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PHENOMENOLOGICAL AND ONTOLOGICAL MODELS IN NATURAL SCIENCE

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Abstract

The observation of the nature and world represents the main source of human knowledge on the basis of our reason. At the present it is also the use of precise measurement approaches, which may contribute significantly to the knowledge of the world but cannot substitute fully the knowledge of the whole reality obtained also with the help of our senses. It is not possible to omit the ontological nature of matter world. However, any metaphysical consideration was abandoned when mainly under the influence of positivistic philosophy phenomenological models started to be strongly preferred and any intuitive approach based on human senses has been refused. Their success in application region has seemed to provide decisive support for such preference. However, it is limited practically to the cases when only interpolation between measured data is involved. When the extrapolation is required the ontological models are much more reliable and practically indispensable in realistic approach.

1 Introduction

Human knowledge is based on the ability of human reason. One starts from the pieces of knowledge obtained by observation of the world (including human existence). All scientific knowledge is based fundamentally on such an approach. The human reason forms some generalized statements (or hypotheses) from the individual pieces with the help of logical induction (event. of intuition). All possible consequences are then to be derived from all these propositions with the help of logical deduction. The statements that do not lead to any mutual contradictions and to any contradictions with world observation may be denoted as plausible. In the case of a contradiction the given hypothesis (or a given set of hypotheses) must be denoted as falsified. It is not possible to start from it in extending our knowledge as far as it is not modified in corresponding way. However, the propositions that have not been falsified may be denoted only as plausible. It is not possible to speak about the verification of scientific theories; see [1].

The main role is played in this approach by natural science, especially by physical, chemical, and also biological research. Such research might be hardly possible without the help of mathematical models. The models used at the present should be divided into two categories: phenomenological or ontological (denoted in biology usually as mechanistic). We will discuss in the following the questions concerning the possibility of using different models in extrapolation predictions and of their contributing to better understanding of natural phenomena.

However, in Sec. 2 we will mention first shortly the possibility of human knowledge and the problem of opinion plurality and in Sec. 3 the successive development of scientific knowledge. The evolution of thinking with the coming of the new age will be mentioned in Sec. 4. The mathematical modelling in natural sciences will be handled in Sec. 5. The necessity of metaphysics will be stressed in Sec. 6. And the problem of intuitive knowledge in the region of microscopic world will be analyzed in Sec. 7. Phenomenological characteristics remaining still necessarily in contemporary basic natural science will be mentioned in Sec. 8.

2 Human knowledge and tolerance problem

It has been introduced already in the preceding section that our knowledge is based on falsification approach. Any positive statement (proposition) may be shown or as falsified or as plausible. It may be never denoted as verified. Consequently, two (or more) mutually contradicting statements may be denoted as plausible if any of them has not been falsified in tests performed in connection with an additional plausible statement set.

That may be denoted as the source of fully legitimate plurality of different opinions (or also theories). The legitimate and fully justified tolerance must be exhibited towards such statements. It means that also two alternative (different) theories should be taken as plausible if they have not been falsified in separate tests. However, that is practically excluded in the contemporary scientific approaches on the basis of falsifiability principle, even if on the other side, the equivalent tolerance is often required in other regions (e.g., in the region of metaphysics) also for statements that have been already falsified in the past. Such tolerance must be denoted as destructive, as it tends necessarily to an untrue picture of the world or human being.

From the fact that the way to knowledge consists in the falsification approach it might seem that practically nothing may be known with certainty. That holds actually for any non-falsified positive statement; it can never be said that it holds actually and will hold also in the future. However, the certain knowledge may exist; it consists of the whole set of all falsifying statements. The certainty may be obtained always about what does not hold; therefore, about what is not true.

3 Scientific knowledge and its evolution

The people were forced to learn to know the nature from the very beginning of their existence to save or to lighten their lives. However, the actual beginning of systematic (scientific) knowledge may be put into the old Greece approximately in the fifth century b. C. The matter structure belonged always to basic considerations. Demokritos (cca 470-360 b. C.) formulated the hypothesis about the existence of atoms (i.e., of furthermore indivisible small bodies) that fill fully their internal space which is assumed to be otherwise empty. From Leukippos he took over also the law of causality: Any thing does not arise without a cause, but everything arises from some reason and necessity. Such intuitive ideas and standpoints did not appear practically in other parts of the world.

The given intuitive approach was conserved also in the metaphysical (ontological) approach of Aristotle (384-322 b. C.), who put also the grounds to whole natural science on the basis of world observation, even if his own statements about the world (starting from the then observations) were later falsified. Aristotle did not limit himself, of course, only to natural science based on direct world observation. Indivisible part of his contribution was the metaphysical approach, when he formulated also different conclusions following from the ontological nature of real matter objects. He formulated also the rules of two-value logic on such a basis and developed further the causality principle.

