the kinematical characteristics of these non-classical objects, from one side, and their dynamic properties, from another side. This is expressed by Heisenberg's uncertainty relations between conjugated measurable quantities in a "strange" way: the knowledge of the value of one of two conjugated quantities leads to the absence of knowledge of the value of the other. If we know for example the place of an electron in space, we do not know the magnitude and the direction of its momentum (the product of its mass and velocity). The principle of complementarity is at the heart of the well-known Copenhagen interpretation of quantum mechanics, but what is most important here is *the necessity of such an interpretation*. Because without it one is deprived of understanding what happens within the domain of quantum phenomena. The abstract mathematical formalism, in spite of its predictive potential, *cannot provide an understanding of the ontology of the micro-world*. As John Cramer puts it, the cognitive function of this interpretation "relates to the question of how the theory deals with unobserved objects" (Cramer 1986, 650). "Unobserved objects" are those hypothetical entities, which are linguistically represented by pure theoretical constructs or terms as the above mentioned in (3).

5. It is sometimes declared that the way out of this epistemological situation is the claim that a non-classical object could not be adequately accounted for unless we change our logic. Thus different versions of *quantum logic* have been suggested for depicting phenomenal paradoxes. But how can a change in

logic contribute to grasping the behavior of quantum objects?[1)] The absence of a cogent answer to this question was the cause for working physicists not to climb on the route of contriving non-classical logical systems, yielding it to the passion of the mathematical logicians.

6. Different competing interpretations of quantum mechanics have appeared since the birth of this theory historically furnished with its Copenhagen interpretation. Leaving aside the theoretical arguments for their proposal and defense (often philosophically motivated by realist or antirealist predilections),[2)] these interpretations appear to be indispensable. For if no interpretation, no understanding of the subject matter of the quantum theory.

7. Understanding of the subject matter of any scientific theory is provided by its conceptual base embedded in its ontology. The different interpretations of quantum theory are certainly a part of the theoretical ontology. Hence, *there are different ways in which the nature of the micro-world is being construed*.

8. The different ways for one to construe the nature of the micro-world are dependent on the semantics of the languages expressing the different interpretations of the theory. As David Finkelstein puts it, "Quantum theory was split up into dialects. *Different people describe the same experiences in remarkably different languages*. This is confusing even to physicists."[3)] Even within the conceptual boundaries of one and the same interpretation one could face *problems with a lack of understanding*. And even N. Bohr, though being the father of the Copenhagen interpretation, has once conceded that: "For those who are not shocked when they first come across quantum theory *cannot possibly have understood it*."[4)] In the end Richard Feynman's famous declaration deserves a special mention: "*I think I can safely say that nobody understands quantum mechanics.*"

9. It was contended in (6) that "interpretations appear to be indispensable, for if no interpretation, no understanding of the subject matter of the quantum theory". But whether such an understanding is really important for scientific practice?

10. If R. Feynman is right that nobody understands quantum mechanics (see the last claim in (8)), and scientists still solve problems both within, and by the help of quantum theory, then the following question comes to the fore: "Which epistemological situation deserves preference in the case of quantum theory: the lack of an interpretation, or different competing interpretations?" *This is a real problem, because both situations are connected with a lack of understanding*. The first of them directly, and the second one indirectly, in so far as many attempts at understanding one and the same thing leads in the end to a lack of proper understanding.

11. If solving problems within the quantum theory is based on the power of mathematics – "that pride of human reason" according to Kant's famous dictum –

and reduced to formal calculations needed for obtaining practical results, one can evade the necessity of an interpretation. But any further theorizing about the micro-world would be hampered without an even scarce understanding of the nature of quantum objects and their interactions. And as was pointed out in (6-7), this understanding is provided through an interpretation. It seems to follow then that a set of interpretations is better than a lack of any interpretation, and thus the problem in (10) appears to be solved. The expectation is that at least one of the (extant or future) interpretations could lead to some kind of scientific progress. But as far as we rely on expectations only, the "interpretation" problem is going to persist. This problem stays not only in front of quantum theory, but also in front of evolutionary theory, contemporary cosmology, and in front of each theoretical model, based on an abstract theory, which itself is in need of an interpretation. Thus for instance, one and the same set of astronomical data covered by a general theoretical scheme, usually named Big Bang cosmology, undergoes different interpretations. They provide different explanations about the cause for the accelerated expansion of the Universe, and what is more important, about the reason for its birth embedded into the strong teleological Anthropic Principle, the classical naturalistic explanation, and the new paradigm of the cosmic landscape.

12. A "meta-interpretational" problem peeps behind the curtain of our analysis. It is presented by the question: "Which of two or more interpretations a theorist ought to choose in order to continue her research program?" The answer to this problem presupposes some arguable criterion for choosing among interpretations. This criterion must be conceptually both strong and broad enough for its aim to pick one among several quite abstract hypothetical possibilities. *It can only be of philosophical nature.*

A nice example for this is the Einstein-Bohr discussion about the completeness of quantum mechanics. According to the Copenhagen interpretation (initiated by Niels Bohr and Werner Heisenberg) quantum mechanics is assessed to be a complete theory. Albert Einstein, however, has held the opposite position: "I am, in fact, firmly convinced that the essentially statistical character of contemporary quantum theory is solely to be ascribed to the fact that this [theory] operates with an incomplete description of physical systems" (Einstein 1970, 666). In contrast to the operational view of N. Bohr to the effect that to determine a physical quantity would mean its experiential observation, Einstein's philosophy could be qualified as constructive realism. His response to the question "How knowledge is possible?" is close to Kant's response. Human cognitive faculties are well tuned to produce different kinds of representations, and the formation of abstract theoretical concepts is a creative activity of human mind. The constructive character of A. Einstein's realism is evinced in a best way in his attitude to quantum mechanics. Unlike the representatives of the Copenhagen interpretation who reject the possibility for a theoretical presentation of atomic objects within space and time (or space-time) that goes beyond their observational appearances, A. Einstein is dissatisfied with the statistical description of their behavior, and believes that such a presentation is attainable through a theoretical model. It seems that the contemporary super-string theory is a good example concerning this expectation of Einstein. Many different interpretations of the quantum theory have been suggested since Einstein's death. One of the most popular is the so called "Many-world interpretation". But it is worth repeating here that the incentives for upholding these different interpretations have a philosophical backing. Even Steven Weinberg, who has a negative opinion concerning the role of philosophy in scientific research, concedes that scientists exploit some working philosophy (1993, 133), and also argues that "all physicists need some sort of tentative worldview to make progress (1993, 135). Indeed, a "working philosophy", or a "tentative worldview" determine the conceptual path of every scientific investigation aiming at some truth about its subject matter. Or, to make use of Einstein's words: "It is open to every man to choose the direction of his striving; and also every man may draw comfort from Lessing's fine saying, that the search for truth is more precious than its possession" (Einstein, 1982, 334-335).

NOTES

1. By "grasping the behavior of quantum objects" I mean explaining their behavior on the basis of knowledge of their nature, i.e. of the type of their structure and of exhibition of observable properties.

2. See in this connection (Anastassov and Stefan

3. (Finkelstein 2004, 181), my italics.

4. N. Bohr quoted in (Heisenberg 1971, 206), my italics.ov 1986).

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