

A Man of Boundless Search - 105th Anniversary of the Birth of Nobel Prize-Winning Physicist Alexander Prokhorov

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I had the great happiness to work with the outstanding Russian physicist Alexander Mikhailovich Prokhorov for more than 30 years, and I never ceased to be surprised by the manifestations of his genius, each time discovering new facets of the teacher's numerous talents.

What first of all is remembered when he has not been with us for almost 20 years and the acute emotions of parting have long since subsided? An incredibly developed sense of intuition, an amazing ability to find the right solutions, an acute sense of a new, fundamentally significant for jumping into the future, humanity. **For example, driven him the invasion of lasers into medicine was his first ingenious move during the time of military fever.** But the sense of the leading edge of science, the trends of its development were, perhaps, the main ones in the character of this phenomenal scientist.

TALENT of EDUCATOR

The P.N. Lebedev Physical Institute of the USSR Academy of Sciences at the stage of formation was lucky to have a leader. The state of high tension in the search for the only correct solutions at that time was replaced by the experienced hand of the conductor by the fun of a successful joke, a joke, an anecdote at a scientific seminar. The chief appreciated witty jokes and skillfully used the key phrases to the place. If during the seminar you did not learn something important, striking on the spot, it meant that you simply did not understand something, that you were out of shape. Loud laughter from the office, heard from time to time even in remote parts of the corridor, confirmed: everything is fine, we continue to move forward, we live. The ability to find a solution even in an insanely difficult situation, when, and this is obvious, there is no place to take it – this is also his school. It is important here, first of all, to think

about the case, not about yourself, not to be afraid to make a mistake. The error can be corrected, but the lost time can never be returned. A good example is a holistic bouquet of solutions from the time of the beginning 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 "anything that is not prohibited by law is possible." The solution was simple and effective: to give freedom to departments and laboratories, to conduct foreign economic activity on a contractual basis and grants. And this is when neither the accounting department nor the planning department simply had specialists to shovel piles of papers in all sorts of imported languages. Scientists with world-renowned names, and there were several dozen of them at the Institute, who traveled the world and understood well how the "decaying" with its predominantly contractual form of science financing works, quickly got used to it and ensured a smooth transition to new forms of work. Now that everyone understands everything and gives advice to others, a lot of things seem trivial. And then it was necessary to see an effective way out of the situation and make a decision, which at that 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, she brought up the democratic approach in everything and the fairness of the decisions made by the Teacher. Any employee could count on being listened to and, if necessary, supported. Even Kirill's son, who still works at IOFAN, often got it - family ties, past regalia were not taken into account, and every day it was necessary to prove his case. Someone has always been wrong in a dispute, but this is not a reason to hang a label, tomorrow it will be the opposite – we need to work and everything

will be fine. The usual question: "What's new?" - And then with a smile the answer for the interlocutor is "Nothing!" It was a common form of dialogue, useful for starting a conversation the next day – they broke up last night, and this morning there can and should be scientific news. Here they are engaged in science, and this is a continuous process. In our life, we spend a lot of time in the laboratory, often missing the everyday 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. They came not only from ours, but also from other institutions, they knew that they would not refuse, and if there was an opportunity to help, they would help. Simplicity in communicating with others is another distinctive feature of Academician Prokhorov. Respect and always an even tone in communication, without emphasizing the rank of the participants in the conversation. Whether it is a student or a specifically educated official of the state apparatus, it does not matter. In his office or in company with him, all this went to the second and third plan. Only the level of intelligence was important – the enduring essence of the development of civilization. And what is quite surprising, people in such conditions of communication with each other seemed to find new opportunities for self-expression, felt a surge of creative forces, and they liked it themselves.

