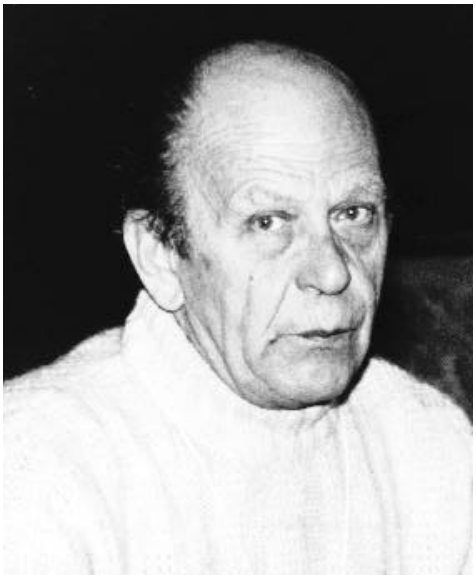
Interview with Alexander Ivanovich Pavlovskii



At the end of the intense week-long meeting at Los Alamos in November 1992 among scientists from Arzamas-16, Los Alamos, and Sandia, we met with the head of the Russian delegation, Alexander I. Pavlovskii, to talk about his experiences as a nuclear-weapons scientist in the former Soviet Union. Pavlovskii had been a protegé of Nobel Peace Prize winner Andrei Dmitrievich Sakharov. At the time of our conversation, he was Deputy Chief Scientist and Head of the Fundamental and Applied Physics Department of the All-Russia Scientific Research Institute of Experimental Physics at Arzamas-16, Russia.

Two translators were present: Elena Panevkina, who was by Pavlovskii's side at all meetings with non-Russian speaking scientists, and Eugene Kutyreff from the Laboratory's International Technology Division. We thank both of them for their patience and endurance.

Just as we were preparing to send this interview to Pavlovskii for his review, we learned of his sudden death on February 12, 1993. We were honored to have met him and moved by the candor and depth of feeling he expressed during our interview. Many scientists at Los Alamos knew Pavlovskii well, and we hope they will find this interview a fitting memorial to an exceptional man.

Los Alamos Science: Tell us how you got into science and how you came to work in a nuclear-weapons laboratory.

Pavlovskii: It's hard to say how I became a scientist because when I was young, you could not decide on a career by yourself—it was something that was decided for you.

In the late 1940s I attended Kharkov University, which is in Kharkov in the Ukraine. It houses the well-known Physicotechnical Institute. Lev D. Landau and Evgenii M. Lifshitz, known so well in the West for their physics textbooks, worked together at that institute during the 1930s before Landau moved to Moscow. During the third year of my university studies, I began to work at the Physicotechnical Institute. At the time, the Director was Kirill Dmitrievich Sinelnikov, one of those physicists who had gone through Cambridge University in England. I was very fortunate to have been associated with him and with Lifshitz, Alexander Il'ich Akhiezer, Giorgii Nikolaevich Flerov, and many other very interesting people.

Los Alamos Science: How did you become involved in nuclear-weapons work?

Pavlovskii: In my time, the Soviet Union had a specialized program for bringing people into a variety of types of work. After you finished at the institute or the university, you would be given your choice of several places where you might want to work. When I picked Arzamas, I didn't really know what was going on at that institute. I had a romantic notion of something new, something different. Sinelnikov didn't really want me to leave the Physicotechnical Institute. He wanted me to stay and work on the equivalent of a master's degree, but after I met in Moscow with Flerov, who was working at Arzamas-16 at that time, I was determined to go there.

My dissertation work had been in classical physics. I had been doing experimental work on the process of fluorescence. So when I arrived in Arzamas I realized that I needed to change my specialty a little bit, and I began studying nuclear physics. My professors at the Kharkov Institute had taught us well, so I was quite prepared to learn new things.

