Physics architecture

Nelly Konopleva[1,⋆]

[1] *"VNIIEM" Corporation", Moscow, Russia*

Abstract. Fundamental physical theory axiomatics is closely connected with methods of experimental measurements. The difference between the theories using global and local symmetries is explained. It is shown that symmetry group localization leads not only to the change of the relativity principle, but to the fundamental modification of experimental programs testing physical theory predictions. It is noticed that any fundamental physical theory must be consistent with the measurement procedures employed for its testing. These ideas are illustrated by events of my biography connected with Yang-Mills theory transformation from an ordinary phenomenological model to a fundamental physical theory based on local symmetry principles like the Einsteinian General Relativity. Baldin position in this situation is demonstrated.

1 Introduction

50 years ago physics theorists were in the permanent expectation of new discoveries in the elementary particle physics. That time there were two main scientific seminars in the P.N. Lebedev Physical Institute in Moscow where such problems were under regular discussion. They were the academician I.E. Tamm's seminar of the theoretical department of LPI and the seminar under the leadership of the academician M.A. Markov and professor A.M. Baldin. I frequented both these seminars.

I graduated the Moscow State M.V. Lomonosov University in 1964, and theoretical physics became my profession. The subject of my diploma thesis (1963) was the classical theory of gauge fields. That time they were called "the compensating fields". Without knowing Utiyama's paper of 1959 I obtained independently the same results that he did for Lagrangian form of the gauge field theory. My work was based on the book "Introduction to the quantum fields theory" (N.N. Bogoliubov and D.V. Shirkov, 1957, Moscow, GITTL). Moreover, I used the second Noether's theorem. This theorem was absent in the mentioned textbook. Geometrical interpretation of the gauge field vector-potentials as connection coefficients in some space of special construction was proposed by me, too. Geometrical part of my diploma thesis included the Einsteinian General Relativity and Weyl's theory of gravity, which is described by quadratic with respect to the Riemannian curvature tensor Lagrangian. So, the theories of gravity of Einstein and Weyl were connected by the local gauge invariance principle. Therefore, the well-known opposition of these great scientists could be finished.

Formally, my diploma thesis supervisor was professor K.P. Staniukowich. But he left the choice of the subject to me.

Attracted by the quantum physics, the theorists were a little interested in the classical field theory. Utiyama wrote about it in his book "Where did physics come to?" (in Japanese, 1983; in Russian,

⋆e-mail: nelly@theor.jinr.ru

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (http://creativecommons.org/licenses/by/4.0/).

1986). I saw it also. But I was inspired by the Einstein's, Weyl's and Cartan's works. If can geometrical equivalent of quantization exist? That was the question.

In 1964 the collection of papers on the classical gauge field theory was published in Russian translation edited by professor D.D. Ivanenko. This collection was named "Elementary particles and compensating fields". It helped Soviet scientists to go into these problems. The main problem is nuclear forces theory construction. Utiyama's paper was present in this book. The paper of Yang and Mills was also there. At that time the main works of professor D.D. Ivanenko were devoted to the elementary particle classification and gravitation theories.

At the same time at the mechanical-mathematics department of the M.V. Lomonosov Moscow State University the lectures on infinite Lie groups and fibre bundle space geometry were given. When I attended them I found that the local gauge groups are the special case of the infinite Lie groups, and the gauge field vector-potentials are the special case of the fibre bundle space connection coefficients. These generalizations of the classical gauge field theory and the statement that the gauge fields must be classified by representations of the infinite Lie groups became the base of my thesis for a candidate degree. So, the compensating procedure ceased to be actual. But the local gauge symmetry became the same fundamental as the global one.

The gauge fields were classified by infinite Lie group representations just as elementary particles are classified by finite Lie group representations. The finite and infinite Lie groups differ from each other in the sense that under the same local algebraic structure their transformation parameters behave differently. The transformation parameters of the finite Lie groups are independent on a space point (the are constants), whereas the transformation parameters of the infinite Lie groups depend on it. Such construction reflects transition from the global symmetry to the local one.

