

N.G. Basov - the genius was there!

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Nikolai Basov was born on December 14, 1922 in the village of Usman, Tambov province and, perhaps, is the only Nobel Prize winner who was born on the territory of the state called the "Russian Soviet Federative Socialist Republic". 16 days after his birth, the Ukrainian and Belarusian SSR, as well as the Transcaucasian SFSR, will join the RSFSR and the Great Union of Soviet Socialist Republics was created. Five years later, the family of Gennady Fedorovich Basov, a professor at the Voronezh Forestry Institute, a specialist in the impact of forest plantations on groundwater and surface drainage, and his wife, Zinaida Andreevna Molchanova, finally moved to Voronezh. I must say that Nikolai Gennadievich's path from the beginning of higher education to the scientific breakthrough that brought the Nobel Prize was exceptionally fast, the fastest for a Soviet physicist. However, higher education itself had to wait: when Nikolai turned 19, the Great Patriotic War began. It was at the Kuibyshev Medical Academy that he was trained as a doctor's assistant and from 1943 went to the First Ukrainian Front, reaching Prague with him. Surprisingly, both Soviet laser creators went through the most brutal war and, nevertheless, survived!

Immediately after the end of the war, Nikolai Basov entered MEPhI and, starting from the third year, began working as a laboratory assistant at the FIAN. All the further scientific life of N. Basov was closely intertwined with the life of A.M. Prokhorov and this article involuntarily reflects this continuous connection. When graduate student N. Basov came to the laboratory of A.M. Prokhorov, the head of the laboratory convinced the director of the FIAN to introduce another staff unit for a novice scientist in the laboratory, and in return promised to provide his synchrotron for research in another scientific direction important for the institute. The FIAN then

said that A.M. Prokhorov exchanged the synchrotron for some student, and Alexander Mikhailovich himself joked that N.G. Basov got him extremely expensive. It was in such conditions that the creative life of an outstanding scientist began! As a matter of fact, the candidate's thesis, defended in 1953, and the subsequent doctoral thesis, defended in 1956, contained sketches of what he and his supervisor were later awarded the Nobel Prize for.

In 1955, A.M. Prokhorov and N.G. Basov published a scientific report on the "three-level method". It should be noted that the American physicist C.H. Townes from Columbia University worked on a similar idea. It was he who called his creation a maser. A.M. Prokhorov and N.G. Basov called it a molecular generator, based on its physical essence. The physical principle of operation of this device can be explained based on the theory of A. Einstein, formulated back in 1917. The result of his research, in particular, was an equation that described the absorption and emission of radiation by molecules. However, for quite a long time the study of these processes was only an important part of theoretical physics. N.G. Basov and A.M. Prokhorov translated this theoretically predicted radiation into a practical plane. They were not only able to amplify this radiation, but also created a molecular maser generator based on it. They managed to achieve an increase in the number of excited molecules using the electric field of a quadruple capacitor. The maser generated radiation with a strikingly narrow line in the centimeter wavelength region.

In 1960, a physicist from the Hughes Aircraft Company (USA) designed a device that radiates already in the optical wavelength range and which was also based on the idea of an inverse population of levels. The device of T.H. Meyman very quickly became widespread. The name of this device was

already predetermined - Laser! In 1964, N.G. Basov, A.M. Prokhorov and C.H. Townes were awarded the Nobel Prize. However, the laureates did not stop there. They continued to develop lasers and laser technologies of various types and directions. It should be said that N.G. Basov, like his teacher, was engaged not only in scientific activities. He was also the editor of several journals: "Science", "Quantum", "Quantum Electronics", "Nature". He was a member of many academies of sciences in various countries of the globe. The scientific work of two front-line soldiers - a teacher and a student - led to a brilliant discovery, which, and there is no doubt about it, is one of the most important in the XX century, the wording of the Nobel Committee reads as follows: "For fundamental work in the field of quantum electronics, which led to the creation of generators and amplifiers based on the laser-maser principle (for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle)."

The essence of the breakthrough that N.G. Basov and A.M. Prokhorov made and which eventually led, in full accordance with the verdict of the Nobel Committee, to the creation of a laser is described in detail in many sources. My task is to add my own colors to complement the image of this great man - Nikolai Gennadievich Basov. In the previous article (BIIK No. 34) I told in detail about my memories of Alexander Mikhailovich Prokhorov.

