Discussion of the Book "The Quantum Challenge"

Pavel A. Stabnikov

Nikolaev Institute of Inorganic Chemistry, SB RAS, Novosibirsk, Russia

Correspondence to: Pavel A. Stabnikov, stabnik@niic.nsc.ru
Keywords: Quantum Mechanics, The Unattainability of the Infinitely Small, Interference
Received: June 26, 2019 **Accepted:** October 29, 2019 **Published:** November 6, 2019

ABSTRACT

Modern but not entirely coordinated foundations of quantum physics are described in the book "The Quantum Challenge". The difficulties and philosophical problems of this area of science are discussed. Discussions of many great scientists who paved the foundations of the physics of micro-world are described. These discussions are still urgent. The diversity of interpretations of the wave function, light interference, uncertainty principle, complementarity and completeness of micro-world description are stressed in this book. Difficulties and problems of quantum mechanics described in this book allowed the author of the present communication to propose a new approach based on the infinitely small metrics The difference of infinitesimals in two geometries allows one to explain W. Heisenberg's uncertainty principle. Interconnection of the images in these geometries is possible with the help of Weierstrass integral transform. This approach allows one to describe the interference of light behind the screen with slits as a sum of the corpuscular component (Weierstrass transform) and the wave component (Fourier transform).

1. INTRODUCTION

The authors of the books describing the foundations of quantum mechanics usually try to avoid the difficulties and to make no mention of the unsolved problems of this area of science. An exception to the publications of this kind is "The Quantum Challenge" by G. Greenstein and A. Zajonc [1]. These authors have set a very difficult problem - to explain, in the most understandable manner, the things that do not cause accordance even between the experts. In [1], the difficulties and philosophical problems of the foundations of physics are described and discussed, rather than the results and achievements of this area of science. Calculations carried out within the framework of quantum mechanics in the overwhelming majority of cases are in excellent agreement with the experimental data. However, sometimes it is very difficult to grasp and understand calculation results attracting usual considerations. This situation is so strange that it seems to violate the principles of elementary logic ([1], chapt. 1.6), because sometimes calculations contradict our intuitive notion of waves and particles.

This book [1] describes discussions and controversy between the great originators of quantum physics such as N. Bohr, A. Einstein, W. Heisenberg, E. Schrödinger, L. de Broglie, M. Planck, M. Born, P. Dirac, W. Pauli, D. Bohm etc. Many problems discussed by these scientists are still urgent. For instance, the development of the idea of wave function is described in ([1], chapt. D.2). E. Schrödinger proposed to interpret the squared wave function is the real density of the matter in a definite site. M. Born made the idea more exact by stating that the squared wave function describes the density of the probability to detect a particle in a given place. The latter assumption is generally accepted at present. However, it is stressed in ([1], chapt. 11.3) that also an information-theoretical interpretation had been proposed, according to which a wave function is a description of our knowledge of the system. This idea of a wave function relieves one from the paradoxes connected with the measurement problem. Measurement causes a change of the wave function, so, first of all, our knowledge of the system changes rather than a real physical process. However, this interpretation has not won wide recognition yet.

Uncertainly principle and complementarity are discussed in [1], as well as many philosophical problems connected with discreteness, completeness of the description of the micro world, and possible hidden parameters. The EPR paradox (Einstein, Podolske, Rosen), entanglement of quantum states, J. Bell's theorem and many other stage things are described. The most essential merit of book [1] is also the fact that it helps rescuing from the illusion of a seeming understanding of quantum physics. The foundations of quantum mechanics still remain the subject of fierce and active debates connected with the interpretation of experiments and calculations. Because of this, quantum mechanics cannot be considered as a completely formed science, for example such as classical mechanics, celestial mechanics, thermodynamics, chemistry and some other areas. At present, there is still a hope that the use of new approaches and ideas will allow creating a new integral and consistent concept of the description of the micro world, which will be recognized by all experimenters and theorists.

