EINSTEIN's "COSMIC RELIGION" AND WIGNER's "EMPIRICAL LAW OF EPISTEMOLOGY"

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Introduction

In the numerous texts of a various sort belonging to classics or the leaders of theoretical and mathematical physics of the XX-th century (from the articles and textbooks up to philosophical and methodological sketches and memoirs), we quite often meet with rather high, pathetic expressions and even with quasi-religious terminology. To some of these expressions repeatedly paid attention E.L.Feinberg by study of intuitive judgements in the science [1,2,3]. The importance of such judgements for the theorists with its unprovability, and logic undeducibility requires attributing to them an imperative character. It forces scientists to use expressions of emotional and even religious kind. The important example, in Feinberg's opinion, gives a statement about reality and cognizability of the physical world, in particular the Einstein's credo: "Most inconceivable in the world that it is conceivable" [1, p.115].

Below we shall consider large group of similar statements concerning "mathematicity" of the physical world, and connected with this "cosmic religion" of Einstein and so called "empirical law of epistemology" of E.Wigner.

From Pythagorean "all things are numbers" to "pre-established harmony" between mathematics and physics

W.Heisenberg remarked correctly, that in the Pythagorean school "has been established the connection between religion and mathematics which ever since has exerted the strongest influence on human thought" and hat "Pythagoreans seem to have been the first to realize the creative force inherent in mathematical formulations" [4, p.67-68]. The Pythagorean line was continued by Plato in his conception of matter on the basis of the doctrine of regular polyhedrons.

The Pythagorean tradition developped in the doctrines of medieval scholastics which considered that God had created the world on a rational mathematical basis has opened in XVII-th century a way for the study of nature as the search for mathematical laws and structures revealing the essence of phenomena and, at the same time, plans of the Creator. Each of coryphaeuses of the scientific revolution of the XVII century (J.Kepler, G.Galilei, R.Descartes, G.W.Leibniz, Ch.Huygens, I.Newton etc.) emphasized in the most high-toned expressions the Pythagorean idea about the divine mathematicity of reality. We shall cite the laconic and expressive formula of Leibniz: "Cum Deus calculat, fit Mundus" sounding in English approximately: *"As the God calculates, so the world works"* (Quoted sentence from [5, ch.12]). Gradually, in the second half of the XVIII – in the beginning of the XIX centuries it happens "removal" of God from mathematical research.

The French leaders of the exact natural sciences J.L.Lagrange, P.S.Laplace, S.D.Poisson, J.B.Fourier, A.M.Ampère etc. almost did not use quasi-religious terminology in the discussions of the mathematical structures of Nature. Nevertheless just mentioned French scientists have

revealed mathematical structure of classical physics, by establishing that the fundamental laws of electricity and magnetism optics, thermal phenomena are described in language of the mathematical analysis, first of all theory of the differential equations with partial derivatives of the 2-nd order. It has become one of the main nerves of the scientific revolutions connected with the creation of classical physics [6].

The next revival of the Plato-Pythagorean tradition, and thus with rather intensive use of the "ennobling", high-toned formulations, right up to quasi-religions expressions, we find out during the development of the mathematically refined relativistic and quantum theories. The expressions in the spirit of Kepler and Leibniz revive also; they are used also by mathematicians (D.Hilbert, H.Minkowski, F.Klein, later - N.Bourbaki) and by physicists (A.Sommerfeld, M.Planck, W.Heisenberg, M.Born, P.Dirac, E.Wigner and certainly Einstein etc.).

D.Hilbert in his Paris report "Mathematical problems" (1900) speaks about "pre-established harmony" between mathematics and physics [7, p.292]. After 30 years enriched by the experience of the participation in elaboration of the general theory of relativity and quantum mechanics, he again speaks about this "pre-established harmony", the most magnificent and most wonderful example of "which is the general theory of relativity and quantum mechanics" [8, p.961].

By mention of this "pre-established harmony between pure mathematics and physics" in case of special theory of relativity the famous report of H.Minkowski "Space and time" (1908) about the four dimensional formulation of this theory [9, p.111] is concluded. The phenomenon of this "pre-established harmony" was marked not only by outstanding Goettingen mathematicians which have brought in first third of the century the significant contribution in quantum-relativistic revolution [10], but also by the physicists-theorists, which were the founders of these theories: by Einstein, Sommerfeld, Heisenberg, Born, Dirac, Schroedinger, Wigner and others.