Almost immediately I became involved in studying physical processes for the development of the first Soviet hydrogen bomb, the father of which is, of course, Andrei Dmitrievich Sakharov. I was involved primarily in studying elementary nuclear cross sections and effective cross sections in special assemblies of materials. These experiments were absolutely necessary in order to understand the physics of nuclear fission and neutron transport.

I was in the department headed by Flerov, and I also worked with Sakharov and many other great men who are too numerous to mention. From the point of view of a scientist, it was a very unusual time, and a very interesting and productive time. All the questions facing us were brand new. In hindsight, other people may look at the development of thermonuclear weapons somewhat differently, but back then all of us were quite sure that in order to preserve peace and maintain a stable environment in the world, this type of weapon was absolutely necessary. As Andrei Sakharov himself said, it was "to prevent temptations."

Our scientists thought about defense in just the same way as the Americans. We thought the development of the hydrogen bomb was a very important undertaking. We worked very, very hard, sometimes around the clock. And through this labor we were able to resolve some very interesting scientific questions. Remember, our country had just undergone tremendous destruction during World War II, and the resources available to us were not nearly as good as those available to the American scientists. Therefore, for us to solve the same problems you were solving required a maximum effort on our part with a minimum of expenditures on materials. It was a time of great tensions but also one of great accomplishment.

Paradoxically, during this period of strenuous demands, the level of intellectual life was also very high. We not only read a great deal of artistic literature, we also looked at all the new inventions and new scientific discoveries. When we had free time, we were involved in sports. Many of us were interested in theater, and at every opportunity during our trips to Moscow we went to plays. In those first few years at Arzamas, I saw more shows than I have seen over the course of the rest of my life.

Los Alamos Science: How far is Arzamas from Moscow?

Pavlovskii: It's about 200 miles or an hour's plane ride. The Institute was necessarily isolated because of

the work that was going on there, but the work sent us to Moscow, Leningrad, which is now St. Petersburg, and other cities, so we traveled quite often.

Los Alamos Science: Is it true that scientists were able to fly to Moscow with their families just to attend the theater or enjoy some leisure time?

Vladimir Chernyshev (l), Max Fowler (c), and Alexander Pavlovskii (r) at Los Alamos.

Pavlovskii: Yakov Zeldovich and Yuli Khariton were absolutely enamored of the theater, and they would sometimes take time off to visit Moscow and attend the theaters.

Los Alamos Science: Arzamas, it seems, had a collection of great physicists just as Los Alamos did during the Manhattan Project.

Pavlovskii: Yes, we had many renowned physicists, but also some young, inexperienced specialists; I was among the latter group. When I arrived at Arzamas in 1951, Andrei Sakharov was 30 years old, the Director of the Laboratory was 31 or 32 years old, and most of the rest of us were 23 to 25 years old. Together we made the first hydrogen bomb and the first thermonuclear weapons.

Los Alamos Science: Would you remind us of the dates of the major Soviet weapons developments?

Pavlovskii: Our first test of an atomic bomb was in 1949, the first hydrogen bomb was in August 1953, and in November 1955 we tested our first thermonuclear bomb.

Los Alamos Science: There was a time when the Americans believed the Russians were six months ahead in developing a thermonuclear device, and the government poured money into Los Alamos to accelerate our research.

Pavlovskii: I don't know whether we were months ahead of you, but the benchmark steps that I listed were not experimental tests, they were full-scale nuclear-weapons tests. If you've read Sakharov's memoirs, you would remember that he referred to the first hydrogen bombs as Idea 1 and Idea 2. Sakharov mentioned these early ideas because he was a very proper, very good person, and he wanted to demonstrate the creative contributions of Vitaly Ginzburg. The third idea, which led to modern thermonuclear weapons, really belongs to Sakharov. But as Sakharov himself has written, he and Zeldovich both developed Idea 3 together. It was essentially the same as the Ulam/Teller idea. What's interesting is that it doesn't really matter what country you were from; the physics is the same, the logical steps of science were identical, and, obviously, you had to come to the same conclusions.

Los Alamos Science: Perhaps you would like to say more about the conditions under which you were working compared with those of the American scientists.