It should be indicated that the author of the present communication is educated in Chemistry, so the notions of quantum mechanics and E. Schrödinger's equation are rather shallow. However, the author has always been interested in the philosophical problems of science, its history and development [2-4]. In this connection, book [1] allowed a new insight into the problems of quantum physics and pave the way for a new alternative to the particle-wave dualism, which may be formulated as the geometric interpretation of micro-world on the basis of differences in the metric of infinitesimal [5-8].

2. DEVELOPMENT OF THE METHODS FOR THE DESCRIPTION OF THE MOTION OF THE MATTER AT THE MICRO LEVEL

At the beginning of the XX century physicists came across the problem of the quantitative description of the world. Results of experiments did not allow one to make a complete and noncontradictory description of processes at the micro level [1]. The major problem in describing the motion of micro particles is discreteness. Discrete are the particles themselves (electrons, protons, molecules), their structures (discrete levels in atoms), and their interactions. Discreteness is so total that all electrons are indistinguishable, all protons are indistinguishable, and the structures of identical atoms and molecules are identical. We do not see anything like this at the macro level. All large bodies always differ from each other. Every human being is individual, even uniovular twins have differences. It is habitual for humans to live in so great diversity of shapes and structures of the objects. However, in some cases people are to take measures against the diversity of bodies close to each other in shape and structure. For instance, to make the parts of machines and devices interchangeable, it was necessary to develop special state standards based on standard units - gram, metre, second, Newton, Watt et al.

However, to describe micro-particles possessing discrete properties, it was necessary to develop new physics, which would operate with discrete transitions. In other words, physics needed a new discrete tool. Mathematical approaches of this kind, in which discreteness had been already designed-in, had been proposed about a hundred years ago [1]. These approaches are matrix mechanics by W. Heisenberg and wave mechanics by E. Schrödinger. A matrix itself is a discrete table. The transition from one matrix to another is discrete too. This is what forms the foundation of W. Heisenberg's matrix mechanics. However, a disadvantage of matrix mechanics is the fact that only the initial and final states are significant. The matrix approach simply does not involve any other states, so the mechanism of transition automatically drops out of this approach. This is why the approach proposed by W. Heisenberg did not become widespread. The approach proposed by E. Schrödinger is based on the representation of a micro object by a wave (wave function) which either moves or is within some limited interval in the form of a stable stationary wave. The transition from one form of the wave to another proceeds in the discrete manner. Because of this, the equation proposed by E. Schrödinger allows one to describe discrete transitions. As a rule, the square of the wave function is the probability to find a particle at a definite site. The structure of micro objects (for example, the distribution of electrons around a nucleus) may be visualized with the help of wave functions. This promoted a wide application of E. Schrödinger's equation to the description of micro objects [1].

It should be noted that the creation of quantum mechanics proceeded using the methods of analytical mathematics. Thirty years later, the first computers appeared. After the next twenty years, it became possible to carry out numerical modeling, to built up plots, and finally to visualize calculations completely with the help of computers. These advances promoted the broad application of computers to solve numerically E. Schrödinger's equation and other problems of quantum mechanics. In addition, with the development of computers, the possibilities of the numerical modeling of integral Fourier, Laplace, Weierstrass etc. transforms were opened. Some of them may be used to describe the phenomena of microworld [9, 10].

3. A DESCRIPTION OF THE INTERFERENCE OF LIGHT

Only the idea of the wave nature of light is used in physics manuals to describe the interference of light [9-12]. The transition of light through one or two slits in a non-transparent screen is usually considered. Diffraction at a semi-plane is also considered. No manualsd include the examples of interference at three, five or more slits in a screen, except for diffraction at a grating. In addition, the manuals consider only the case of rather remote recording of interference (from 2 m. Fig.6.2 [10], to 3.8 m. Fig.40 [9]) from a screen with slits. With this approach, the distance range closer than 2 m from the sreen with the slits falls out of consideration. However, it should be noted that book ([1], chapt. 6) provides a description of a trick proposed by D. Bohm, who presented a new interpretation of the wave function. He wrote the wave function in polar coordinates and separated it into two parts: classical and quantum [12]. This allowed him to describe diffraction effects at a shorter distance from a screen with two slits. The close to the screen, the larger is the contribution from the classical component of the wave function ([1], Fig. 6.12).