However, the approaches of Aristotle were not known in Europe practically for the whole thousand of years a. C. Islam brought them to Europe only in the beginning of the second millennium. They were taken over by Albert Magnus (1193-1280) and also by Thomas Aquinas (1225-74), who then continued in developing further all previous philosophical aspects. Thomas was developing, of course, also theological philosophy that tended from the Christian revelation towards the matter world and had, therefore, a source differing from that of metaphysics. It is then possible to say that Thomas was distinguishing in principle always between these two different philosophical regions. And the natural science was developing at that time always in full harmony with metaphysical consideration, practically till the beginning of the new age.

It is possible to say that successive changes occurred when the followers of Thomas Aq. were not able to continue in keeping the metaphysical consideration in agreement with nature observations and took some metaphysical statements as dogmas. And also some statements of natural sciences were not corrected in agreement with contemporary observations and remained under the influence of different earlier convictions; e. g., F. Bacon (1561-1626) was speaking about different idola (mistakes). At that time the importance of falsification approach was, of course, not yet known and realized.

4 Evolution of scientific thinking in the new age

A series of different ideas appeared gradually in the new age that were accepted as new starting points for formulating corresponding scientific hypotheses. It is possible to say that mainly three newly formulated concepts influenced the development of the modern physics and whole natural science. It was the overestimation of the human reason by R. Descartes (1596-1650), the refusal of causality and the overestimation of chance in natural evolution by D. Hume (1711-76) and the positivist philosophy of A. Comte (1798-1857) who limited all considerations to mere measured data and refused any metaphysical thinking. It was probably also the discovery of molecular and atom structures in the 18th century that contributed at least partially to these trends as the probability distribution started to play an important role in the interpretation of physical phenomena.

It is then possible to say that the origin of two main physical theories of the 20th century (i.e., Copenhagen quantum mechanics and special relativity theory) was influenced fundamentally by E. Mach (1838-1916), who refused any metaphysics in physical considerations [2]. Thus the purely phenomenological mathematical models were strongly preferred and the modern physics was built up practically on them.

As to the quantum mechanics it is well known that the contemporary model leads to logical quantum paradoxes and that until now the sharp gap between the microphysics and macrophysics has not been removed, either. We have analyzed the basis of quantum mechanics and its reasoning to a much greater detail in the last time; see [1,3] and papers quoted there. And we have shown that the Schrödinger equation itself (without any additional assumptions) must be preferred to the Copenhagen quantum mechanics as well as to mere classical physics, even if there is not any difference in the description of stable objects with the help of Schrödinger or classical equations. Thus, the so-called hidden-variable theory represents the best description of physical reality (see also Sec. 5). And we may conclude that also in the microscopic world the corresponding ontological model is to substitute the purely phenomenological Copenhagen mathematical model. All earlier quantum paradoxes disappear and the microscopic physics may be interpreted in intuitive ontological way as the macroscopic one. Also the interpretation gap between microscopic and macroscopic physical regions disappears [3].

The preference of ontological models in natural science seems to be strongly supported in such a case, which will be discussed to a greater detail in the next section.

5 Mathematical modeling of natural processes

It is possible to say that any research concerning the matter world (including human society) cannot manage without using mathematical models, being partly very simple and partly very complex. They were introduced into the life by G. Galileo (1564-1642) and I. Newton (1643-1727). Their models may be denoted as ontological. Sometimes it is spoken about such models as about mechanistic ones, to stress that they should represent matter mechanism hidden behind, at the difference to purely phenomenological representation of measured values.

The contemporary physical theories are based, of course, practically fully on phenomenological models, without devoting any interest to deeper matter (ontological) mechanisms. One obtains mostly quite non-intuitive description of corresponding phenomena in such cases. The quantum paradoxes (wave-particle duality, non-localization of microscopic particles, tunnel phenomenon, and similarly) have been derived with the help of the phenomenological Copenhagen quantum-mechanical model. Such phenomena have been denoted oft as the reality of the microscopic world, differing significantly from the macroscopic one.

Any objections against phenomenological quantum-mechanical models and against corresponding consequences have been refused by arguing usually that these models have been very successful in passing to technological applications. It holds, however, to the extent when the interpolation in the region of measured values is being performed. Different unsuccessful cases may be shown if the extrapolation outside the region of measured values has been done. Such failure has not been exhibited as a rule when ontological models have been made use of.

The abandoning and refusing of ontological approaches must be denoted as a mistake also from another reason. It would not be possible to speak about scientific thinking or approach if the already mentioned two-value logic were not involved. And Aristotle proposed just this kind of logic starting in principle from the ontological basis of the matter world.