Pavlovskii: There was a very big difference during the 1950s because we had very little laboratory equipment. We had to develop amplifiers, discriminators, and other electronics needed for our experiments from spare parts left over from the equipment of some Canadian radio stations that had been lend-leased during World War II. Despite the poor conditions, our specialists were still able to come up with electronic equipment that performed no worse than that of our American counterparts. The lack of equipment meant we had to apply more intellectual skill. It is a much more difficult task to develop the needed apparatus than to order it from some company.

The amplifiers we worked on, for example, were done using Elmore's book, a standard electronics text from those years. We needed to measure very fast processes in gas dynamics, and special amplifiers had to be built to record the signals. You eventually developed the PHERMEX radiographic facility in the United States. But in those days we just didn't have the capability of making that kind of equipment. Nonetheless, we achieved some very-good-quality results just by modifying other equipment and using materials that were available. There are many similar examples that I could mention.

Los Alamos Science: During that same period, you started to work on

the types of pulsed-power experiments that are being discussed at this week's meeting with the American scientists. Is that correct?

Pavlovskii: While we were developing the first thermonuclear devices, we began working on many types of problems because the intellectual level of scientists at Arzamas was very high. As happened in America, all the great scientists in our country came to work on the project, but there was a slight difference—in the United States, they collected all of the best scientists from the rest of the world; we were limited to those in our country.

Los Alamos Science: Not all the great scientists who worked on the Manhattan Project worked on the hydrogen bomb. Many of them left Los Alamos after 1945.

Pavlovskii with John Immele, director of the Nuclear Weapons Program at Los Alamos.

Pavlovskii: Many of our best physicists left as well, but Sakharov, for example, stayed and worked for quite a long time, until 1968. During the years that he worked at Arzamas, we were extremely productive. Sakharov was a man who thought about many ideas at once. Even before he came to Arzamas in 1950, he had already begun to study cosmology and a variety of problems in quantum electrodynamics, such as the Lamb shift. He had also proposed an idea for muon-catalyzed fusion in 1948. The idea is to create molecular ions, each consisting of two deuterons held together by a muon rather than by an electron. Since the muon is 209 times heavier than the electron, it draws the two deuterons 209 times closer to each other. In fact, the two positively charged deuterons are so close together that they can fuse by quantum tunneling, form a helium atom, and release a great deal of energy in the process. He put forth the idea of using muons as passive catalysts for fusion in 1948.

In about 1950 or 1951 he and Igor Tamm proposed another idea for controlled thermonuclear fusion, namely, the magnetic thermonuclear reactor, the design of which is the progenitor of the present tokamak designs for magnetic-fusion reactors. At about the same time, he started talking about the design of magnetocumulative generators, which could concentrate magnetic field lines into small volumes using explosive compression. His original interest was to use the generator to achieve thermonuclear fusion. A little-known fact is that he later proposed using lasers to implode spherical targets filled with thermonuclear fuel and achieve thermonuclear fusion that way. That idea came to him immediately after scientists in the United States announced the invention of the ruby laser in 1960. I remember his great excitement when he returned from Moscow after conducting several seminars on the possibilities of laser fusion.

Bob Gibson with Pavlovskii at Trident laser in Los Alamos.

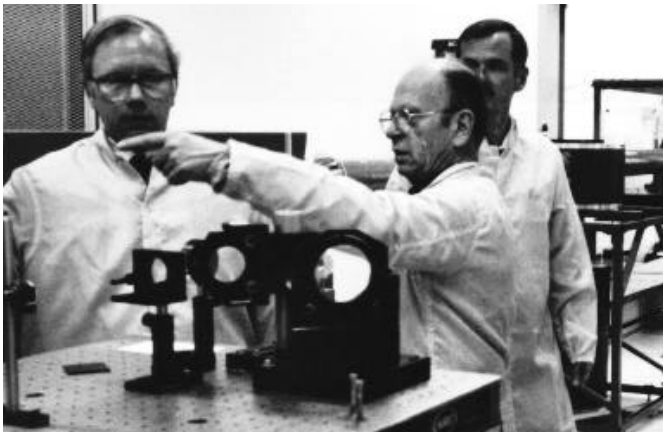
Los Alamos Science: How did the idea of using muons to catalyze fusion occur to him so early?