It was found that the system of the Lagrangian equations of the gauge field theory after symmetry localization contains less equations than before localization. The equations of motion became corollary of the conservation law of energy-momentum tensor. So, the Einstein's idea that particles can be considered as singularities of the gravitation field can be extended to the gauge field sources.

This approach helped to construct the theory of topological generators - the sources of electric current of new type. In that generators the electric current is determined by the motion of the magnetic flux instead of the electron motion in the usual generators. This theory was tested and confirmed experimentally with one percent uncertainty at IHEP (Protvino) in middle 1980s. The topological generators were made and used for the pump magnetic field by the real solenoid of the UNC superconducting circle (on the IHEP stand).

Now is 100th anniversary of the General Retivity, and we have unified the geometrical theory of all interactions, including gravity, thanks to Einsteinian stubborn struggle for the right of the local symmetry to be the basis of the fundamental physical theory.

2 A.M. Baldin influence on my life

Alexander Michailovich Baldin belonged to a circle of eminent scientists, which enclosed me since I was a student (when I became one of the authors of the proton-neutron nucleus model of professor D.D. Ivanenko, who was my father in law). But the interaction between theorists can be named a "long-range action". If they are not co-workers, they meet each other at seminars, lectures, conferences and so on, that is mainly in an official way.

Our first talk with Alexander Michailovich was in 1967 at the P.N. Lebedev Physical Institute. He invited me to give a talk about my geometrical interpretation of the gauge (at that time - compensating) fields at his seminar which he organized together with the academician M.A. Markov. I was very exited by this invitation. At the academician I.E. Tamm's seminar I could only listen and participate in discussions, but not to speak myself. After my talk the academician M.A. Markov said: "When

a child arises, it is difficult to say what will with him/her later, but here, I think, something very interesting will come out". Since then they both followed my fortune.

Later M.A. Markov collaborators began to study the black holes, Einsteinian and Kaluza-Klein 5D unified classical theory of gravity and electromagnetism, and supergravity. Moses Alexandrovich proposed a model of elementary particle as a closed universe (simultaneously with professor K.P. Staniukowich). He assumed that the radius of such particle could be defined by the Plank length. He was also interested in description of a particle motion in the very small space-time domains (less than Plank length).

Alexander Michailovich looked for an experimental confirmation of the vector dominance idea. It was very interesting to me because it meant that the universal forces of new kind could exist. Not only gravity, but nuclear forces could also be described by some universal interaction, if it is found that the vector dominance idea is true. So, the quest for construction of the nuclear interaction theory by analogy with the General Relativity was opened.

A.M. Baldin was not only an excellent theorist, but he also had brilliant ideas about how to organize experiments. His activity inspired the hope for experimental progress in the theory of elementary particle interactions. It was very necessary because many different models of such interactions were proposed, but not a one selection principle was proposed. Sometimes even non-scientific arguments were used to support a concrete model. Yang-Mills model was not popular among Soviet theorists. Some scientists, as V.I. Ogievetskiy (JINR), E.S. Fradkin (LPI), B.L. Ioffe (ITEP) and others assumed that this model can never become a good physical theory. The time showed the opposite. The main selection principle for A.M. Baldin were symmetry principles. And for me, too.

So, in 1967 I submitted for consideration to the theoretical department of LPI my PhD (candidate) thesis on the classical gauge field theory "Geometrical description of interactions". I worked in another institute and was not a post-graduate student. The consideration was lasted two years but in the spring of 1969 it was successfully completed. My thesis was recommended for publication. On its basis I wrote my three-chapters part of the well-known book N.P. Konopleva and V.N. Popov "Gauge fields" (1972, Atomizdat, Moscow, in Russian). My chapters were devoted to the classical gauge field theory in Lagrangian and geometrical forms. The fourth chapter of this book was written by a mathematician from LOMI Victor Nicolaevich Popov. He wrote about the quantum theory of the gauge fields. This text became the basis of his Habilitation thesis. My Habilitation (doctor) thesis contained an extended version of these three chapters in the second edition of our book and it was devoted to the classical gauge fields plus the geometry with torsions. It was defended in 1983 at the Moscow State University.

