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The Great Russian Tandem

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I had the great fortune to study and work closely with outstanding Russian physicists Alexander Mikhailovich Prokhorov and Nikolai Gennadievich Basov. I have never ceased to be amazed at the manifestations of their genius, each time discovering new facets of the teachers' many talents.

What is the first thing that comes to mind when they are no longer with us for more than 20 years and the acute emotions of parting have long since subsided? An incredibly developed sense of intuition, an amazingly quick ability to find the right solutions, a keen sense of the new, fundamentally important for the leap into the future, humanity. But a sense of the cutting edge of science, of the trends of its development, were perhaps central to the character of these phenomenal scientists. My task in this article is to add my colors to complement the images of these great scientists and citizens of Russia - Alexander Mikhailovich Prokhorov and Nikolai Gennadievich Basov [1, 2].

Introduction

In 1955, A. M. Prokhorov and N. G. Basov published a scientific communication about the "three-level method". It should be noted that the American physicist C.H. Townes of Columbia University was working 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 this device can be explained based on the theory of A. Einstein's theory. The result of his research, in particular, was an equation that described the absorption and emission of radiation by molecules. For quite a long time, however, 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 practical applications [3-6]. Not only were they able to amplify this radiation, but on its basis they created a molecular generator - a maser. They managed to increase the number of excited molecules by means of the electric field of a quadrupole capacitor. The maser generated radiation with a strikingly narrow line in the centimeter wavelength range.

In 1960, a physicist from Hughes Aircraft Company (USA) designed a device that radiated already in the optical wavelength range and was also based on the idea of inverse population levels. T.H. Maimen's device quickly became widespread [7]. 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 and A.M. Prokhorov were not only engaged in scientific activities. They were also editors of several scientific journals. They were also members of many academies of sciences in different countries of the globe. The scientific work of the two front-

runners, teacher and pupil, led to a brilliant discovery, which, there is no doubt, is one of the most important in the 20th century, The wording of the Nobel Committee reads as follows: "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 this grandiose breakthrough, which was made by N.G. Basov and A.M. Prokhorov, and which eventually led, in full accordance with the verdict of the Nobel Committee, to the creation of the laser is described in detail in many sources.

In his Nobel lecture A. M. Prokhorov described in detail the history of quantum electronics, beginning with A. Einstein's idea of stimulated emission in 1917, its significant advance in terms of theoretical development of the model of stimulated emission by an excited atom in interaction with an external field in 1927 by Dirac. Its independent emergence in 1955 in the USSR and in the USA was predetermined by the appearance of pumping method to create conditions for negative absorption. The fact that this occurred for the first time in the radio range was explained by the considerable development of electron paramagnetic resonance methods by that time. Scientists thought that the transition to the optical range would not take much time, it turned out not so. It took almost 6 years to find an alternative to the radio-band resonator and an effective method of creating the inverse population, but already in the optical range. Further in the lecture of A.M. Prokhorov the possibilities of generation of coherent radiation in the X-ray wavelength range were considered. Also, the possibility of building laser systems with smooth tuning of the radiation frequency in a wide range was foreshadowed. The lecture highlighted important applications of lasers in various fields of science and technology. In particular, he expressed powerful ideas for applications of lasers in the study of multiquantum processes, the possibility of creating conditions for ionization and dissociation of molecules under strong fields created by laser radiation and realization of optical breakdown conditions in matter.

N.G. Basov in his lecture allowed himself to philosophize on the role of theory and experiment, dividing all physicists into two groups. In modern physics, as may have been the case before, there are two different currents. One group of physicists sees their goal in the knowledge of new regularities and in the resolution of existing contradictions. They see the output of their work as theory, in particular the development of the mathematical apparatus of modern physics. As a waste of production, new principles of construction of devices and physical instruments appear. The other group of physicists, on the contrary, seeks to create physical instruments based on a new principle, and heading towards this goal, tries to circumvent the inevitable difficulties and contradictions. This group considers the various hypotheses and theories as a waste of production. Both groups have outstanding achievements. One group creates a breeding ground for the other and so 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 being abstract and sometimes aimless.