Pavlovskii: It is difficult to describe the logic of Sakharov's thinking. Many of us had great difficulty understanding even the simplest things he said. We had many seminars at Arzamas, during which Zeldovich used to serve as an interpreter between Sakharov and the rest of us. Sakharov made quantum

leaps in his logic, and his words needed to be translated into much simpler language in order for everybody else to understand what he was talking about.

Los Alamos Science: Is Sakharov a hero to you?

Pavlovskii: That is a difficult question to answer. When I listed the various areas of work that Sakharov was involved in over a very short time, it was to show his unique genius and his ability to think in parallel. For example, when I would talk with him, he would stick his chin on his palm and appear to be listening intently. Then suddenly I would become acutely aware that he was thinking about something entirely different even though he never lost the train of thought of our conversation. We still have on hand his notes and papers on the magnetocumulative generators, and on the back side of these pages are some of his calculated estimates of the masses of the quarks. So, in addition to his very high moral character, he was a very unusual person. You almost had the feeling that he had mystical powers, that you were dealing with someone who lived, in part, on another plane of existence.



Steve Younger and Pavlovskii at the Trident laser.

Los Alamos Science: How did you feel when in the late 1950s Sakharov objected to the continuation of nuclear testing and then in 1968 called for disarmament and a rapprochement between the United States and the Soviet Union?

Pavlovskii: Well, my previous comments have only skimmed the surface of Sakharov's personality. He also had a peculiarity of looking at everything with a degree of innocence. He had this habit of thinking about society and government in very idealistic—you might even say naive—terms. That's why the first book he published after he left Arzamas and started public work was devoted precisely to what he called convergence, or the rapprochement between the socialist and capitalist systems.

When Sakharov was at Arzamas, I always looked at him as more of a scientist than a political man. Given the tense time and all the work we were doing, most of us didn't have any time to think about politics. It is difficult to judge whether it would have been better if he had simply remained a scientist rather than getting involved in political activities because in both fields he accomplished a great deal. The things he talked about publicly throughout his lifetime were very unusual, and the same can be said for his ideas in science. Not long before his death we met and discussed magnetocumulative experiments in great detail. But he seemed unable to separate his public life from his scientific life. Politics just seemed to have enveloped him fully.

Los Alamos Science: In the early 1970s you must have had a chance to read his report to the Central Committee of the Communist Party on the convergence of two global systems. That essay was published abroad in 1968 as "Reflections on Progress, Peaceful Coexistence and Intellectual Freedom." In it Sakharov warned of the dangers of thermonuclear war, he condemned dogmatism, terror, and Stalin's crimes, and he urged democratization and the convergence of political systems as the way to avoid global destruction.

Pavlovskii: Many people at Arzamas-16 had copies of his book in the '70s, and they read and discussed those issues. Sakharov never made a secret of the fact that he had such ideas. He always spoke freely about them, and because they were at a popular level, they could be discussed by everyone.

Los Alamos Science: In the Soviet Union were scientists pressured to work on nuclear weapons or could they make that choice independently?

Pavlovskii: For the most part, although some would tell you differently now, most people went to work on nuclear weapons voluntarily. There were some who were motivated by the slightly higher salaries we received, but the difference in payment was not very great. The majority of the scientists at Arzamas

wanted to prove their abilities to their peers. In those years the climate was set for us by the great men with whom we worked. Although they were working primarily on weapons, their initiatives in other areas of science were usually well supported. For those who were truly interested in science, Arzamas provided a unique opportunity to do research in many interesting fields.

Los Alamos Science: So, if you worked on weapons, then you had other opportunities?