My and V.N. Popov book arose due to the support of the academician M.A. Markov and professor A.M. Baldin. Moses Alexandrovich wrote to Atomizdat the recommendation to publish it. Alexander Michailovich became a reviewer. This book ran into three Russian (1972, 1980, 2000) and one English (1981) editions. Hence, something interesting, as M.A.Markov earlier said, really was presented! This book was the first to contain both classical and quantum theory of the gauge fields. It was the only textbook on the gauge field theory existing in Russia at that time.

After the defense in LPI A.M. Baldin invited me to participate in the International Seminar on electromagnetic interactions and vector dominance, which took place in 1969 in Dubna. My talk was entitled "Geometrical description of the gauge fields" (in Russian). Soon after this presentation I was forced to leave the K.P. Staniukowich's group as the financial support of theme "the gauge fields" was stopped. This theme was recognized to be not perspective. But geometrical methods in the field theory became active. When I left the K.P. Staniukowich's group I wrote my book to show them their mistake.

The International Seminar at JINR organized by M.A. Markov and A.M. Baldin in 1969 generated a set of regular Seminars "Relativistic nuclear physics and quantum chromodynamics", which was

named "Baldin autumn". Now we have XXIII Seminar of this series. Gradually I became a permanent participant of these seminars. They became to me the necessary and sufficient condition of scientific existence.

In 1991 I began to collaborate with BLTP at JINR. Once when A.M. Baldin constructed his Nuclotron, he told me about the problem of magnetic flux pump to superconducting solenoids. I recommended him to make use our topological generators to solve this problem. Alexander Michailovich acquainted me with A.D. Kovalenko. Sometimes we discussed this problem together. Unfortunately, financial problems made impossible the application of this beautiful technical solution.

3 Conclusion

Alexander Michailovich Baldin and me were neither collaborators, nor friends, we did not have any relations. Nothing except science was connecting us with each other. But in critical moments we always proved to be at the same barricade side. Someone said: "To love is not every time to look at each other. It means to look in the same direction". The direction, which interested all of us, was always science. It was the sense of our life.

A.M. Baldin was a well educated and gifted person. His aid was always disinterested. He supported young scientists and new ideas not only of his group but in others too, if he thought that it would be useful for science. He was a devoted son of his motherland. All his efforts were always directed to its prosperity.

In memory of Alexander Michailovich I proposed in 2006 to Anton Alexandrovich Baldin to organize the Baldin Physical Institute. From this idea the Advanced Studies Institute was born.

Acknowledgments. It is a pleasure to thank the Organizers of the International Seminar ISHEPP XXIII for their support.

References

[1] R. Utiyama, Phys. Rev. **101**, 1597 (1956)
[2] N.N. Bogoliubov, D.V. Shirkov, *Introduction to the quantum fields theory, 1th ed.* (GITTL, Moscow, 1957, in Russian)
[3] R. Utiyama, *Where did physics come to?* (Japan, 1983, in Japanese)
[4] Collection of papers, ed. by D.D. Ivanenko, *Elementary particles and compensating fields* (Mir, Moscow, 1964, in Russian)
[5] C.N. Yang, R.L. Mills, Phys. Rev. **96**, 191 (1954)
[6] N.P. Konopleva, V.N. Popov, *Gauge fields, 1th ed.* (Atonizdat, Moscow, 1972, in Russian). N.P. Konopleva, V.N. Popov, *Gauge fields, 2th ed.* (Energoatomizdat, Moscow, 1980, in Russian). N.P. Konopleva, V.N. Popov, *Gauge fields, 3th ed.* (URSS, Moscow, 2000, in Russian)
[7] N.P. Konopleva, V.N. Popov, *Gauge fields* (Harwood academic publisher, Chur-London-N.-Y., 1981)
[8] Proc. of Int. Sem., ed. by A.M. Baldin, *Vector mesons and electromagnetic interactions* (JINR, Dubna, 1969)
[9] Collection of papers, ed. by A.M. Baldin, *Electromagnetic interactions and elementary particles structure* (Mir, Moscow, 1969, in Russian)