Victor Isaakovich Ogievetsky: scientist and teacher. Notes of disciple

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I first heard about Victor Isaakovich Ogievetsky in 1967, being a 4th-year student in the Theory group of the Physics Faculty in the Saratov State University (SSU). At the time an agreement between SSU and the Dubna branch of the Moscow State University (MSU) allowed selected students to spend two years in Dubna and prepare their diploma (master) thesis at the Joint Institute for Nuclear Research (JINR). One such student (a year senior) told me about an extraordinary theoretician at the Laboratory of Theoretical Physics (LTPh), V.I. Ogievetsky who, together with I.V. Polubarinov, was very actively working on a new approach to gauge theories and gravity. At the time I knew almost nothing on the subject, still I thought that it would be great to graduate under the supervision of such a distinguished scientist. My friend immediately cooled my ardor by saying that it was very hard to convince V.I. that a student was capable of working with him. He rather quickly lost any interest if he felt that the student was not good enough. I was a very shy youngster and I thought that I was just the right candidate for failure. Nevertheless, I was selected and in February 1968 I arrived in Dubna and started attending the remarkable lectures of the leading JINR scientists. At the library I found the recent (now seminal) papers by Ogievetsky and Polubarinov on the spin principle in gauge theories and gravity. They seemed to me rather understandable and very exciting, both because of their beautiful logic (different from the standard textbooks) and the future wide prospects they opened. I frequently met Igor Vasil'evich Polubarinov at the library and decided (after some hesitation) to ask him something about his very recent preprint. He answered my query in detail and I asked him if I could come to his office occasionally with more questions. He accepted with a smile. Soon he agreed to be my Advisor and in December 1969 I successfully defended my Diploma Thesis on the tree diagrams in Yang-Mills theory.

Soon after our acquaintance, I.V. introduced me to V.I. Ogievetsky. I was rather surprised to find out that V.I., who seemed to me a kind of "heavens inhabitant" at the distance, turned out very friendly and amicable at personal contacts. In 1969, by request of I.V. Polubarinov, he wrote a very positive referee report on my Diploma.

The following year, after graduating from SSU, I was temporally employed at LTPh as a probationer for two years. During this period I came across Boris Zupnik, a PhD student of V.I. from his native city of Dniepropetrovsk (now Dniepr in Ukraine). He was working on non-linear realizations theory, the main focus of V.I. in those days. Boris introduced me to some important papers on the subject. This direction seemed to me very interesting and I started studying it with great enthusiasm. Boris and I wrote two joint papers, and in the process I had more close and frequent contacts with V.I. I realized that he much appreciated in his students and collaborators self-dependent thinking and proposing their own ideas and well-motivated suggestions. Perhaps I possessed this quality a little bit and, as a result, at the end of 1972 I became a PhD student ("aspirant") at the Physics Faculty of MSU under the supervision of V.I. and Dmitry Ivanovich Blokhintsev. At the time V.I. was excited by the idea of applying the nonlinear realizations method to space-time symmetries including Poincaré symmetry. He worked on this subject with his PhD student Alexander Borisov from Sverdlovsk (now Ekaterinburg). They reformulated gravity as the joint nonlinear realization of two well-known space-time symmetries, the conformal and affine ones. This construction was based on the remarkable "Ogievetsky theorem": the infinite-dimensional group of space-time

diffeomorphisms is the closure of the two finite-dimensional subgroups above. The graviton field got the beautiful interpretation of a Goldstone field. I was highly impressed by these results and came to V.I. with the suggestion how a similar idea could be applied to gauge theories, with the Yang-Mills or Maxwell fields as Goldstone fields. We published a joint paper on this subject. My first joint paper with V.I. was "Inverse Higgs phenomenon in nonlinear realizations" where we showed that the standard Goldstone theorem does not always fully apply to the nonlinearly realized space-time symmetries and some Goldstone fields are not independent. These results, in particular, constituted my PhD Thesis which I defended in 1976. At the time I was already employed as a Junior Scientific Researcher at LTPh, in the group headed by Academician Moisei Aleksandrovich Markov (to which Polubarinov and Ogievetsky belonged).