Pavlovskii: Yes, in those years we began to study many fields and trends of science that are still interesting today. The work on magnetocumulative generators is a good example. Sakharov wanted to use magnetic-flux compression, or "magnetocumulation," as we called it, in developing impulse accelerators that could create beams of elementary particles with high energies and high intensities. It could also be used to create super-strong magnetic fields and strong currents for a period of time long enough to study material properties under extreme pressure and extreme magnetic fields.

I became involved in that work from the beginning, and it has continued through all these years. Very similar work has been going on at Los Alamos under the direction of Max Fowler since 1953, and now we are here at Los Alamos, together with our American colleagues, discussing the possibilities for collaborative work in this area.

Los Alamos Science: Has basic research remained a strong effort at Arzamas?

Pavlovskii: Most of the people in our institute continue to do basic research as well as weapons research, and they take their basic research work very seriously. But recently it has become very difficult for us again, in some respects as difficult as it was when we first started. We lack a good industrial base, the ability to obtain equipment, and so on, just as in the early days.

Los Alamos Science: What is the economic situation of the scientists at Arzamas? Previously you were treated rather well by the State, and now?

Pavlovskii: Now that we are becoming a market economy, we don't understand what money means anymore. All the gradations have disappeared. There are now, in essence, only two categories: first, the workers, a group that is shrinking rapidly, and second, those engaged in the resale of goods, which doesn't involve any intellectual or physical prowess. In the second category are people who earn tens to hundreds of times more than the real workers. So the weapons scientists have no real privileges anymore. In fact our situation is even worse—it's turned 180 degrees.

Russian-American meeting in University House in Los Alamos.

Los Alamos Science: Will the weapons scientists be able to maintain their integrity in the present environment?

Pavlovskii: Within the overall spectrum of scientists in our country, you're always going to find a small group who could be bought or sold or coerced or subverted to become involved in other activities. The relatively young physicists are in the most vulnerable position, and there are those who want to leave the country. It is a very difficult time.

Los Alamos Science: So who is protecting and safeguarding the nuclear-weapons establishment?

Pavlovskii: The first line of defense is the people who designed the weapons in the first place. Those people are truly interested in science, and they have a rather high moral character. They understand the situation in the world today, and they know that they must play an extremely important and responsible role in controlling nuclear weapons. But it's hard to accomplish for various reasons.

During this meeting, in the evenings, I made some toasts, and we talked about the fact that labora-

tories such as ours, weapons laboratories, are beginning to have closer ties to one another. This development is not happening because of the will of individual scientists, but rather because of the collective feeling that we need to help stabilize the situation. There is also the need to find a colleague with whom you are of one opinion and can talk to in the same language, the language of science. That's a very important aspect of any type of collaborative efforts on the part of scientists. There are no limitations or difficulties in collaborations among scientists. It is natural. The politicians and those higher up in the power structure, however, have reservations.

Los Alamos Science: So, in your country what is the attitude about both the weapons and the weapons scientists?

Pavlovskii: It is a rapidly changing situation. At first those people who are now in power and who call themselves the democrats, despite the fact that they are still the old Communist Party functionaries, were saying, "Away with everything! Do away with these scientists who are studying weapons, do away with nuclear weapons, do away with nuclear testing!" That is an indication of the types of things that are going on in our country. But then, let's ask the question: If we do away with weapons scientists, what are we going to do with the weapons? There are many examples of that kind of question.