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

History of n.g. Bassov's coming to the vibration laboratory

Let us return to those years, when the great associate of A.M. Prokhorov, who passed through the war and was seriously wounded, with the consequences of which he suffered all his life, namely, the frontman N.G. Basov started his first steps to the tops of science. Immediately after the end of the war, Nikolai Basov entered MEPhI and, starting from his third year, began working as a laboratory assistant at FIAN. All further scientific life of N. Basov was closely intertwined with the life of A.M. Prokhorov and this article reflects this continuous connection involuntarily, starting from the moment when Nikolai Basov, a graduate student, came to the laboratory of A.M. Prokhorov. It should be said that the way from the beginning of higher education to the scientific breakthrough that brought the Nobel Prize to Nikolai Gennadievich was extremely fast, the fastest for a Soviet physicist. However, the higher education itself had to be delayed: when Nikolai turned 19, the Great Patriotic War began. It was at the Kuibyshev Medical Academy that he was trained as an assistant doctor and from 1943 he went to the First Ukrainian Front, reaching Prague with it. Amazingly, both Soviet creators of the laser went through the most brutal war and yet survived! The head of the laboratory convinced Acad. D.V. Skobeltsyn to introduce for

the novice scientist in the laboratory one more staff unit, and for this he promised to provide his synchrotron for research in another scientific area, important for the institute. At that time at FIAN it was said that AM Prokhorov exchanged the synchrotron for some student, and Alexander Mikhailovich joked that he got N.G. Basov extremely expensive. That's under such conditions the creative life of an outstanding scientist began! As a matter of fact, his Ph.D. thesis, defended in 1953, and his subsequent Ph.D. thesis, defended in 1956, contained drafts of what he and his scientific advisor were later awarded the Nobel Prize for.

After receiving the Nobel Prize, Academicians N.G. Basov and A.M. Prokhorov lived another almost four decades. Some sources wrote that upon their return from Stockholm, the scientists allegedly quarreled over access to the country's military state order. And the division in those years of the P.N. Lebedev Physical Institute of the USSR Academy of Sciences into two separate institutes was also, as it were, a consequence of worsened relations. And laser physics in our country, allegedly, began to develop in two separate and independent branches. But this is far from being true! Idle speculation and gossip, as many scandal-hungry journalists and unnamed scientists have done and continue to do. Nevertheless, due to this "hostility" Russia has become a world leader in laser physics, both in civil and military fields. In any actively developing field of knowledge, and this is an axiom, competition is necessary for its further development. It also exists in science, even more so than anywhere else. So, it is the reasonable and useful competition that has been perceived by others as a basis for gossip. As someone who has worked in laser physics for over 50 years, I assert that animosity did not and could not exist between these distinguished scientists steeped in science! But there were a few people who wanted to warm themselves at the semblance of a fire - kindled by them for their own career purposes.

A.M. Prokhorov - Educator of Talents

The Institute of General Physics was lucky to have a leader at its formative stage. The state of highest tension in the search for the only right solution at that moment, by the experienced hand of the conductor, was replaced by merriment from a good joke, witticism, or anecdote at a scientific seminar. The chief appreciated witty jokes and skillfully used key phrases to the point. If you didn't learn something important during the seminar, it meant that you just didn't understand something, that you were out of shape. The loud laughter from the office, occasionally heard even in distant parts of the corridor, confirmed: everything is fine, we keep moving forward, we live. The ability to find a solution even in an insanely difficult situation, when it is obvious there is no solution and nowhere to take it - this is also his school. Here it is important, above all, to think about the case, not about yourself, not to be afraid to make a mistake. A mistake can be corrected, but lost time can never be recovered. A good example is the holistic bouquet of decisions from the time of perestroika. Here is one of them: at the most difficult moment, when science had just been thrown overboard, it was necessary to quickly comprehend the phrase "everything that is not forbidden by law is allowed." The solution was simple and effective: to give freedom to departments and laboratories, to conduct foreign economic activities on a contract basis and grants. And this at the time when neither accounting department nor planning department had specialists for piles of papers in all kinds of imported languages. Scientists of world renown, and there were dozens of them in the Institute, who had traveled around the world and had a good understanding of how "rotten" with its predominantly contract-based form of financing science works, quickly adapted and ensured a smooth transition to new forms of work. This is now, when everyone understands everything and gives advice to others, many things seem trivial. And at that time, it was necessary to grasp an effective way out of the situation and make a decision, which at the time gave a very significant result in terms of the survival of science.

