# To the memory of V. G. Bar'yakhtar — scientist and person

Five years ago, a remarkable person — scientist, teacher of many generations of physicists and organizer of science, Victor Grigorievich Bar'yakhtar, passed away. This happened shortly after Viktor Grigorievich's relatives, friends, students and followers celebrated his 90th birthday. Our journal published a special issue dedicated to this event, important for so many [*FNT*/*LTP* **46**, No. 8 (2020)], and we are happy that Victor Grigorievich had time to read it. And now five years have passed since he is not with us.

Perhaps it is too early to summarize the creative life of Victor Grigorievich (VG, as his students, collaborators and followers called him). Great things must be seen at a distance... And the bitterness of the recent loss has not yet gone away. But, reflecting, remembering and talking with colleagues, we can already note something that will remain with us forever. Without pretending to complete the picture, let us note some of them.

First of all, it is the school of Victor Grigorievich Bar'yakhtar — the VG School. Behind these formal words one should see something much more than a list of scientists who defended their dissertations under his guidance. Very many people who do not fall under this formal criterion, consider him their Teacher, include themselves to the VG School. The fact is that VG himself, who comes from the Landau School, a direct student of A. I. Akhiezer (our journal wrote in detail about the initial stage of VG's formation as a scientist [*FNT*/*LTP* **36**, No. 8/9 (2010)], throughout his long creative career took very seriously the education of young researchers, in particular, those who wanted to be his graduate and PhD students or to work in his department. In general, everything started back in Kharkov, where the traditions of L. D. Landau were still alive. Anyone who wanted to work in Akhiezer's department had to pass the "Landau theorminimum". The examiner on quantum mechanics was usually A. I. Akhiezer. VG's exam was the last; formally, he was an examiner on statistical physics, but it was not a postulate — one of the authors of this article in the mid-70s passed the full course of solid state physics. Years and decades passed, institutions changed, but the essence of VG's approach to selecting members of his team remained the same. VG's exam was never reduced to answering some formal questions — it was always a long, thoughtful conversation, where VG not only tried to understand what the examinee knew or did not know, but also explained "how it really is". VG taught not only the methods of theoretical physics, but also the love of labor (Monday begins on Saturday — that's about him), scientific and human decency — all on the principle of "do as I do". As a result, there is now a significant cohort of VG students, and the VG School is actively developing.

We felt that the best memorial to VG would be this special issue (SI), featuring his disciples and closest followers who are common to him in spirit. Here are articles not only of direct students (time goes on, not all are with us, not all are active), but also of students of students — "scientific grandchildren", "scientific great-grandchildren"; even "scientific great-great-grandchildren" are already active in physics.

The most important element of VG's legacy is the Institute of Magnetism, which he founded more than 30 years ago. VG worked in many institutes, in Kharkov, Donetsk, Kiev, and everywhere he was one of the most important "center of attraction", always open for scientific discussions and always ready to give important advice at the highest level. However, VG almost never headed large institutes (only four years during his long journey in science); probably, he simply did not have the strength to know all the directions of research closely, to really get into all the problems and to help everyone in the way he wanted and was used to — and without this he did not think of true leadership of a scientific team.

The Institute of Magnetism of the National Academy of Sciences of Ukraine and the Ministry of Education and Science of Ukraine (IMag, now the V. G. Bar'yakhtar Institute of Magnetism of the National Academy of Sciences of Ukraine) was established in 1995 on the basis of the Department of Magnetism headed by VG and several other departments of the Institute of Metal Physics of the National Academy of Sciences of Ukraine. VG conceived it as a harmoniously organized research and educational structure, where theoretical and experimental activities

of scientists were organically combined and teaching activities were stimulated in every possible way. Hence the unusual double subordination of the National Academy of Sciences of Ukraine and the Ministry of Education of Ukraine. The organization and formation of IMag fell on hard times — difficult economic situation in the country, significant underfunding of science. Thanks to the organizational talents of VG, as well as the support of colleagues (first of all, VG's disciple Yu. I. Gorobets and A. N. Pogorely), the team headed by VG successfully overcame all the obstacles on the way to its formation.

In this rather compact institute VG could realize his vision of the organization of scientific work and the responsibility of the scientific director for everything that is done in the institute (here it is impossible not to draw a parallel with the institute created in his time by P. L. Kapitsa). VG invariably participated in the admission examinations to graduate school and candidate examinations; he knew what was being done in the departments and always tried to help with scientific advice and a kind word. On his initiative, at the beginning of each year the Institute held so-called scientific sessions, where the team leaders reported the results of their work. It was at these sessions that the ability to clearly explain the idea and results of a scientific task was "forged". The lessons and traditions laid down by the VG made IMag a stable "ship" capable of overcoming all storms and hurricanes in our complex, fastly-changed world. At present IMag is one of the leading research institutions of Ukraine in the field of physics of magnetic phenomena and magnetic materials, and we hope that it will remain the same alma mater for many and many generations of Ukrainian scientists as it was for us.