In 1930-th about it rather colorfully spoke A.Sommerfeld, reminding Plato's expression that God is geometer, and emphasizing, that Nature is considerably better mathematician than we are [11, p.111-113]. W.Heisenberg, one of his most famous pupils wrote just about the same in 1950-th: *"If we follow the Pythagorean line of thought we may hope that the fundamental law of motion will turn out as a mathematically simple law... It is difficult to give any good argument for this hope for simplicity-except the fact that it has hitherto always been possible to write the fundamental equations in physics in simple mathematical forms. This fact fits in with the Pythagorean religion, and many physicists share their belief in this respect, but no convincing argument has yet been given to show that it must be so"* [4, p. 73].

Other founder of the quantum theory P.Dirac in the beginning of 1960-th spoke out in the same spirit: *"It seems be one of the fundamental features of nature that fundamental physical laws are described in terms of a mathematical theory of great beauty and power, needing quite a high standard of mathematics for one to understand it. You are wonder: Why is Nature constructed along this lines? One can only answer that our present knowledge seems to show that Nature is so constructed. We simply have to accept it. One could perhaps describe the situation by saying that God is a mathematician of a very high order, and He used very advanced mathematics in constructing the Universe. Our feeble attempts at mathematics enable us to understand a bit of the Universe, and as we proceed to develop higher and higher mathematics we can hope to understand the Universe better"* [12, p. 53].

Let's notice, that the phrase about God-mathematician in Russian translation of this Dirac's article is absent [13, p. 139]. The absurdity of the censorship's tyranny in this case is amplified by that circumstance, that Dirac was not only nonbeliever, but, if we can trust Heisenberg, even a "militant atheist" [14].

This phenomenon continues to be discussed by mathematicians and theorists right up to the present time, including Russians. For the sake of brevity, we only shall refer (no adducing the

citations) to the statements of N.Bourbaki [15, p.231], V.I.Arnold [16, p.5], Yu.I.Manin [17, p.4], I.Yu.Kobzarev and Yu.I.Manin [18], L.D.Faddeev [19, pp. 11-12].

Bourbaki spoke that the physical theories are kept within mathematical structures "as though as a result of predetermination"; Arnold noticed, that this harmony between mathematics and physics "so has struck Newton, that he has found as a proof of existence of God"; Kobzarev and Manin speak about "double being" or "double semantics" of language of the physical theory; Faddeev emphasizes fundamentality of essentially empirical (and consequently mysterious) fact of the mathematical construction of the physical world etc. E.Wigner at the end of the 1950-th has found one more successful name for this fact, by naming it "unreasonable effectiveness of mathematics in the natural sciences" [20, p. 222].

The "Cosmic religion" of Einstein

Intensive use of a quasi-religious terminology can be found in the philosophical and methodological texts and in those devoted to the history of science by Einstein, which introduced such expressions as "cosmic religion", or "cosmic religious feeling", for a designation of deep belief of the physicists in the rational structure of the world. For the first time, apparently, this expression occurs in his articles and speeches in the beginning of the 1930-th, though close ideas, a sketch of his epistemological credo are contained in his speech devoted to the 60-year jubilee of M.Planck (1918) [21, pp. 226-227]. This sketch contains also Einstein's model of constructing the scientific theory, later stated rather laconically and clear in the letter to M.Solovine (from May 7, 1952) [22]. Also it is spoken rather pathetically about "the supreme task of the physicist", and about "pre-established harmony" of G.W.Leibniz, and about "the state of mind" of the theorist close "religious worships or love". In view of importance and "primacy" of this text, we shall cite rather extensive excerpt from it: "The supreme task of the physicist is to arrive at those universal elementary laws from which the cosmos can be build up by pure deduction. There is no logical path to this laws; only intuition, resting on sympathetic understanding of experience, can reach them. In this methodological uncertainting one might suppose that there were any number of possible systems of theoretical physics all equally well justified; and this opinion is not doubt correct, theoretically. But the development of physics has shown that at any given moment, out of all conceivable constructions, a single one has always proved itself decidedly superior to all the rest.