Academician Prokhorov was an outstanding educator of young and not so young talents. In particular, he fostered a democratic approach to everything and the fairness of the decisions he made. Any employee could count on being listened to and, if necessary, supported. Even my son, Kirill, who still works at IOFAN, often had his hands full: family ties and past regalia were not taken into account; every day he had to prove himself right.

Always in an argument someone was wrong, but this is not a reason to label, tomorrow will be the opposite - you have to work and everything will be fine. The usual question is, "What's new?" - and immediately, with a smile, the answer for the interlocutor was, "Nothing!" It was a common form of dialogue, useful for starting a conversation for the next day - last night's separation, and this morning there can and should be science news. This is where science is done, and it's an ongoing process. In our lives, we spend a lot of time in the laboratory, often missing the mundane little things that make up life outside the institute. But there are serious and very

serious situations when it seems that there is no solution and help will not come. And here (and this was well known in the scientific world), the best solution was to go to Alexander Mikhailovich. Not only people from our institutes, but also those from other institutes knew that he would not say no and, if it were possible to help, he would definitely help.

Another distinctive feature of Prokhorov is his ease of communication with people around him. Respect and always an even tone of communication, without emphasizing the rank of the conversation participants. Whether it is a student or a specifically bred official of the state apparatus, it does not matter. In his office or in the company of him, all this faded into the background. The only thing that mattered was the level of intellect, the enduring essence of the development of civilization. And what is quite surprising is that people in such conditions of communication with each other as if found new opportunities for self-expression, felt a burst of creative energy, and they liked it themselves.

Here is an incident that happened in Japan at a meeting with the governor of Tokyo Metropolis, Mr. Shikaya. I was fortunate to be a participant in and witness to that event. The Japanese, who had studied the Russian visitors well, briefed our delegation in a few minutes on what was considered appropriate to the centuries-old customs and rules of good manners in their homeland. One could talk about flowers, about nature, about health. All other topics of conversation could be interpreted as inappropriate to the level of good upbringing of the interlocutors. And you should have seen the faces of these grief-stricken instructors after a few minutes of conversation between Academician Prokhorov and the governor of Metropolis, Mr. Shikaya-san, where the city of Tokyo enters as a small part. They talked as if they had known each other since childhood and were insanely happy to be able to talk to each other. In this life, wasting time talking about flowers and bows simply means not respecting each other. Apparently, this protective form of communication is implemented in Japan in case of visitors from Russia, who only know how to talk about preferential loans and section.

About A Scientist's Intuition

Alexander Mikhailovich Prokhorov was a physicist not only by specialty, but, as they say, by essence, and his habits were physically correct. Here's one of them - he liked when the room was warm, well, very warm, just Sahara. "And why warm the room with your heat? What's the average temperature of a normal person? 36,6? Here you go!". It was not easy to sit long in his office, the heaters were directly behind the visitor's back and quite close to that very back. For someone thermodynamic equilibrium, and for someone thermal shielding of the boss. It is difficult to overestimate the importance of the laser in solving medical and biological problems. Back at the dawn of the laser revolution, when the excitement of military applications went over all possible limits, Academician A.M. Prokhorov began to implant into the minds of the Institute staff and various chiefs the idea of effective use of laser methods for treatment of patients and of laser application in biological research.

Laser can be and is actively used in solving military tasks, and it is not a secret for a long time. It cuts, melts, reduces mechanical stability of structures, provides mechanical impulse transmission and provides a forceful mode of defeat for military equipment. That is why the attention of the military was drawn to the prospect of using lasers specifically for military purposes. Alexander Mikhailovich enthusiastically undertook the development of an interesting and important topic, the creation of powerful laser systems. At that time, the Institute's budget consisted of only one-third of the money coming from the USSR Academy of Sciences, most of it was given to us by industrial enterprises. Their representatives, active and demanding, knocked on the door of the Institute every day, providing us with new orders for civil and military needs. A great merit in the fact that we were constantly busy and did not idle was due to A.M. Prokhorov. It was he who managed to establish good contacts with both industrialists and the military.