VG was a Scientist with a capital letter, who did a lot in various fields of physics — both theoretical physics and in creative cooperation with experimentalists, see the already mentioned articles in our journal. But let us take the liberty to state that the first place for him was the physics of magnetism. We would like to note here VG's contribution to the deepest foundations of an important branch of this field of physics, the phenomenological theory of magnetism.

The phenomenological theory of magnets is based on the famous Landau–Lifshitz equation (LLE), closed evolution equation for the magnetization of ferromagnet, which was proposed in 1935, about 90 years ago. VG evaluated this work in the highest way; on his initiative, a conference devoted to the 50th anniversary of LLE was held in Kiev in 1985; later he organized the publication of the special issue "80 years of LLE" [*FNT/LTP* **41**, No. 9 (2015)]. It so happened that the next important step in the development of the phenomenological theory of magnets was made in the late 50s by A. I. Akhiezer, VG and S. V. Peletminsky. The full story was as the following: they predicted the effect of magnetoacoustic resonance, and their result was obtained on the basis of a microscopic approach, using the representation of spin operators through Bose operators. But when the work was discussed with L. D. Landau, the latter in a rather harsh form suggested to redo it in the framework of the phenomenological approach (VG liked to tell this story in all details). For this purpose, the authors had to first construct a consistent macroscopic theory of ferromagnetism, and only then to consider on its basis a specific effect of magnetoacoustic resonance. As a result, a consistent theory was constructed, accounting for the dependence of magnetization on temperature, the role of boundary conditions, energy and spin transfer between different subsystems of the magnet, and much more. This work took almost two years, but the resulting article has been widely recognized worldwide. When one reads this paper, one can see that its content is much broader than its title, "Coupled magnetoelastic waves in ferromagnetic media and ferroacoustic resonance". Subsequently, these ideas were further developed, especially in depth in the remarkable monograph "Spin Waves" [1967, Engl. translation 1968], on which many generations of "magnetic people" grew up.

The next step has been done in 1984, when VG proposed the serious modification of LLE, by addition of a relaxation term of the exchange origin to this equation. That times, VG told to one of the authors of this paper that the initial motivation of this modification lies in the dissatisfaction with the discrepancy in the behavior of the dissipation rate of exchange-dominated high-frequency magnons, found from an exact microscopic approach and from the LLE in its original form. VG's exchange dissipation term reproduces well the exact microscopic result and removes this discrepancy. But, additionally, it turns out that such modification leads to a significant change of an important feature of LLE: the longitudinal evolution of magnetization, i.e., the dynamics of the modulus of the magnetization $M = |\mathbf{M}|$ (absent in the original form of LLE), appears unavoidable. In fact, in 1984 VG proposed the significant modification of the general form of phenomenological theory of magnetization, having to that times almost a half-of-century history of successful application for description of various dynamical effects in magnets. In this theory, based on the modified equations, commonly called now as Landau–Lifshitz–Bar'yakhtar (LLBar) equation, the longitudinal evolution of magnetization is present naturally. That times, the question on the evolution of highly-nonequilibrium states of magnets with strong deviation of $M$ from its equilibrium value $M_0$ was not of a big interest. But the situation was changed significantly after the development of a new direction in fundamental and applies physics of magnets, so-called femtomagnetism, based on the application of ultrashort (duration of about 100 fs and even shorter) laser pulses of high energy. The first sign of the opening of this new direction in the field of spin dynamics was the experimental observation of a drop in the magnetization of simple, single-element ferromagnetic nickel by more than 50%, followed by fast (picosecond-timescale) relaxation of the magnetization length after the pulse. For ferrimagnetic alloy of rare earth and transition metals, GdFeCo, the ultrafast (during the "exchange" times, of the order of picoseconds) "switching" of the direction of magnetization under an action of such pulse was observed and later proposed for new generation of ultrafast magnetic all-optical memory. Nonlinear longitudinal evolution of sublattice spins was shown to be the origin of this fantastic effect, and LLBar equations was found to be the only way of its analytical description. We have no doubt that the phenomenological theory based on the LLBar equation still has a long way to go in terms of development and a long life ahead of it.

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