The obtained result is in good agreement with the experiment. It is necessary to give D. Bohm's genius his due, for having found a classical constituent in the wave function. However, E. Schrödinger developing his equation did not expect the presence of a corpuscular component in the wave function. So, according to D. Bohm, to provide a descritpion of light interference at any distance from the screen with the slits, it is necessary to take into account both the corpuscular and the wave components of light. The approach proposed by D. Bohm was further developed in [5-7], but the classical scatting behind a screen with holes was described by the integral Weierstrass' transformation, with its core being varied depending on the distance to the recording site. The contribution from classical scattering decreased with an increase in the distance, for example, as $\mathrm{Exp}(-\alpha R^2)$, where α is a constant, and R is the distance from the screen. The wave function was described by the squared Fourier screen transformation, the contribution from which increased as $\{1 - \mathrm{Exp}(-\alpha R^2)\}$. The total value was normalized over the energy that passe4d through the slits in the screen. The results of numerical calculation of diffraction were published in [5, 6, 8]. This approach allows one to describe the distance and interference of light for any number of slits in the screen and at any distance from the screen. Theoretical considerations substantiating the application of Weierstrass and Fourier transforms to the description of light interference will be presented below.

4. A NEW INTERPRETATION OF INFINITELY SMALL VALUES

The use of the Fourier integral transform for the description of wave phenomena is well known. For instance, this transform was used by R. Ditchburn for the description of light interference [10]. The idea of using Weierstrass integral transform appeared as a geometric alternative explaining W. Heisenberg's uncertainty principle. Weierstrass transform is actually a decrease in the sharpness of the original with the conservation of its total area. This transformation causes an increase in uncertainty, or blur. A comparison of two images linked through the Weierstrass integral transform is equivalent to their comparison in two geometries with different infinitesimal metrics. This is a completely new geometric approach within which a comparison of one and the same image (object) is complicated by the different infinitesimal values in the two geometries. With this approach, the description of images in each geometry is usual, classical. However, if the features of image properties are considered relying on the geometry with the smaller infinitesimal, the uncertainty and apparent discreteness of interaction arise [5, 6], **Addition 1**. The assumption concerning an increased infinitely small point means an increase of the infinitesimal to a finite value.

It should be stressed that similar transformations but with infinitely large values are already known in physics. Ancient people believed that temperature could take any value from $-\infty$ to $+\infty$. However, Lord Kelvin proposed to transfer the minimal temperature to a finite value (−275.15˚C) and accept this value to be equal to zero. In this case, many thermodynamic expressions are written in a simpler form. In fact, this approach is the transfer of an infinitely remote value ($-\infty$ for temperature) to the zero of Kelvin's scale. This approach also automatically transfers unattainability of the infinitely far point into the zero of Kelvin's scale, and this value becomes unattainable. Another finite unattainable value for any object with non-zero mass is the velocity of light. Ancient philosophers (with rare exception) thought that the velocity of light is infinite. However, in 1905, A. Einstein developed the Special Theory of Relativity (SR) to adjust the laws of classical mechanics and electrodynamics. According to this theory, the velocity of light measured in any inertial reference system is the same and independent of the motion of the system and irradiator. According to SR, the velocity of light is the maximal velocity with unattainability attribute.

These two examples show that in modern physics it is sometimes useful to make unusual deformations (approximations) of infinitely large values to finite ones. The assumption concerning an increased value of infinitesimal has some similarity with these two examples. It is still unclear whether it would be easier to explain the properties of micro-particles if we assume an exaggeration (increase) of infinitesimal.