So basically the people in Arzamas are put in the position of trying to find contacts on their own. We feel very little involvement from the government, although they have supported us in this initiative to develop collaborations with Los Alamos. The contacts, however, were made at the lab-to-lab level. For example,

Alexander Pavlovskii

here at Los Alamos, I was very familiar with Max Fowler, Dennis Erickson, and others and with their work on pulsed power and high magnetic fields. We've met at international conferences, we've read each other's publications, and as a result we came up with the idea of starting collaborative efforts. Then, in February 1992 we had an exchange of delegations at the director level of our respective laboratories. First, the directors of our two nuclear weapons laboratories visited Los Alamos and Livermore, and then the Los Alamos/Livermore delegation came to Arzamas and Chelyabinsk. A memorandum was signed, stating that we had agreed to engage in collaborative efforts on a wide range of scientific topics. In my opinion, those topics are very important. They include questions on nonproliferation, storage of nuclear weapons, destruction of weapons, ecological problems, and nuclear-energy safety concerns. I'm not going to list them all, but there are a great many scientific areas that we want to talk about.

Los Alamos Science: Are you free to talk about anything, even if it's about nuclear weapons?

Pavlovskii: With whom?

Los Alamos Science: The American weapons scientists.

Pavlovskii: No. In fact, neither we nor our American counterparts will discuss, for example, bomb designs with each other because we have an obligation to safeguard that knowledge. Just as in the United States, the Russian government has issued an entire series of rules and regulations about safeguarding nuclear weapons.

Los Alamos Science: People here are worried that other countries, such as Libya or Iran or Iraq, may make overtures to the Russian weapons scientists. Do you know of any such instances?

Pavlovskii: No, I don't know of any actual instances.

Los Alamos Science: What was the reaction in the former Soviet nuclear weapons community to President Reagan's Strategic Defense Initiative proposal?

Pavlovskii: We perceived there were some scientific opportunities in SDI, but as for its chances of success, you should perhaps ask the American authors of SDI. When I

was a young man, I used to play with electron beams and shoot things with them, but that was when I was a boy.

Los Alamos Science: The Russians weren't worried about SDI?

Pavlovskii: No. I had some conversations about SDI with American representatives when I was at the Beams '92 conference in Washington at the end of May. They had asked me to give a talk, and afterwards I asked them several questions about SDI, and I understood from their answers that SDI is a dead end.

Los Alamos Science: Were the Russians working on similar technology?

Pavlovskii: Sure, there was some work going on in this area, but it was looked at from a different perspective—more as research-type work. It has many purposes, so it's not really a total waste of time. It opened up some interesting directions of research.

Los Alamos Science: In the research areas that you shared this week, did you feel that the Russian work was superior to the American work?

Pavlovskii: That's really not the proper question. We've always had very talented mathematicians and theoreticians in Russia. For experimentalists, however, life is a little harder. In addition to paper and pencil, they need all kinds of equipment, and in our country there is a lack of necessary equipment. Nevertheless, in many areas they were able to overcome these difficulties and come up with some very good results. So let's consider the work that was discussed at the meetings we had here this week. While American scientists have an obvious interest in helping Russian scientists, the fact remains that in the magnetic-field-generator work, for example, we have been able to produce the highest magnetic fields in the world. And this is not the only area in which we've been able to achieve a lot with little.

Los Alamos Science: Are your best students going into physics?

Pavlovskii, Mikhail Dolotenko, and Alexander Petrukhin overlooking Pueblo Canyon.

Pavlovskii: Unfortunately not. The process is different now. Given the circumstances in our country, the morale of our people more or less dictates where the youth goes. The young people who are subverted by cars, by toys as it were, see it would be far too hard to get those things through a career in science. They want instant gratification. They go into what we call "business." The new word for it is business, but I think the old word for it was primitive speculation, black markets—let me finish, hold on—I don't think it's just a Russian problem, it's now becoming a world-wide problem. In many respects, the level of intellectuality has dropped significantly all over the world.

Los Alamos Science: Once again, science in the United States is becoming dependent on foreigners. In many areas of science, the ranks are being filled by students and postdoctoral fellows from other countries.

Pavlovskii: One of the first things I noticed when visiting the United States was that about half of the best mathematicians in American institutes are Russians. I'm not saying that the directors of your institutes are all going to be foreigners, but when I ask American scientists about the quality of the Russians who are working, teaching, and studying at American universities and institutes, they always express the highest opinion of their Russian colleagues. ■