At the beginning of the Nobel Lecture, N.G. Basov allowed himself to philosophize on the role of theory and experiment, dividing all physicists into two groups. In modern physics, as it may have been before, there are two different currents. One group of physicists sees its goal in the knowledge of new laws and in the resolution of existing contradictions. They consider theory to be the output of their work, in particular the development of the mathematical apparatus of modern physics. As a waste of production, new principles of device construction and physical devices appear. Another group of physicists, on the contrary, seeks to create physical devices based on a new principle, and heading towards this goal, tries to circumvent the inevitably

encountered difficulties and contradictions. This group considers various hypotheses and theories to be production waste. Both groups have outstanding achievements. One group creates a breeding ground for the other, and therefore they cannot live without each other, although their relationship is quite acute. The first group calls the second "inventors", the second accuses the first of abstraction, and sometimes aimlessness.

At first glance, it may seem that we are talking about theorists and experimenters. But this is not so: both the first and second groups include both of these varieties of physicists. Currently, the division into these two groups has become so sharp that entire areas in science can be attributed to the first or second group, although there are sections of physics where both groups work together. The first group of physicists includes the majority of researchers working in the field of quantum field theory, elementary particle theory, many issues of nuclear physics, gravity, cosmogony, and a number of issues of solid state physics. A striking example of the second group are physicists engaged in the development of issues of thermonuclear fusion, quantum and semiconductor electronics and related fields.

After receiving the Nobel Prize, academicians N.G. Basov and A.M. Prokhorov lived for almost four decades more. Some sources wrote that upon returning from Stockholm, the scientists allegedly quarreled over access to the country's military state order. And the division of the Lebedev Physical Institute of the USSR Academy of Sciences into two separate institutes in those years was also, as it were, a consequence of the deteriorating relations. And laser physics in our country, allegedly, began to develop in two separate and independent branches. But this is far from the case! Idle speculation and gossip, than many scandal-hungry journalists and scientists without a name have sinned and sin. Nevertheless, thanks to this "enmity", Russia has become a world leader in laser physics, both in the civilian and military spheres of activity. In any actively developing field of knowledge, and this is an axiom, competition is necessary for its further development. There is it in science, even more than

anywhere else. So, it was the reasonable and useful competition that was perceived by others as the basis for gossip. As a person who has worked in laser physics for more than 50 years, I affirm that there was no enmity and could not be between these outstanding scientists immersed in science! But there were several people who wanted to warm up at the campfire kindled by them for career purposes!

N.G. Basov worked closely with the 25th Department of MEPhI. Half of the staff of his laboratory worked with students, selecting the best after graduation to their research groups. To get a job or to graduate school at FIAN was the secret desire of many students who were doing research work at the department. It was also my desire, which I managed to realize immediately after defending my diploma. Only I got into the FIAN not in the Laboratory of the KRF to N.G. Basov, which would be logical, but in the Laboratory of Vibrations, which at that time was headed by another Nobel laureate A.M. Prokhorov. M.D. Millionshchikov, who headed the 10th department of MEPhI, actively cooperating with the 25th, influenced this. The fact is that my thesis was carried out at this department of Mass Spectrometry, where a powerful solid-state laser was assembled for the study of multi-charged ions. Mikhail Dmitrievich was often interested in my work and immediately before graduation from the institute advised me to go to his close friend. I must say that the laboratories of N.G. Basov and A.M. Prokhorov closely cooperated and conducted joint scientific seminars. There was an exchange of ideas, results and scientific equipment. It helped a lot in the work and in finding valuable advice at the right moments.