At the very beginning of the "laser way" it was necessary to make a very important decision: to start development of lasers for so-called power defeat, or to choose the second direction - functional, when electronics and optical systems were disabled and all kinds of trigger effects in engineering elements were provoked. It was necessary to have deep knowledge and the gift of foresight in order to make the right step. And Alexander Mikhailovich, as time showed, turned out to be right, stating that we should have developed exactly this direction at that time. In 1973, Academician A.M. Prokhorov wrote a letter to Marshal Grechko. He wrote that power defeat was unattainable in the next 30-40 years, which was why it was necessary to develop functional defeat. Unfortunately, the venerable scientist was not listened to at that time - there were no quick financial benefits behind this decision - it was necessary to work laboriously

with much less financing. Alexander Mikhailovich was very long and persistent in proving his point, and if we talk about today, 90% of modern laser weapons (LW) are purely functional. However, the power industry has not yet reached the multi-megawatt, medium power levels required to solve both strategic problems and a new class of civil problems where high energy lasers look very promising.

I was lucky to work with Alexander Mikhailovich on very serious problems; he was not afraid to take on the most difficult tasks. His way of thinking was original, he was able to look at a problem out of the box. When working with powerful lasers, there was a need for an efficient way to cool the resonator mirrors, which are not perfect - they absorbed huge power due to their not one hundred percent reflection coefficient. The effect that we first encountered as the output power of the lasers was increasing showed that further increasing the output power of the device was impossible, because the mirrors in the place of incidence of the laser beam were locally heated and locally deformed. That is, the beam was reflected not from the flat surface, but from the hump on it. Due to distortions in the resonator, the total laser power decreased and the beam divergence increased. In this situation, no LE with a range of hundreds of kilometers was out of the question. It was precisely this problem, discovered in our experiments, that became the topic of my PhD thesis. Thus, I got under the close attention of the academician that was responsible for the research of physical processes in creating small arms. 1970 became the year of birth of a new discipline - power optics. Alexander Mikhailovich, and he was my scientific advisor, was interested every day in the course of research and gave very valuable advice. We consistently analyzed a wide range of dielectric solid materials, because polishing metals in the optical workshop next to expensive crystals seemed to be a big mistake. That's when silicon carbide was chosen. Today this material has become practically the basic material for creating superstable optical telescopes and other optical devices. But silicon carbide did not solve the problem of optical stability of mirrors either; it improved compared to quartz and seals, but did not solve it. The prospect of switching to highly conductive but solid metals also did not lead us to a solution to the problem of multi-megawatt lasers, which politicians and journalists were already talking about.

It was necessary to take the next step, simply choosing a material did not solve the problem of stable laser mirrors. It was necessary to involve very effective cooling. And here again we encountered a big contradiction: huge heat flows from the mirror surface with the help of coolant in the known at the time physical and technical models could be removed only at high temperature. At the same time, the system of coarse cooling channels was not compatible with the ultra-precise mirror surface, the details of which are measured in nanometers. As a result of the research, and they had to be very fast and efficient, a lot became clear in the problem of power optics of high-energy LW. In power optics, these channels had to be very thin, and there had to be a lot of water, and its temperature could not exceed a few tens of degrees. But the liquid could not push in large quantities through thin channels at low pressure, in addition, when the magnitude of the flow was increased, there were vibrations that distorted the surface. Alexander Mikhailovich supported my idea about possible resemblance of the mirror cooling system to the human circulatory system, in which hundreds of smaller, even smaller, etc. capillaries branch off successively from a large blood flow main, to reassemble into a single macro-channel afterwards. And all this should happen in the mirror on the scale of a few millimeters deep in the mirror. Fifteen years of testing the physical model of high-energy laser mirror, development of structural models and technologies were successful, the ultimate goal was realized. Our team was awarded the State Prize of the USSR in 1982 for a cycle of works in the field of power optics.

The Americans worked on the problem of resonator cooling in parallel with us. As a result, they solved it in a similar way. When in the 90s we started to fraternize with the USA, I got an invitation to visit the companies that were dealing with power optics at that time and I got convinced that the achieved parameters of mirrors were very close, and the constructional features of these mirrors were similar. To date, this technology is not sold on the international market, because any country will be able to immediately reach the levels of megawatt capacity, which means access to the creation of LW. Mirrors suitable only for technological lasers are sold; they are mirrors for a small level of power compared to the capacity of military LW complexes.