5. CONCLUSION

The authors of book [1] described the modern state of the development of quantum physics. At present, there are many scientific schools and scientists who adhere to different opinions of the foundations of this branch of science. These opinions are not always concordant with each other. The authors of [1] describe different considerations and explanations of the same things without stating which of the explanations is better (more correct). The authors of [1] also pay attention to the problem of a photon passing through one or two slits in a screen. According to the wave notions, a photon has a trajectory different from the classical understanding, so it is quite able to pass simultaneously through more than one slit. However, D. Bohm relying on his calculations assumed that any particle passes through only one slit, but the presence of other slits affects the trajectory of the particle through the quantum potential, which is permanently increasing behind the screen. This allows one to describe the interference of light as a sum of the corpuscular and wave components at any distance behind the screen.

In the approach proposed by the author of the present communication, the size of infinitesimal in the geometry of the moving photon is larger than the distance between the slits on the screen. Because of this, the two slits are perceived as a single one in this geometry. However, interference is recorded in the geometry of the experimenter. Because of this, it is possible to describe interference as a sum of the corpuscular and wave components. At present, mathematical and topological approaches to the comparison of two geometries with different infinitesimal metrics have not been elaborated yet. However, the author of the present communication hopes that the assumption concerning exaggeration of infinitesimal will provide a better explanation of the features of micro-particle motion. Maybe, this will allow one to combine classical mechanics with quantum mechanics, similarly to how A. Einstein and other scientists succeeded in uniting classical mechanics with electrodynamics.

ACKNOWLEDGEMENTS

The author is grateful to S.P. Babailov (professor, physicist by training) for the discussion and valuable comments.

CONFLICTS OF INTEREST

The author declares no conflicts of interest regarding the publication of this paper.

REFERENCES

1. Greenstein, G. and Zajonc, A. (2012) The Quantum Challenge. Modern Research on the Foundations of Quantum Mechanics. “Kwantovy Vyzov”, Translation Editors V.V. Aristova, A.V. Nikulova. Moscow, “Intellekt” 431 P. (In Russian)
2. Stabnikov, P.A. (2011) Progress of Computer Potential of Mankind as the Basis for a New Model of the Universe. *Natural Science*, **3**, 91-100. https://doi.org/10.4236/ns.2011.32013
3. Stabnikov, P.A. and Babailov, S.P. (2017) An Addition to the Classic Gravity Interstellar Interactions. *Journal of Astrophysics and Aerospace Technology*, **5**, 1. https://doi.org/10.4172/2329-6542.1000138
4. Stabnikov, P.A. (2018) Alcosmology and Alastrophysic of the XXI Century. Palmarium Academic Publishing, p. 53. (In Russian)
5. Stabnikov, P.A. (2018) Frames in Which Matter Develops. Palmarium Academic Publishing. (In Russian)
6. Stabnikov, P.A. and Babailov, S.P. (2019) Types of Interactions and Material Islands of Stability: From the Micro World to the Universal Scale. IIC SB RAN, Novosibirsk. (In Russian)
7. Stabnikov, P.A. (2019) Geometric Interpretation of the Uncertainty Principle. *Natural Science*, **11**, 146-148. https://doi.org/10.4236/ns.2019.115017
8. Stabnikov, P.A. (2019) A New Geometric Approach to Explain the Features of the Micro World. *Natural Science*, **11**, No. 7. (In Press) https://doi.org/10.4236/ns.2019.117024
9. Pohl, R.W. (1963) Optik und Atomphysik. Springerverlag, Berlin, 552 p. https://doi.org/10.1007/978-3-662-01525-4
10. Ditchburn, R.W. (1965) Light. London, Glasgow. (In Russian, Moscow, “Nauka” 631 p)
11. Landsberg, G.S. (1957) Optik. Moscow, 759 p. (In Russian)
12. Bohm, D. (1952) A Suggested Interpretation of the Quantuv Theory in Terms of Hidden Variables, Parts I and II. *Physical Review*, **85**, 166-193. https://doi.org/10.1103/PhysRev.85.180

ADDITION 1

Paragraph from the book Stabnikov P.A. "Ramki, v kotorykh razvivayetsya materiya (Frames in which matter develops)", published in 2018 by Palmarium Academic Publishing.