The Laboratories of Oscillations and Quantum Radio physics of the FIAN conducted a lot of scientific research in the interests of industry and the defense complex of the country. Due to this, the real budget of the laboratories increased many times in comparison with others who lived on purely academic money. By the will of fate, I happened to be in the thick of events related to the creation of high-energy lasers. That is why meetings with NG Basov have become more frequent. Often on behalf of A.M. Prokhorov had to take part in discussions of

scientific and technical issues at meetings of various councils for the development, creation and application of high-power and high-energy lasers in industry and in the defense sector. The fact is that I was lucky enough, together with A.M. Prokhorov and A.I. Barchukov, to formulate the basics of the Static and Adaptive Power Optics that we discovered, without which no high-International conferences and communication on the sidelines, discussion of the prospects for the development of laser diode bars and LD-matrices technology. In Russia, we were the first who, thanks to efficient cooling, taken from high-power optics technology, reached the level of 100 watts from one bar. It was precisely these that N.G. Basov and his collaborators did not have when creating the first disk laser, and the disk had to be pumped using another laser with the appropriate wavelength. This caused smiles and even irony among many famous scientists of the FIAN. But the greatness of the great ones is that they see much further than their contemporaries and create the future with every step they take. Today, a disk laser is the only candidate that allows the creation of strategic laser systems with minimal weights and dimensions!

In the 90s, which were very fruitful for laser forums in Japan, I was lucky enough to take part in an international conference on modern powerful lasers and their applications held by the Japanese School of Laser Physics. The work of the International Conference was headed by Academician N.G. Basov, A.M. Prokhorov and C.H. Towns. A.M. Prokhorov could not come because of the heavy workload at the Academy of Sciences. C.H. Towns came and, as always, was very active in terms of questions to the speakers. I had to make several joint reports with A.M. Prokhorov. But I also had to take part in the meeting of the Presidium of the Academy of Sciences of Japan together with the Nobel Laureate instead of my boss, which was a great honor for me. NG Basov was at the Forum with his wife Ksenia Tikhonovna and went to the meeting with her. And then there was an incident with Ksenia Tikhonovna, she was simply not allowed to attend the meeting, apologizing to her star husband for a long time. The fact is that up to the end of the XX-th

century, all full members of the academy were male individuals, which is reflected in detail in fiction. Only very recently, the first and only female professor of social anthropology, Tee Nakane, was elected to the number of full members of the Academy. The Basov's family respected the tradition of the Academy of Sciences of Japan and Ksenia Tikhonovna went to the hotel, and Nikolai Gennadievich, as if nothing had happened, went to the meeting with a smile. It is possible that this case also influenced the acceleration of changes in the gender preferences of the Japanese Academy of Sciences.

N.G. Basov, together with Yu.M. Popov and B.M. Wool, proposed the idea of creating various types of semiconductor lasers. In 1962, the idea of creating an injection laser was put forward, then lasers excited by an electron beam were created, and in 1964 — semiconductor lasers with optical pumping. N.G. Basov developed research on powerful gas and chemical lasers. In his laboratory, fluorohydrogen, iodine lasers and excimer lasers were created, as well as adders — converters of laser radiation. A number of works by N.G. Basov is devoted to the propagation and interaction of high-power laser pulses with matter. He had the idea of using lasers to control thermonuclear fusion (1962), he also proposed methods for laser plasma heating, as well as stimulating chemical reactions with laser radiation. N.G. Basov and his collaborators also developed the physical foundations for creating quantum frequency standards, put forward ideas for new applications of lasers in optoelectronics, such as the creation of optical logic elements, and initiated many studies on nonlinear optics and medical applications.

The genius of N.G. Basov is also involved in the "modern" solid-state laser - disk. This idea of Academician N.G. Basov has been true for 57 years, but it is this principle of building powerful laser complexes that is dominating today and for a long time in the future. With the same, very advantageous weight factor as for fiber, today this constructive principle allows the implementation of a high-energy high-frequency pulse-periodic mode, since the aperture of the existing disk laser has a diameter of

about 1.5 cm, which is significantly larger than the diameter of the active body of the fiber laser. Here it is necessary to recall the long-standing visit of the German delegation to the Laboratory of Quantum Radio physics, which was headed by N.G. Basov. Not fully understood by the guests, the solid-state laser technology demonstrated by them on the basis of disk geometry (the patent, however, belongs to one of the guests - A. Giessen, Stuttgart, Germany) led to a modern design of disk laser systems that does not allow significant scaling of the power of a laser weapon (LW) complexes to a strategic level. Much later, during a conference in Japan, I managed to talk several times over breakfast and lunch with the author of the idea about its future. N.G. Basov, who opened the conference, shared with me his vision of the problem of disk geometry. In his opinion, the only promising approach to the creation of the entire line of high-power solid-state lasers from the tactical to the strategic level could be mono modular technology. But for this it was necessary to find solutions to two problems: cooling of a large diameter disk and suppression of amplified spontaneous noise.