More Powerful, Even More Powerful

Under Alexander Mikhailovich's leadership, my research team was lucky enough to solve the problem of creating a superpower pulsed CO2 laser. The problem was initially dealt with by the Astrophysics Research and Production Association. It was required to create an air defense complex based on a powerful pulsed laser with pulse energy of about 30 kJ. Unfortunately, the first developers

could not solve this problem. They failed to solve the problem of pumping the active medium with powerful electron beams in non-self-discharge mode. Alexander Mikhailovich proposed to the Ministry of Defense Industry to transfer the work to our team and to apply the pumping methods we had developed. The proposal was accepted. Here, too, Alexander Mikhailovich had a flair for intuition; he quickly realized that our method was scalable and suitable for large apertures, and, therefore, for practical applications. In 1983, the Americans announced the beginning of a long-term SDI program and the holding of an international symposium in Las Vegas to discuss this program. Academicians Prokhorov and Basov were invited as participants. It was a difficult political moment - their presence at the event would have given much more significance to the U.S. program. And in the Defense Department of the CPSU Central Committee, where such issues were handled at the time, it was suggested "not to go". But since one wanted to understand what was going on, they decided to send two young scientists. The phone rang in the laboratory and I was told to be at Staraya Ploshchad in an hour. The next day we flew to the United States. My colleague was excited about the goals and objectives of the U.S. program, he understood that if you deploy such a program in the USSR, then in science will go a lot of money, orders from the defense industry, and therefore positively assessed everything that was happening in the United States. My assessment was negative. When I came to Alexander Mikhailovich with my report, he frankly said: "What a fool. You're absolutely right, though. You won't be understood, you'll end up an outcast. And indeed my report was assessed as positive by my colleagues, a race of laser armament began, which ended, as you know, and my report was shelved. Incidentally, I had just returned from a six-month layover in Canada, before going to Las Vegas. At the time, such a trip was tantamount to a miracle; most young scientists could not even dream of it. Alexander Mikhailovich, as well as the second Nobel laureate Nikolai Gennadievich Basov, spent a lot of effort on sending their employees to the West for internships after defending their doctoral theses. Calling to him, Alexander Mikhailovich liked to start the conversation about the internship with a joke: "Tell me, how do you feel about good beer and Bavarian sausages?" Going abroad provided a tremendous opportunity to compare one's achievements with what was being done in the world, to integrate more tightly into the world's scientific environment, and to learn the language effectively. And when perestroika began and hard times came for science, it was those people who had a good command of the language and connections abroad who began to find international contracts... We had several dozen such scientists in the Institute; it was they who "fed" GPI RAN during difficult times; we formed several dozen joint-stock companies.Alexander Mikhailovich had the wisdom to let go of the bureaucratic reins and let scientists work freely. Or maybe he simply foresaw it all [8-9].

Our Calibr

The democratic nature of Alexander Mikhailovich's character was already evident when we first met. In 1970, I was graduating from MEPhI, I was working on my diploma at the Department of the Vice-President of the Academy of Sciences, Mikhail Dmitrievich Millionshchikov. The task was very interesting: we were trying, with the help of a powerful pulsed solid-state laser, to receive multicharged ions of very high chargeability. I must pay tribute to Igor Mikhailovich Buzhinsky, chief technologist of the Lorraine Optical Glass Plant, who provided me with new active rods made of glass with neodymium ions that had just come out of production. In the country, he was the developer of this material and ensured the success of many scientific developments in the country. But after starting these interesting works and expecting to continue them, I could not stay at MEPhI for certain reasons (the son of a high-ranking official pretended to the results of my research and a post-graduate course). According to the logic of events, after graduation I had to go to the laboratory of academician N.G. Basov. He lectured and conducted seminars with us, many lecturers of the institute were from his scientific team. But conversations with Academician M.D. Millionshchikov encouraged me to go to another Nobel laureate, Alexander Mikhailovich Prokhorov. I was very embarrassed: "How can I go, I don't have even the slightest experience with him. Finally, I decided to call. Alexander Mikhailovich listened attentively, asked me about the subject of my research work and invited me to talk to the Soviet Mecca of laser physics of the time - FIAN. We talked about the results of my thesis work related to the use of powerful lasers for the generation of multicharged ions from laser plasma. In my first independent scientific work, heavy metal ions with chargeability up to +30 were obtained for the first time. But in this case, he said, we will get a simple and efficient source of multicharged ions. And if before the gas pedals accelerated protons to high energies, when working with multicharged ions, the energy of the accelerated particle could increase many times at once. This would allow an important step in obtaining relativistic beams of heavy ions. The first experiments in this direction were carried out in Dubna together with Academician G.N. Flerov. Today we know about similar experiments with multiparticle ion accumulators at CERN.