Here is a case that happened in Japan at a meeting with the governor of Tokyo Metropolis, Mr. Shikaya. I was lucky enough to be a participant and witness of that event. The Japanese, who had studied the visitors from Russia well, instructed our delegation for a few minutes about what was considered appropriate to the centuries-old foundations and rules of good manners in their homeland. You can talk about flowers, about nature, about health. All other topics of conversation can be interpreted as inappropriate to the level of good education of the interlocutors. And it was necessary to see the faces of these would-be instructors after a

few minutes of conversation between Academician Prokhorov and the governor of the Metropolis, Mr. Shikaya-san, where the city of Tokyo is included as a small part. They talked as if they had known each other since childhood and were insanely happy with the opportunity to communicate with each other. In this life, spending time talking about flowers and bows simply means not respecting each other. Apparently, this protective form of communication is being introduced in Japan in case of visitors from Russia who are able to talk only about preferential loans and the division of dividends, which, of course, is extremely relevant today.

ABOUT THE INTUITION OF A SCIENTIST

Alexander Mikhailovich Prokhorov was a physicist not only by profession, but, as they say, in fact, his habits were physically correct. Here's one of them – he liked it when the room was warm, well, very warm, just Sugar. "And why warm the room with your own warmth? What is the average temperature of a normal person? 36, 6? Here you are!" It was not so easy to sit in his office for a long time, the heaters were directly behind the visitor's back and quite close to this very back. For whom thermodynamic equilibrium, and for whom thermal shielding of the boss. It is difficult to overestimate the importance of the laser in solving problems of medicine and biology. Even at the dawn of the laser revolution, when the excitement of military applications exceeded all possible limits, Academician Prokhorov began to introduce ideas about the effective use of laser methods of treating patients and the use of lasers in biological research into the minds of the Institute's staff and various bosses. The laser can be used and is actively used in solving military tasks, and it has not been a secret for a long time. It cuts, melts, reduces the mechanical stability of structures, provides the transmission of a mechanical impulse and provides a power mode of destruction of military equipment. That is why the attention of the military was drawn to the prospect of using lasers for military purposes. Alexander Mikhailovich enthusiastically took up the development of an interesting and important topic, the creation of powerful laser systems. The

Institute's budget at that time consisted of only a 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 doors of the Institute every day, providing us with new orders for civil and military needs. A huge merit in the fact that we were constantly loaded and not idle belongs to Prokhorov. It was he who managed to establish good contacts with both industrialists and the military. At the very beginning of the "laser path", it was necessary to make a very important decision: to start developing lasers for the so-called power defeat, or to choose the second direction - functional, when electronics, optical systems were out of order and all kinds of trigger effects in the elements of technology were provoked. It was necessary to have deep knowledge and the gift of foresight to make the right move. And Alexander Mikhailovich, as time has shown, was right when he argued that we should have developed this particular direction at that time. In 1973, Academician Prokhorov wrote a letter to Marshal Grechko. It said that a forceful defeat in the next 30-40 years is unattainable, and therefore it is necessary to develop a functional defeat. Unfortunately, the opinion of the venerable scientist was not listened to at that time – there were no quick financial benefits behind this decision, it was necessary to work painstakingly with much less funding. Alexander Mikhailovich has been proving his case for a very long time and persistently, and if we talk about today, then 90 percent of modern laser weapons are exclusively functional. And the power plant has not reached the levels of multimegawatt average power required to solve strategic tasks.

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 the problem outside the box. When working with powerful lasers, there was a need for an effective way to cool the resonator mirrors, which are not ideal – they absorbed huge power due to a non-one hundred