ISBN: 978-620-2-38223-6

Let us consider a task. There are two pupils standing before the blackboard. Each pupil holds several circles of the same size, but the circles in the hands of the first pupil are larger than those in the hands of the second pupil. Let every circle be an infinitely small point specified for each pupil. How will these pupils measure an increasing size of a segment? If the segment is shorter than the diameter of the smallest circle, both pupils will say that the length of the segment does not exceed the infinitely small value (a point). If the length of the segment is longer than the size of the smallest circle but shorter than the length of the larger circle, one pupil will say that the segment is small but its length may be estimated, while the other pupil will say that the segment still does not exceed the infinitesimal. When the segment length becomes larger than the sizes of both kinds of circles, both pupils will be able to estimate the length of the segment relying on the sizes of the circles identifiable as infinitely small points. They also may estimate the length of longer segments packing their circles along the segment to cover it completely. Of course, their results will differ from each other but they will be represented by jogged lines (Figure A1(a)).

It follows from Figure A1(a) that the resulting jogged lines have different slopes, which will cause inconsistence for long distances. To make estimation results close to each other for long distances, it is necessary to multiply them by correction coefficients. These coefficients are equal to the true segment length divided by the estimation result for the first value different from zero. Plots taking into account the corrections are shown in Figure A1(b).

This approach declaring the differences by the metrics of infinitesimals for the geometry of the motion of micro particles potentially allows us to explain the discreteness with an increase in the distance. It should also be noted that the images in the geometry with the larger value of infinitesimal will be more blurred or fuzzy. This approach was developed as an alternative with the help of which one might explain W. Heisenberg's uncertainty by geometric statements. The most important item is that this geometric approach is more fundamental because it is based on clear geometric statements, unlike for the wave-corpuscle dualism relying on two antagonistic notions: a wave and a particle.

This addition is an attempt of the topological extension of the geometric principles of an infinitely small value. According to this approach, the geometry of microworld does not differ from macro geometry except for the size of an infinitely small point. In the opinion of the author, this approach allows us to explain the discreteness of microworld. In addition, this will allow us to extent Galilean relativity principle to the micro level.

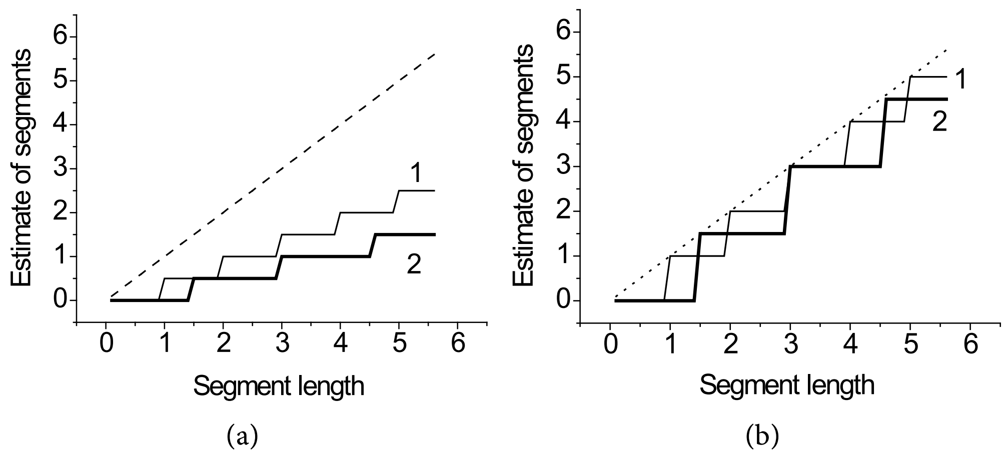

Figure A1. Estimations of segment length based on different ideas of infinitesimal (a) and taking into account the corrections (b).