After examining me from all sides, he exclaimed: "Our caliber." The fact is that I was tall since childhood and was always ashamed of it. Many staff members of the Vibration Laboratory at FIAN were under two meters tall, like Alexander Mikhailovich. This fact was the subject of many jokes and even anecdotes.

Friendship of Academicians - Friendship of Laboratories

The Fluctuations and Quantum Radiophysics Laboratories at PhIAN conducted a lot of research in the interests of industry and the national defense complex. Due to this, the real budget of the laboratories increased manifold compared to others, which lived on purely academic money. By the will of fate, I found myself in the thick of events related to the creation of high-energy lasers. That is why meetings with N.G. Basov became more frequent. Often, on behalf of A.M. Prokhorov, I had to take part in discussions of scientific and technical issues at meetings of various councils on development, creation and application of powerful and high-energy lasers in industry and in the defense sphere. The point is that I was lucky enough, together with A.M. Prokhorov and A.I. Barchukov, to formulate the foundations of the Power Static and Adaptive Optics that we discovered, without which no high-energy laser can operate. We in Russia were the first to reach the level of 100 W from a single line thanks to the effective cooling taken from the power optics technology. This was exactly what N.G. Basov and his collaborators did not have when they created the first disk laser and had to pump the disk with another laser with an appropriate wavelength. This caused smiles and even irony among many famous scientists at FIAN. But that is the greatness of the greats: they see far beyond their contemporaries and create the future with every step they take. Today the disk laser is the only candidate for the creation of strategic LW systems with minimal weight and dimensions!

The relationship of the laboratory staff was particularly important at International Conferences, when help and support was especially valuable. In the 1990's, which were very fertile for laser forums in the USA and Japan, I was fortunate to attend the International Conference on Modern High Power Lasers and Applications held by the Japanese School of Laser Physics. The International Conference was led by Acad. N.G. Basov, A.M. Prokhorov, and C.H. Towns. A.M. Prokhorov was unable to attend due to a heavy workload at the Academy of Sciences. C.H. Towns came and, as usual, 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 a meeting of the Presidium of the Academy of Sciences of Japan, together with a Nobel laureate, instead of my boss, which was a great honor for me. N.G. Basov was at the Forum with his wife Ksenia Tikhonovna and went to the meeting together with her. And then there was a mishap with Ksenia Tikhonovna, she long apologized to her star husband simply was not allowed to the meeting. The fact is that up to the end of XX century, all full members of the Academy were males, as reflected in detail in the fiction. Only recently, the first and only woman - professor of social anthropology Tie Nakane - was elected as a full member of the Academy. Basov's family respected the tradition of the Academy of Sciences of Japan and Ksenia Tikhonovna left for the hotel, while Nikolai Gennadievich, as if nothing had happened, went to the meeting with a smile. It is possible that this incident, too, influenced the acceleration of change in the gender preferences of the Academy of Sciences of Japan.

N.G. Basov and His Creations

For the first time our team had to refer to the remarkable ideas of Acad. N.G. Basov during the search of new modes of high-energy laser irradiation influence on the solid body. Low-frequency modes of radiation generation with long-lasting pulses, typical of the late 70s, suffered from a number of negative manifestations. On the other hand, traditional schemes to produce pulsed-periodic (P-P) radiation resulted in huge weight characteristics and cumbersomeness. Our choice fell on the regenerative mode of amplification proposed by N.G. Basov and colleagues in 1965, in which a low-energy signal with a duration of several tens of nanoseconds was separated from the starting radiation of high-energy laser module and the regeneration mode was transformed into a sequence of pulses or into a sequence of pulse beams with adjustable repetition rate. In this case the peak power of individual pulses tens or hundreds of thousands of times greater than the value of power of injected primary pulse. The leading specialists in the field of creating powerful high-frequency high-energy P-P lasers and the authors of the patent were the staff of the Institute of General Physics of the Russian Academy of Sciences, working under the leadership of Acad. On the basis of this mode, we proposed and experimentally implemented a laser engine based on the mechanism of high-frequency optical pulsing discharge and obtained record thrust characteristics of the engine. With the help of high-frequency P-P laser for the first time the intensive and frequency-varying sound in the far zone was obtained, the