percent reflection coefficient. The effect that we first encountered as the output power of the lasers increased showed that a further increase in the output power of the device was impossible, since the mirrors at the point of incidence of the laser beam were locally heated and locally deformed. That is, the beam was reflected not from a flat surface, but from a hump on it. Due to distortions in the resonator, the total laser power decreased, and the divergence of the beam increased. In this situation, there could be no question of any LO with a range of hundreds of kilometers. It was this problem, discovered in our experiments that became the topic of my PhD thesis. So I came under the close attention of an academician who was responsible for the research of physical processes during the creation of the LO. 1970 was the year of the birth of a new discipline - power optics. Alexander Mikhailovich, and he was my supervisor, was interested in the progress of research every day and gave very valuable advice. We have consistently analyzed a wide range of dielectric solid materials, since polishing metals in an optical workshop next to expensive crystals seemed to be a big mistake. It was then that the choice fell on silicon carbide. Today, this material has become practically the main material for the creation of super stable optical telescopes and other optical instruments. But silicon carbide did not solve the problem of optical stability of mirrors, improved in comparison with quartz and sital, but did not solve it. The prospect of switching to highly conductive, but solid metals also did not lead us to solve the problem of multimegawatt lasers, which politicians and journalists have already talked about. It was necessary to take the next step, it was not possible to solve the issue of stable laser mirrors simply by choosing the material. It was necessary to attract very efficient cooling. And here again we are faced with a big contradiction: huge heat flows from the surface of the mirror with the help of a coolant in the physic technical models known at that time could only be diverted at high temperature. At the same time, the system of coarse cooling channels is 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, much became clear about the problem of high-energy power optics. 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 several tens of degrees. But the liquid cannot be forced in large quantities through thin channels at low pressure, in addition, when the flow value increased, vibrations occurred that distorted the surface. Alexander Mikhailovich supported my idea of a possible similarity of the mirror cooling system to the human circulatory system, in which hundreds of smaller, even smaller, etc. capillaries branch off sequentially from a large bloodstream highway, in order to reassemble into a single macro channel. And all this should happen in a mirror on a scale of several millimeters in depth of the mirror. Fifteen years of testing of the physical model of a high-energy laser mirror, the development of structural models and technologies were crowned with success, the ultimate goal was realized. In 1982, our team was awarded the USSR State Prize for a series of works in the field of power optics. The Americans worked on the problem of cooling the resonator in parallel with us. As a result, they solved it in much the same way. When fraternization with the States began in the 90s, I received an invitation to visit companies that were engaged in power optics at that time and made sure that the achieved parameters of the mirrors turned out to be very close, and the design features of these mirrors were similar. To date, this technology has not been sold on the international market, because any country will be able to immediately reach the levels of megawatt capacity, which means it will have access to the creation of laser weapons. Mirrors are sold that are suitable only for technological lasers, these are mirrors for a small level of power in comparison with the capacities of military LO complexes.

EVEN MORE POWERFUL...

My research team was lucky enough to solve the task of creating a super-powerful pulsed CO₂ laser under the leadership of Alexander Mikhailovich. This problem was initially dealt with by the NGO

"Astrophysics". It was necessary to create an air defense system based on a powerful pulsed laser with a pulse energy of about 30 kJ. Unfortunately, the solution to this problem turned out to be beyond the teeth of the first developers. They failed to solve the problem of pumping the active medium with powerful electron beams in the mode of independent discharge. Alexander Mikhailovich proposed to the Ministry of Defense Industry to transfer the work to our team and apply the pumping methods developed by us. The offer was accepted. Here, too, the flair of Alexander Mikhailovich manifested itself, he quickly realized that our method is scalable and suitable for large apertures, which means that it can be used in practice. In 1983, the Americans announced the launch of a long-term SOYBEAN 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 importance to the US program. And in the Defense Department of the Central Committee of the CPSU, where such issues were then resolved, it was suggested "not to go." But since I wanted to understand what was going on, we decided to send two young scientists. A call rang in the laboratory, they told me to be at the Old Square in an hour. The next day we flew to the USA. The colleague was completely delighted with the goals and objectives of the American program, he understood that if such a program was deployed in the USSR, a lot of money would go to science, orders from the defense industry would go, and therefore he 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. Although he's right. You will not be understood, you will turn out to be an outcast." And indeed, colleagues recognized the report as positive, the laser arms race that ended began, and my report was put under the cloth.