The discovery of supersymmetry in the 1970s deeply influenced the research activity in Markov's Group. V.I. quickly realized the potential importance of this new concept in particle and mathematical physics. One of the pioneers of supersymmetry was Dmitry Vasil'evich Volkov (1925 - 1996) from the Kharkov Institute of Physics and Technology. For a long time he and his group had close scientific and human contacts with Ogievetsky and his collaborators. So it was not surprising that supersymmetry became the main research direction in the group of young researchers around Ogievetsky. The active members of this team were Luca Mezincescu from Bucharest and Emery Sokatchev from Sofia. Boris Zupnik, who defended his PhD earlier and got a position in the Institute of Nuclear Physics near Tashkent, also dwelled deeply into this new area. I also focused on this line of investigations. Later on, this research team constituted the main staff of the sector "Supersymmetry" at LTPh headed by V.I. Ogievetsky. In the beginning of the 1980's the group was enriched by the talented and enthusiastic PhD student Alexander (Sasha) Galperin from Tashkent. Later on, it was further strengthened by D. V. Volkov's student Anatoly Pashnev. I should also mention Stilyan Kalitzin from Sofia who, like A. Galperin, belonged to the second generation of supersymmetry adepts at LTPh. To "recruits" of supersymmetry there could be as well attributed aspirants from Dniepropetrovsk A.S. Sorin and C.O. Krivonos (now they are in staff of LTF). A frequent guest of Dubna was a docent of the Physical Faculty of DSU (Dniepetrovsk State University) Aleksander Kapustnikov.

Since the start of the supersymmetry era, the main interests of V.I. and his entourage were concentrated on the superspace approach to supersymmetric theories. The spin-principle which inspired the view of gauge invariance as a way to ensure the propagation of a definite spin in an interacting field theory proved very fruitful in supersymmetric gauge theories. This includes, most notoriously, supergravity which is the unique self-consistent theory of interacting gauge fields of the spins 2 (graviton) and 3/2 (gravitino). Actually, Ogievetsky and Polubarinov (in their 1964 lectures) asked the question about a possible gauge theory of an interacting Rarita-Schwinger field carrying spin 3/2. They made a serious efforts to find an answer, but failed because nobody was aware of supersymmetry at the time. The 1971 discovery by Gol'fand and Likhtman from the Lebedev Institute of Physics (FIAN) of the supersymmetric extension of the Poincaré algebra remained largely unnoticed, including by Ogievetsky[1].

A non-trivial generalization of the spin principle to superfields was the elegant formulation of $\mathcal{N} = 1$ supergravity by V.I. and E. Sokatchev in 1977 - 1980 as the theory of an axial-vector gauge superpotential carrying superspin $\mathbf{3/2} = (2, 3/2)$. Supersymmetry led to a new gauge principle, the preservation of $\mathcal{N} = 1$ chirality in interacting theories. $\mathcal{N} = 1$ chirality amounts to the realization of $\mathcal{N} = 1$ supersymmetry in a complex superspace containing only half of

[1]Supersymmetry was independently discovered by D.V. Volkov and V.P. Akulov in 1972 in the framework of nonlinear realizations.

the original 4 Grassmann coordinates. This geometric principle underlies both $\mathcal{N}=1$ gauge and supergravity theories in superspace. A key remaining problem was finding a geometric formulation of theories with extended $\mathcal{N}\geq 2$ supersymmetry. A decisive steps toward this goal was our 1981 paper with V.I. and A. Galperin where we studied $SO(2)$ extended $\mathcal{N}=2$ supersymmetry and found a generalization of $\mathcal{N}=1$ chirality. $\mathcal{N}=2$ superspace contains a subspace with half the original 8 Grassmann coordinates, different from the standard chiral subspace. V.I. invented the name "Grassmann analyticity" for this new phenomenon of complex subspaces with a fraction of the Grassmann coordinates. Our hope was that the new concept underlain all gauge theories with extended supersymmetry. The idea about the right type of Grassmann analyticity in the simplest $\mathcal{N}=2$ case, occurred to me at the end of 1983. One has to extend the standard $\mathcal{N}=2$ superspace by the pure internal coordinates of the 2-dimensional sphere $S^2\sim SU(2)_R/U(1)_R$. Here $SU(2)_R$ is the group of automorphisms (or R-symmetry group) of the $\mathcal{N}=2$ Poincaré superalgebra. In this enhanced superspace one can define a new type of Grassmann analytic subspace containing as usual half of the Grassmann coordinates but also (necessarily!) the set of internal coordinates of S^2. Both the $\mathcal{N}=2$ matter hypermultiplet and gauge prepotential admit a nice representation as unconstrained superfields living on this analytic subspace. The expansion of such Grassmann analytic superfields in terms of spherical harmonics implies the presence of an infinite number of ordinary component fields. In the $\mathcal{N}=2$ gauge theory these are pure gauge degrees of freedom. On the other hand, in the hypermultiplet case they are genuine auxiliary fields needed for the off-shell description of the multiplet in the enhanced superspace, something impossible in the standard $\mathcal{N}=2$ superspace. The new type of superspace was later dubbed "harmonic superspace" (HSS).