Nobody who has really gone deeply into the matter will deny that in practice the world of phenomena uniquely determines the theoretical system, in spite of the fact that there is no logical bridge between phenomena and their theoretical principles; this is what Leibnitz described so happily as a "pre-established harmony"... *"The longing to behold this pre-established harmony is the source of the inexhaustible patience and perseverance with Planck has devoted himself, as we see, to the most general problems of our science, refusing to let himself be diverted to more grateful and more easily attained ends. I have often heard colleagues try to attribute this attitude of his to extraordinary willpower and disciplinewrongly?, in my opinion. The estate of mind which enables a man to do work of this kind is akin to that of religious worshiper or the lover; the daily effort comes from no deliberate intention or program, but straight from the heart"* [21, pp. 226-227].

In 1930 in the essay about J.Kepler, Einstein comes back to the idea of this harmony, and this time the question is just about pre-established harmony between physical reality and mathematical structures: "Our admiration for this splendid man is accompanied by another feeling of admiration and reverence, the object of which is no man but the mysterious harmony of nature into which we are born. (i.e. the same "cosmic religious feeling" - V.V.) [23, p.265].

Further Einstein, on an example of conic sections realized in orbits of heavenly bodies, explains the sense of this harmony and summarizes: *"It seems that the human mind has first to construct forms independently before we can find them in things (i.e. to develop mathematical structures* - V.V.)". [23, p. 266].

However, both Einstein and respected by him Planck, and other theorist, speaking about elements of religion and belief in scientific cognition, quite often meant the belief in real existence of the world, of nature, or the belief in their cognizability, in their rational structure etc. Let's adduce one more rather voluminous Einstein's statement in 1930, in which, probably, for the first time is spoken about importance of "cosmic religious feeling", consisting in "a conviction of the rationality of the universe": *"...I maintain, that the cosmic religious feeling is the strongest and noblest motive for scientific research. Only those who realized the immense efforts and, above all, the devotion without which pioneer work in theoretical science cannot be achieved are able to grasp the strength of the emotion out of which alone such work, remote as it is from the immediate realities of life, can issue. What a deep conviction of the rationality of the universe and what a yearning to understand, were it but a feeble reflection of the mind revealed in this world, Kepler and Newton must had to spend years of solitary labor in disentangling the principles of celestial mechanics!...It is cosmic religious feeling that gives a man such strength. A contemporary has said, not unjustly, that in this materialistic age of ours the serious scientific workers are the only profoundly religious people"* [24, pp. 39-40].

This conviction stated by Einstein repeatedly in 1930-th and 1940- — 1950-th, has kept up to the end of his life. In the letter to M.Solovine from January 1, 1951 he wrote briefly and expressively, but, in fact, about the same: *"...I have found no better expression, than "religious" for confidence in the rational nature of a reality...Wherever this feeling is absent, science degenerates into uninspired empiricism"* [22, pp. 119]. The understanding of "rationality", "of the rational structure of the universe", "of the rational nature of reality" Einstein connected with mathematical construction of the world, with "pre-established harmony" between mathematics and physical reality. In 1933 he wrote: *"Our experience hitherto justifies us in believing that nature is the realization of the simplest conceivable mathematical ideas. I am convinced 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. Experience may suggest the appropriate mathematical concepts, but they most certainly cannot be deduced from it. Experience remains, of course, the sole criterion of the physical utility of a mathematical construction. But the creative principle resides in mathematics. In a certain sense, there - fore, I hold it true pure thought can grasp reality, as the ancients dreamed"* [25, p. 274].

So "the cosmic religious feeling" of Einstein is closed with Hilbert's and Minkowski's "pre-established harmony", with mathematical conception of the world of Plato and the Pythagoreans, about which spoke Sommerfeld, Heisenberg, Dirac and others and with "the unreasonable effectiveness of mathematics in the natural sciences" of Wigner. By the way, Wigner reformulated a little his conception of "unreasonable effectiveness of mathematics" by attributing it the status of the fundamental epistemological law.

"The empirical law of epistemology" of Wigner

Wigner also begins from fixing the phenomenon of "unreasonable effectiveness": *"My principal aim is to illuminate it from several sides. The first point is that the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it."* [20, p. 223].

Further, it seems to him not less amazing "that the mathematical formulation of the physicist's often crude experience leads in an un- canny number of cases to an amazingly accurate description of a large class of phenomena". [20, p. 230].