Some efforts to introduce more-value logics appeared in the 20th century. However, the attempts to apply them to natural phenomena in connection with quantum mechanics were unsuccessful. And there is not any reason for it, either, since we have shown that the quantum theory must be based on the mere Schrödinger equation (as introduced already in Sec. 4), which provides the results for stable microscopic objects to be practically equivalent to classical physics [3]. It is the theory with hidden parameters supported all the time by A. Einstein that must be applied to if the microscopic phenomena are to be described in agreement with reality [1,3].

6 Physics and metaphysics

As there is not any reason for a more-value logic the way is again fully open for applying ontological considerations in extending our knowledge. Especially, when commonly used standard logical rules represent practically indivisible part of any scientific approach.

It is also the intuitive insight that is to come back into the natural science. It may be hardly possible to interpret further the real world by manipulating mathematical artifacts that are usually linked up with phenomenological models. There is not any doubt that the actual knowledge of the world should be connected with ontological models. One is entitled to expect that a similar synthesis of scientific and philosophical (metaphysical) thinking may occur again as it was in the time of Aristotle and also of the middle age.

However, the other philosophical region (i.e., theological philosophy) introduced in the middle age need not be influenced very much in such a case as it has a quite different starting point than natural science. It starts from the Judaic-Christian revelation that is contained in the books of Old and New Testament. The theological philosophy combines, of course, its conclusions also with the pieces of knowledge obtained on the basis of world observation, which means that we are entitled to apply the standard falsification approach to corresponding theologically oriented statements as far as they concern the world and human being. It means that also in this region some plurality of mutually contradicting opinions may exist when none of them was falsified separately. It is possible to lead a dialogue between corresponding statements in looking for a true answer; a kind of dialectic synthesis may be formulated when the whole known non-falsified "truth" is taken into account and falsification does not occur. On the other side some new hypotheses concerning the matter world might be initiated by corresponding considerations.

7 Microscopic world and sense knowledge

One region of the physics of the 20th century was devoted mainly to the description of the microscopic world. It was based practically on phenomenological models and the derived picture of the microworld was very different from that might be obtained by extrapolating the experience gained with the help of our senses. The ontological models have commemorated the situation of the intuitive approach started by Demokritos (as mentioned already in Sec. 3) or developed further mainly by Aristotle and Thomas Aq. The given picture was supported in principle also by discoveries in the 17th and 18th centuries when the actual existence of atoms and molecules was discovered.

However, at that time different trends started to appear when instead of ontological models the phenomenological ones were made use of. Important example may be represented by the discovery of entropy increase when this phenomenological characteristic was denoted practically as a natural law or as the cause of corresponding behavior of many-bodies systems even if it should be interpreted as the consequence of other rules holding for interactions of individual bodies under given conditions. The situation did not change even if the entropy increase was substituted by the probability increase of atom (or molecule) distribution. The given evolution continued when the causality principle was refused and the chance (and probability) was declared as the basic characteristic of natural evolution, as Hume proposed it.

Phenomenological models represented always important lost of intuitive insight as to the matter structure. N. Bohr contributed then further to such trends when in 1913 he formulated two postulates concerning the atom structure [4]; two phenomenological characteristics were denoted in principle as physical laws being fully responsible for corresponding physical behavior. To the given evolution also L. de Broglie [5] contributed when he attributed a pilot wave to any mass particle, for which any ontological reasoning did not exist. However, N. Bohr brought a decisive contribution to the support of phenomenological models, when he introduced the Copenhagen quantum mechanics [6]. It was based on time-dependent Schrödinger equation [7], to which, however, some further additional important (in principle only mathematically formulated) assumptions were added. The given theory has led then to some paradoxical properties that have been denoted as actual properties of microworld.

It has been often stated that many experiments have entitled us to take the Copenhagen quantum mechanics as actually valid. However, it has been almost always only the mere Schrödinger equation that has been tested in corresponding experiments; none of the mentioned additional Copenhagen assumptions was actually taken into account in such tests. And it has been already shown that the basic solutions (i.e., containing only one Hamiltonian eigenfunction) of the time-dependent Schrödinger equation have led to the results that are fully equivalent to those of classical physics [3]. It does not hold for superposition solutions (involving at least two Hamiltonian eigenfunctions), which makes the Schrödinger equation more general than the equations of classical physics. That is in full agreement with the conclusions of Hoyer [8] and Ioanidou [9] who showed that the Schrödinger equation may be derived if the classical physics is combined with a statistical distribution of some basic physical parameters. There are then some experimental facts (existence of discrete states) indicating that the Schrödinger equation should be preferred to other model alternatives in the region of microscopic world [3].

One may say that the EPR experiment measuring two-photon coincidence was the only one where the mentioned additional Copenhagen assumptions were actually discussed and practically tested. However, the violation of Bell's inequalities found experimentally by Aspect et al. [10] has been interpreted in such a way that two untrue statements have been involved; see [1] and papers quoted there. In fact only a simplified hidden-variable theory may be excluded together with classical alternative by the given experimental data; the corresponding violation has not concerned the general hidden-variable alternative (or the mere Schrödinger equation). It means that nothing prevents us from returning to intuitive ontological picture of matter structures in the region of microscopic phenomena.