By the way, before going to Las Vegas, I just returned from a six-month internship in Canada.

Then such a trip was tantamount to a miracle, most young scientists could not even dream about it. Alexander Mikhailovich, as well as the second Nobel laureate Nikolai Gennadievich Basov, spent a lot of effort to send their employees to the West for internships after defending their PhD thesis. Calling to himself, Alexander Mikhailovich liked to start a conversation about the internship with a joke: "Tell me, how do you feel about a good sausage and Bavarian sausages?" Trips abroad gave a tremendous opportunity to compare their achievements with what has been done in the world, integrate more closely into the world scientific environment, and also effectively learn the language. And when perestroika began and difficult times came for science, it was those people who knew the language well and had connections abroad who began to find international contracts... We had several dozen such scientists at the Institute, they were the ones who "fed" IOFAN in difficult times, and we formed several dozen joint - stock companies. Alexander Mikhailovich had the wisdom to let go of the bureaucratic reins, to allow scientists to work freely. Or maybe he just foresaw all this?

"OUR CALIBER"

The democratic character of Alexander Mikhailovich manifested itself already at our first acquaintance. In 1970, I graduated from MEPhI, wrote a diploma at the department of the Vice-president of the Academy of Sciences Mikhail Dmitrievich Millionshchikov. The task was very interesting: I tried using a powerful pulsed solid-state laser to obtain multi-charged ions of very high charge. I must pay tribute here to the chief technologist of the Lorraine Optical Glass Factory, Igor Mikhailovich Buzhinsky, who provided me with new active glass rods with neodymium ions that had just left production. In the country, he was the developer of this material and ensured the success of many scientific developments. But having started these most interesting works and hoping to continue, for certain reasons (the son of a high-ranking official applied for the results of research and a place in graduate school), I could not

stay at MEPhI. According to the logic of events, after defending my diploma, I had to go to the laboratory to Academician Basov. He gave lectures, conducted seminars, and a lot of teachers at the institute were from his research team. But conversations with Academician Millionshchikov and the staff of the department pushed me to go to another Nobel laureate, Alexander Mikhailovich Prokhorov. I was very confused: "How can I go, there is not even the slightest experience of communicating with him, why should he need me?" Finally, I decided to call. Alexander Mikhailovich listened attentively, asked about the subject of the work and invited for a conversation to the Soviet Mecca of laser physics of that time – FIAN. We talked about the results of my thesis related to the use of high-power lasers to generate multi-charged ions from laser plasma. In the first independent scientific work, heavy metal ions with a charge of up to +30 were obtained for the first time. But in this case, he said, we will get a simple and effective source of multi-charged ions. And if earlier protons were accelerated to high energies on accelerators, then when working with multi-charged ions, the energy of the accelerated particle could increase many times at once. This would make it possible to take an important step in obtaining relativistic beams of heavy ions. The first experiments in this direction were conducted in Dubna together with Academician Flerov. Today it is known about similar experiments with accumulators of multi-charged ions at CERN. After examining me from all sides, he said: "Our caliber." The fact is that I have been tall since childhood and have always been shy about it. Many employees of the FIAN Vibration Laboratory were under two meters tall, like Alexander Mikhailovich. This fact has been the subject of many jokes and even anecdotes...

ABOUT A PLACE IN HISTORY

The Nobel Prize is a universally recognized indicator of outstanding personal abilities. But even here, "not all yogurts are equally useful." Among several hundred Nobel laureates, there are geniuses who have received awards for revolutionary

transformation. The Nobel Prize of Alexander Mikhailovich Prokhorov and Nikolai Gennadievich Basov for laser and maser principles of generation and amplification of electromagnetic radiation using the stimulated emission effect in quantum transitions of atomic and molecular systems is one of them. Today it is impossible to imagine our life without lasers in the widest range of their applications.