conductive channel with minimum resistivity was experimentally realized, the possibility of its scaling up to considerable distances and the reality of such a high conductive channel in the air medium and in vacuum was shown.

Academician N.G. Basov together with Yu.M. Popov and B.M. Vul proposed the idea of creating different types of semiconductor lasers, which today are the main means of pumping of modern solid-state lasers. Of particular interest are the studies of Acad. N.G. Basov nowadays are related to the emergence of fiber and disk laser systems, which define the movement towards high energy lasers in minimum dimensions and at minimum weight. It was in the case of the first laser on the disc geometry of the active body, proposed by N.G.Basov, that this type of effective pumping was lacking. Pumping was carried out by another laser, which caused smiles of contemporaries. However, with the advent of laser diodes and laser diode matrices everything fell into place. Thus, in 1962 N.G. Basov put forward the idea of creating an injection laser, then electron beam lasers were created, and in 1964 semiconductor lasers with optical pumping. N.G. Basov developed research on high-power gas and chemical lasers as well. His laboratory created hydrogen fluoride and iodine lasers, an excimer laser, as well as summator-converters of laser radiation. A number of works by N.G. Basov were devoted to the issues of propagation and interaction of powerful laser pulses with matter. He was the author of the idea of using lasers to control thermonuclear fusion (1962), and he proposed the methods of laser heating of plasma, as well as of stimulation of chemical reactions by laser radiation. N.G. Basov and his collaborators also developed the physical basis for creation of quantum frequency standards, put forward the ideas for new applications of lasers in optoelectronics for creation of optical logic elements, and initiated many studies on nonlinear optics.

The genius of N.G. Basov is also involved in the “modern” and still promising solid-state disk laser with semiconductor pumping. This idea of Acad. N.G. Basov’s idea is 60 years old, but it is this principle of building powerful laser complexes that appears today and will remain dominant for a long time in the future. With the same very favorable weight factor (<5 kg/kW) as for a fiber laser, this solid-state technology is sharply different from the technologies of the recent past, which led to creation of LW systems of “monster type” characterized by an unacceptable in our days weight factor (>200 kg/kW). Today, this constructive principle allows the realization of a high-energy, high-frequency P-P mode, since the aperture of the existing disk laser has a diameter of about 1.5 cm, which is much larger than the diameter of the active body of the fiber laser, which is hundreds of microns. Here it is appropriate to recall the long-standing visit of a German delegation to the Laboratory of Quantum Radiophysics at FIAN, which was headed by Acad. N.G. Basov. The solid-state laser technology based on disk geometry (the patent, however, belongs to one of the guests - A. Giessen, Stuttgart, Germany) which was not fully understood by the guests led to the current design of disk laser systems, unfortunately, not allowing a significant scaling of the power of the LW complexes to the strategic level. We have discussed the disk laser topic with Nikolai Gennadievich on numerous occasions; the last discussion was during a conference in Japan where I was able to talk to the author of the idea over breakfast about its future. N.G. Basov, who opened the conference, shared with me his vision of the disk geometry problem. In his opinion, the only promising approach to creating the entire line of high power solid-state lasers from the tactical to the strategic level could be a mono-modular technology. But that required solutions to several other serious problems: large-diameter disk cooling, more efficient disk pumping methods, and suppression of amplified spontaneous noise.