8 Ontological basis and some remaining phenomenological characteristics

Nevertheless, it is necessary to introduce that the physics is still fully dependent on one quite phenomenological quantity. It is the distant force action. One may easily imagine and interpret ontologically the action of a force (repulsive as well as attractive) at very small distances (objects being in contact). The force action at a distance (electromagnetic and gravitation forces) may be understood until now on phenomenological level only, even if it may be practically clearly defined on the basis of corresponding consequences. There is a quite open (till now unanswered) question how it might be possible to interpret it ontologically as other physical characteristics. The phenomenological description may be, however, made use of, too, when the ontological mechanism of some part of reality is very complex and for the analysis of the whole system a phenomenological relation is sufficient.

On the other side it is hardly possible to accept an interpretation, even if it is ontologically based if some violation of logical principles is involved. Such a problem concerns the strong interactions (between hadron particles) that may be regarded in principle always as contact interactions. At the present the hadrons are assumed to consist of smaller quarks and all mutual interactions between them are interpreted on the basis of interactions between individual quarks. It follows from experimental data and is practically certain that hadrons cannot be regarded as elementary objects; they must consist of some smaller parts, having been denoted commonly as partons. However, one should ask whether these partons may be identified with contemporary quarks as it is generally assumed.

The quarks are assumed now to have relatively low rest masses and, therefore, they should be loosed normally as free objects in hadron collisions at sufficiently high energies. However, only many other secondary hadrons (or their resonances) have been always found in such collisions. As there has not been any direct evidence for the quark existence one special property has been attributed to them, which may be described mathematically but it may be hardly understood ontologically and intuitively. When brought to high velocities (as parts of an accelerated hadron) and to interactions with other quarks (present in a different colliding hadron) the pair of mutually interacting quarks has been assumed to be unable to withdraw oneself from another one. They have been expected to remain mutually bound and only the process of their hadronization (i.e., transmutation to hadrons) has been assumed to occur. And one must assume further that even many tens of secondary hadrons may be formed from one couple of colliding quarks. There is not any description, either, what occurs with other quarks that do not collide directly.

No explanation (or concrete description) has been given until now for such unusual phenomenological quark behavior, even if already a very long time has passed from the time when the given assumption was formulated. And so, even if at the first sight the existence of quarks might represent quite intuitive approach one is forced to ask whether their mysterious properties (or rather the mathematical artifacts) do not disqualify them actually from further considerations. The usual argument that any other explanation does not exist until now should be denoted as contra-productive (having been untrue at the same time).

There has been the question put before several decades of years and not answered until now: whether the secondary hadrons and hadron resonances (appearing in hadron collisions) are not preformed in individual hadrons before being loosed in a collision. The mentioned partons might be then identified with these resonances. However, in the past they were identified in principle with individual quarks representing basic states in SU(3) theory.

The partons (similarly as all hadrons) might then consist of other smaller objects (i.e., of some quasi-quarks). These quasi-quarks should be then very heavy being mutually strongly bound at very small distances. Different changeable parton structures might be then formed inside individual hadrons, while individual partons (i.e., contemporary resonances) might be get free in hadron collisions by different stripping reactions, which would be followed by the decay of highly excited objects. Very heavy resonances (corresponding to partons) might be then formed also in direct mutual collisions of partons existing in colliding hadrons when also some quasi-quark pairs should be created (or again annihilated). Jets consisting of many secondary hadrons might be then formed by successive decays of highly excited resonances. Thus, the purely phenomenological quantum chromodynamics might be substituted by a model more acceptable from purely logical as well as ontological views.

What remains open is the nature of the corresponding quasi-quarks and of their mutual interactions. The forces between them must change strongly with their mutual distances and act mostly in a collective manner. And just this property should be described in a quite new way. It would be necessary to describe (or explain) also the changeable parton structure inside individual hadrons during their free existence between mutual collisions and interactions on the basis of such quasi-quark property.

9 Conclusion

There is not any doubt that the modern physics would not be so successful without making use of mathematical models. However, one must ask whether the contemporarily used phenomenological models may really contribute to the true knowledge of the world. Especially, if they are in disagreement to the knowledge gained with the help of human senses.

It is evident that our sensual ability leads always to fully ontological view, which is in agreement with the fact that no science would be possible without using the two-value logic based on realistic ontological view. It has been introduced in Sec. 7 that especially the phenomenological model of Copenhagen quantum mechanics has not been based on realistic grounds. The way has been opened to substitute it by a fully ontological hidden-variable model [3]. There is not more any actual reason for making use of purely phenomenological models at the present time, either.

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