In the current geometry of the disk laser, developed by Germany, the USA and Japan, to increase the average power of the system, the radiation of several disks is added to the optical sequence "ZIG-ZAG", the value of the average power of such a module today is already 50 kW. The radiation of modules, as in the case of fiber systems, can be combined into a single beam. Based on the figures given, it can be seen that a 100 kW laser will weigh less than 500 kg!!! However, it should be noted that LW complexes of significantly higher average power are needed to fulfill the tasks of the Armed Forces of the Russian Federation. But from the disk geometry of modules with a capacity of even 75 kW (this increase is planned due to the quality of reflective coatings) to the power level of the entire system of about 10 MW, the distance is gigantic. It is not possible to combine the power of more than 100 modules into a single beam in the case of a mobile complex. It is the ideas of N.G. Basov that are working today and on the paths of a single large-diameter disk, further scaling of the output power of such a laser is possible. It is

this path of development of high-energy disk lasers that we are developing today thanks to the true author of the idea - N.G. Basov.

N.G. Basov took an active part in the celebrations on the occasion of the 60th anniversary of A.I. Barchukov, a man who did an incredibly difficult job of preparing and approving documents submitted to the Swedish Academy at the stage of nomination for the Award. In those years he was the Scientific Secretary of the FIAN and his area of responsibility included the complex dispatch of documents of future laureates at that time. To better understand the situation around the nomination in those years, I will try to convey the conversation of the two laureates during the celebration of the anniversary of prof. A.I. Barchukov. It was about the loss of almost guaranteed Nobel Prizes due to bureaucratic obstacles built by officials. The Swedish Academy, according to them, consistently offered to name three names involved in the launch of the first satellite, the first cosmonaut, the first docking in space, the first spacewalk, etc. But every time something prevented it from being done. Either the difficulty in identifying three of the long list of success creators, or secrecy, or something else. So, A.I. Barchukov had a really difficult job, but a man with a capital letter and a scientist who went through the war from bell to bell, coped with his task at that moment perfectly! And a few more words on the topic of the Nobel Prize and bureaucratic delays. An outstanding Soviet and Russian theoretical physicist, a pioneer of laser physics, in particular, the method of laser cooling of atoms, V.S. Letokhov, lived and worked in our great country. The 1997 Nobel Prize in Physics was awarded to a group of researchers - Stephen Chu, William Phillips (USA) and Claude Cohen-Tannouji (France) for their work on laser cooling of atoms. There was no place for the author of the idea and theoretical justification in this award. This is a kind of Bose - condensation of the opinions

of the Anglo-Saxon majority. As our Russian laureates said, the number of laureates from the United States and UK is the beginning to determine the quality of the awards given out annually!

Well, in conclusion, I would like to quote the words of another great Nobel Prize laureate to Nikolai Gennadievich Basov. According to Zhores Ivanovich Alferov, the technological and social progress of the twentieth century was determined by three discoveries in the field of physics. This is the fission of uranium, discovered by German scientists Gann and Strass Mann in 1938. The second is the invention of transistors in 1947 by D. Bartin and V. Brattain, which prepared the computer revolution. And the third is the discovery by N.G. Basov, A.M. Prokhorov and C.H. Towns of the laser-maser principle, which served as an impetus for the development of many military and peaceful technologies. These are primarily semiconductor lasers and fiber-optic communication.

At the beginning of the XXI century, this outstanding scientific tandem left with a difference of a little more than six months. The first, on June 1, 2001, a disciple, N.G. Basov, passed into eternity. The second, on January 8, 2002, was the teacher, A.M. Prokhorov. Alexander Mikhailovich loved his talented student very much, treated him with great respect and grieved over the untimely departure of a colleague in a new section of knowledge created by them. And they lie in the "Novodevichy Cemetery" nearby, just as they have lived in the same house in Kuntsevo for the last decades and worked side by side in their institutes on Vavilov Street. They have not been with us for more than 20 years, and the science created by these titans continues to keep many thousands of scientists and engineers in suspense around the world and create new growth points in many fields of science, technology and civil applications.