In the current disk laser geometry developed by Germany, USA and Japan, in order to increase the average power of the system the radiation of several disks are stacked into an optical sequence “ZIG-ZAG”, the average power value of such a combined module today is already 50 kW. The radiation of such modules, as in the case of fiber systems, can be folded into a single beam. Based on the above figures we can see that a 100 kW laser will weigh less than 500 kg!!! However, it should be noted that LL systems of much higher average power are needed for military applications. But from the disc geometry of even 75 kW modules (an increase planned by Lockheed Martin at the cost of quality reflective coatings), to an entire system on the order of 10 MW, the distance is gigantic. Putting the power of more than 100 modules into a single beam in the case of a mobile complex is not possible. It is the ideas of N.G. Basov that work today on the path of a single large-diameter disk, on which further scaling of its average power is possible. It is this way of development of high-energy mono-module large-diameter disk lasers that we are developing today thanks to the true author of the idea - academician Nikolay Gennadievich Basov.

From the history of preparations for the nobel prize.

N.G. Basova and A.M. Prokhorov took an active part in the celebrations on the occasion of the 60th birthday of Prof. A.I. Barchukov, the person who did the incredibly difficult work of preparing and coordinating the documents submitted to the Swedish Academy at the stage of nominating A.M. Prokhorov and N.G. Basov for the Nobel Prize. In those years he was Scientific Secretary of PhIAN, and his area of responsibility included both the complicated coordination in various instances and the shipment of the documents of the future laureates. To understand better the situation around the nomination in those years, I will try to relay the conversation of two laureates during the celebration of the anniversary of A.I. Barchukov. They were talking about the loss of almost guaranteed Nobel prizes due to bureaucratic hurdles set up 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 woman cosmonaut, the first docking in space, the first spacewalk, etc. But every time something prevented it. Either the difficulty of identifying three from the long list of creators of successes, or secrecy, or something else. So, A. I. Barchukov had a difficult job, but a man with a capital letter and a scientist, who had gone through the war from bell to bell, coped with his task splendidly at that moment!

And a few more words about the civil position of laureates on the subject of the Nobel Prize and bureaucratic delays, but already on a global scale. In our great country, there lived and worked an outstanding Soviet and Russian physicist-theorist, pioneer of laser physics, in particular, the method of laser cooling of atoms-V.S. Letokhov. The 1997 Nobel Prize in Physics was awarded to a group of researchers - Steven Chu, William Phillips (USA) and Claude Cohen-Tannoudji (France) - for their work on the laser cooling of atoms. The author of the idea and theoretical justification did not find a place in this prize. Such a peculiar "Bose condensation" of the opinions of the "Anglo-Saxon" majority clan of laureates. As our Russian creators of laser physics used to say, the number of laureates from "this brave team" begins to determine the quality of annual awards!

Conclusion

The Nobel Prize is a universally recognized indicator of an individual's outstanding ability. But even here, "not all yogurts are equally useful. Among the several hundred Nobel laureates there are geniuses who received prizes for an absolutely revolutionary transformation of the world. The Nobel Prize of academicians Alexander Mikhailovich Prokhorov and Nikolai Gennadievich Basov for laser-maser principles of generation and amplification of electromagnetic radiation using the effect of stimulated emission in quantum transitions of atomic and molecular systems is one of them. Today it is already impossible to imagine our life without lasers in the widest spectrum of their applications.

Well, to conclude my homage to the outstanding scientists of Russia and the world, Academicians N.G. Basov and A.M. Prokhorov, I would like to quote another great Nobel Prize laureate. According to Zhores Ivanovich Alferov, the technological and social progress of the 20th century was determined by three discoveries in physics. These are uranium fission discovered by German scientists Hahn and Strasman in 1938. The second is the invention of transistors in 1947 by D. Bartin and W. 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 triggered the development of many military and civilian technologies. This is primarily semiconductor lasers and fiber-optic communications.

At the beginning of the 21st century, this outstanding scientific tandem left a little more than six months apart. The first, on June 1, 2001, his disciple, N.G. Basov, passed into eternity. The second, on January 8, 2002-teacher, A.M. Prokhorov. Alexander Mihajlovich loved very much his talented pupil, treated him with a great respect and heavily experienced the untimely departure of his colleague in the new section of knowledge created by them. And they are lying side by side at Novodevichy Cemetery, just as they lived for decades in the same house in Kuntsevo and worked side by side in their institutes on Vavilova street. They are no longer with us for more than 20 years, but the science created by these titans continues to keep many thousands of scientists and engineers busy all over the world and to create new points of growth in many fields of science, technology, and civil applications.

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