During one of our first discussions of this new approach together with V.I. and Sasha Galperin, V.I. called Emery Sokatchev, who had just returned to Sofia, and pronounced the sacramental phrase: "Emery, come urgently to Dubna, the $\mathcal{N}=2$ case has been done!". All the basic features of the modern $\mathcal{N}=2$ HSS (the invariant superfield actions for all $\mathcal{N}=2$ theories of interest, including supergravity, quantization, etc) were worked out together with Emery and Stilyan Kalitzin who joined the four of us somewhat later. The name "harmonic" of the new extended superspace was suggested by Boris Zupnik, who also made essential contribution to the field and became its adept for the rest of his life. Soon after publishing our ground breaking paper on $\mathcal{N}=2$ HSS (in 1984 in Class. Q. Grav.), we found the relevant $\mathcal{N}=3$ harmonic superspace. In it we (with the active involvement of Stilyan Kalitzin) constructed for the first time an off-shell formulation of a gauge theory with three manifest supersymmetries. Its main features were the infinite sets of both gauge and auxiliary fields, as well as the action of Chern-Simons type. Further developments and applications of the HSS approach (summarized in the Monograph A. Galperin, E. Ivanov, V. Ogievetsky, E. Sokatchev "Harmonic superspace", CUP, 2001), as well as some updated relevant references can be found in my recent review (E. Ivanov, 1604.01379 [hep-th]).

It is rather difficult to adequately express my impressions of Victor Isaakovich as a scientist and human being. I admired him. My own scientific style and circle of interests were formed under his great influence. I think that his main character traits were his absolute honesty and integrity, as well as the unlimited devotion to science. He shared the political views of the finest layer of Russian intellectuals in those years. His hero was Academician A.D. Sakharov. I remember how upset he was by the exile of Sakharov to the city of Gorky. He really believed in Gorbachev's "perestroika" only after Sakharov returned to Moscow. V.I. suffered from the fact that, being recognized world-wide for his outstanding work, he could not travel abroad

despite the numerous invitations from top scientists. Only in the 1990s, close to the end of his life, V.I. could undertake a long scientific tour of the USA. He also spent a year in Germany as a Humboldt prize winner. He was on friendly terms with many people from literature and art, for example the poets Alexander Galich and Yuli Kim, the writer Arkady Belinkov (the author of the known book about Yuri Olesha). They visited him and Margarita Mikhailovna in Dubna, V.I. boated them to picturesque places on the riverside of Volga in environs.

While we were actively working on HSS (and later, when we wrote joint brief papers for Mathematical Encylopaedia), I was a frequent guest at V.I.'s home, where occasionally we would drink a little bit of vodka. V.I. possessed a remarkable collection of classical books and I sometimes borrowed some of them to read at home. In this way I red almost the whole corpus of novels by Charles Dickens, while before I was familiar only with few ones. My favorite novel was "A Tale of Two Cities". It turned out that V.I. very liked it as well.

He taught me how to present talks at seminars according to the so-called "Zermelo rules", two of which were "You can never underestimate the ignorance of the audience", "Pass by the essential, but stop at the trivial". Now I try to follow these rules, though not always successfully. In science V.I. put above all the beauty of formula or concept. He stated that the beauty is one of the basic criterions of validity of one or another theory. Though the supersymmetry was not still discovered in experiment, this idea is so beautiful that it cannot be wrong. Just for this reason it was in the center of attention of V.I. until his last days. As a faithful disciple of V.I. I also believe in the existence of supersymmetry and will seemingly never pass to other research subjects. The most negative judgment of a physicist by V.I. was "he is a scoop-up".

We are good friends with his son Oleg who is now a Professor in Luminy (France).