Laws of nature formulated in mathematical language, notes then Wigner, have unprecedented accuracy, but, at the same time, they have validity in the precisely outlined area of change of characteristic physical quantities. Just this combination of features of interrelation of physics and mathematics he has offered to name as "the empirical law of epistemology"; "the preceding three examples (i.e. Newton law of gravitation, quantum mechanics and quantum electrodynamic theory of Lamb shift - V.V.), which could be multiplied almost indefinitely, should illustrate the appropriateness and accuracy of the mathematical formulation of the laws of nature in terms of concepts chosen for their manipulability, the "laws of nature" being of almost fantastic accuracy but of strictly limited scope. I propose to refer to the observation which these examples illustrate as the empirical law of epistemology" [20, p.233].

This "law", according to Wigner concerns to epistemology and in this respect is related to methodological principles of physics. But Wigner compared it only with principles of invariance ensuring, in particular, opportunity of experimental confirmation of the physical theories. However meaning of Wigner's "law" is different: *"If the empirical law of epistemology was not correct, we would lack the encouragement and reassurance which are emotional necessities, without which the "laws of nature" could not have been successfully explored"* [20, p. 233].

Unlike the same principles of invariance, which we can give an non-trivial theoretical (logic, philosophical) substantiation, the concept of "pre-established harmony" or its Wigner's form, are deprived of such substantiation, but prove to be true by all experience of history of physics. Therefore Wigner names the discussed "law of epistemology" empirical and by advice of one of the colleagues has agreed to attribute to it the status of "an article of faith of the theoretical physicist", as it obviously is not a "necessity of thought" [20, p.233].

Wigner does not use a quasi-religious terminology, but the epithets "supernatural", "wonderful" etc. with reference to this law are quite characteristic of him. Thus he emphasizes that many of physicists and mathematicians are not amazed already by discussed harmony and perceive it as a self-obvious "fact": *"It is surprising how readily the wonderful gift contained in the empirical law of epistemology was taken for granted"* [20, p. 233].

Further Wigner notes some difficulties connected with "unreasonable effectiveness of mathematics" in physics: its "empiricism" and uncertainty, of its borders of applicability; going out of the frameworks of that part of the observable phenomena, which we consider as "initial conditions"; absence of unified mathematical structure, which should be displayed in case of complete "pre-established harmony"; the existence of the obviously erroneous physical theories having nontrivial mathematical structures and uncommon power of explanation and prediction (for example, Ptolemy's system, the "old" quantum theory etc.). And, despite of it, he considers that the outstanding successes of the Plato-Pythagorean conception are unprecedented: *"Let me end on a more cheerful note. The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning"* [20, p. 237].

The final remarks

The given material and its analysis have shown deep relationship or even equivalence of such phenomena of the theoretical cognition in modern physics (wider — in physics of XX century),

as "pre-established harmony" between mathematics and physics, "unreasonable effectiveness of mathematics in the natural sciences", "cosmic religion" of Einstein and Wigner's "empirical law of epistemology". These phenomena "considered as manifestation of one fundamental regularity of the scientific knowledge, have the several interconnected features:

1) evident connection of this incorporated phenomenon with Pythagorean tradition of scientific cognition;

2) its empirical character, i.e. its repeated verification by all experience of the development of theoretical physics;

3) its empirical character meaning the absence of any convincing logical, theoretical or philosophical substantiation;

4) the accompaniment of this phenomenon with a halo of quasi-religious (or high-toned) expressions;

5) giving it the character of the epistemological imperative and the emphasizing of its extraordinary importance as a powerful emotional stimulus in the work of the theorists.

The absence of a convincing logical substantiation of this phenomenon and in the same time its confirmation by historical experience of the development of physics and consequently the confidence of the theorists in its efficiency results in necessity to make it aesthetic, emotional attraction, "to consecrate" it. All that explains the use by the theorists so high-toned and ever religious terminology for description of considered phenomenon. This situation is comparable with the relation between ethic and religion.

The principles of morals, extremely important for mankind, but also unprovable??, required "consecration". F.A.Hayek wrote in this connection that the loss of faith would result in fall of morals and that may be that the people mean, speaking about a God, is only a personification of those traditional moral norms and values, that supports life of their community [26].

"The empirical law of epistemology", alongside with methodological principles of physics, is included into an arsenal of few, but extremely important means, which are used for the construction of the new fundamental physical theories. The tasks of historian and philosopher of science are, on the one hand, the discovery of the analogous epistemological imperatives, and on other hand, the search of their theoretical substantiation.

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