A. F. Ioffe and I. V. Kurchatov[1)]

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The article contains the author's personal recollections of two outstanding physicists of the twentieth century, A. F. Ioffe (1880–1960) and I. V. Kurchatov (1903–1960). The author was one of the first staff members of the A. F. Ioffe Physicotechnical Institute of the Academy of Sciences of the USSR, at the beginning of his career, and he associated and worked a great deal with I. V. Kurchatov.

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Sixty years have passed since that memorable day when I crossed the threshold of Nikolai Nikolaevich Semenov's laboratory at the Physicotechnical Institute to become an experimental physicist. As Pushkin's Pimen, since that time I witnessed many discoveries in physics, chemistry, and other natural sciences. Many of these discoveries profoundly affected the lives of people over the course of the last half-century. In this period of time, I had many contacts, both friendly and professional, with many outstanding scientists.

I want to recount my recollections about two of them, A. F. Ioffe and his famous student I. V. Kurchatov. Fate brought us together and gave me the opportunity to work closely with them for many years. I will also briefly recount encounters with other outstanding physicists, in order to reconstruct a picture of the times many years ago that to a large extent, determined the development of science in our country.

Almost a quarter century has passed since Abram Fedorovich passed away, but recollections of him are still the most precious memories in my life.

I first saw him at a lecture. In 1920, I entered the Electromechanics Department at the Polytechnical Institute in Petrograd. There were several so-called "streams," i.e., groups of students from different departments coming together to listen to lectures in the large physics auditorium of the Polytechnical Institute. I was lucky: I got into the group in which the general physics course was given by Abram Fedorovich. Having heard two or three of his lectures, I realized that the most interesting area of science is not electrical engineering, with which I was absorbed at the time, but physics. Somewhat later, when I discovered that there was a Physicomechanical Department, formed about a year earlier, at the Polytechnical Institute, during the second half of the year, i.e., in the beginning of 1921, I transferred into this department.

Abram Fedorovich's lectures made an indelible impression. I will describe some of the characteristic, most memorable moments. Abram Fedorovich delivered lectures during the fall and winter of 1920–1921. The building in which the Institute was located was not heated and the audience sat in fur coats and felt boots. When the time for the lecture arrived, Abram Fedorovich entered from the doors leading into the lecture hall wearing an austere black suit with a white collar. His appearance was always neat and austere. When the lecture began, the entire auditorium quieted down and listened to what Abram Fedorovich had to say with great excitement.

I remember especially well the lectures on the kinetic theory of gases, which he included among other areas of physics. He derived unusually simply and clearly the famous equations for the coefficients of thermal conductivity, diffusion, and viscosity of gases. As it happened, I had a great deal to do with precisely these coefficients in my life. And always, when I started to read anything, the young Abram Fedorovich appeared before me standing at the blackboard deriving these equations.

At the end of the first school year, Abram Fedorovich instructed a number of students to write papers over the summer and to read them at a future seminar. I was assigned the following theme: Rutherford's work on the structure of the atom. This was my first, on direct instructions of Abram Fedorovich, encounter with nuclear physics, in which I always remained interested.

After completing the first course, another significant event, very important for me, occurred in my life. Nikolai Nikolaevich Semenov wanted to talk to me and together we went for a walk in the park at the Polytechnical Institute. I still remember the park bench on which we sat. Semenov proposed that I begin working at the laboratory which he was planning to create at the Physicotechnical Institute. He invited Aleksandr Filippovich Val'ter and Viktor Nikolaevich Kondrat'ev at the same time. In the fall of 1921, we began work at the Physicotechnical Institute, which was located in several rooms of the Polytechnical Institute.

Working at that time was not easy. During the winter, we had to obtain wood, light the woodstove that was in the room, and bring in two pails of water from the professors' building which had water (there was no water in the main building). I should also point out that the tramways were very irregular at that time. I lived in the center of Petrograd; the distance to the Polytechnical Institute was 8 kilometers. Often I had to walk to the Institute, and sometimes back as well; from time to time, working late, I had to stay at the laboratory and sleep on the laboratory table. But, at 17 this is not very difficult to do.

One of my strongest impressions, related to the beginning of my work at the Physicotechnical Institute, was left by a seminar which was conducted weekly by Abram Fedorovich. At that time, we received many foreign scientific journals. For a long time, the Soviet

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Union had no contact with the West and the scientific literature began to appear only in 1921, after trips by Abram Fedorovich to Western Europe in order to restore scientific contacts, buy scientific equipment, and obtain literature. For this reason, many problems had to be "passed" through the seminar, so that the members of the Institute could completely familiarize themselves with the course of the contemporary states of physics, which progressed appreciably in the West.

The seminars were conducted on a very high level, and they encompassed all of physics. At that time, physics was not so specialized as it is now, when only very small numbers of physicists can consider themselves more or less competent in all areas of physics. To participate in or simply be present at Ioffe's seminars was fantastically interesting.

It is interesting to note the following detail. When Kapitsa began working at the Cavendish Laboratory, on the recommendation of Abram Fedorovich, there was no seminar there. Petr Leonidovich, having become accustomed to discussions of this type with Ioffe, could not restrain himself and organized a seminar in his apartment. At the time, he was not married and he lived directly at the college, as was required of unmarried members of the laboratory. Ten to 15 members of the Cavendish Laboratory began to meet in his small apartment and in this manner the Kapitsa Club was organized. This club existed for a long time and, following its example, a club of young staff members at the Cavendish Laboratory was later organized. I was a member of Kapitsa's club, participated in its activities, and listened to discussions of work being performed in different areas of physics. Of course, most of the work here involved problems in nuclear physics and general problems in theoretical physics.

I want to describe two events that occurred in Ioffe's seminar. After the Physicotechnical Institute moved in 1923 from the rooms in the Polytechnical Institute into a separate building, the seminars were conducted in a large room, which contained the Institute's library. The event occurred in 1928, when G. A. Gamow's work on the theory of alpha decay appeared (the first work in which a sub-barrier transition was studied). A young, but already well-known theoretician presented this work and then said that all of this can be done much more simply than done by Gamow, and he wrote down several equations. And here, Abram Fedorovich, who immediately understood the extraordinary importance of the idea of a sub-barrier transition, abruptly interrupted the speaker and said: "Can it be that you actually do not understand that it is completely unimportant how such an important result is obtained?" For Ioffe, who was an extremely polite person, such a comment was out of character.

In Shakespeare, there is this phrase: "The time is out of joint." I want to present, on the contrary, an example of the profound connection between the times. There recently appeared work, done in part at the Institute of Chemical Physics of the USSR Academy of Sciences, according to which a number of chemical reactions can occur following the sub-barrier path. Everyone knows Arrhenius' law: the rate of a reaction depends practically exponentially on the temperature. But here a number of reactions have been discovered whose rate first decreases exponentially as a function of temperature, and then becomes constant due precisely to this sub-barrier transition. This is a very interesting phenomenon and it permits thinking about the formation of organic substances in the cosmos and about the problems of the origin of life in the universe in a completely different way. Thus the fact that interested us so strongly in Ioffe's seminar in 1928 was reconfirmed and infused with new meaning at the end of the 1970s.

The second incident is a comical one. Once one of the young staff members was giving a seminar. He was an intelligent person, but somehow did not think clearly. And so, during his seminar, he drew a curve on the blackboard. No one understood anything and Abram Fedorovich politely interrupted him and asked: "Tell us, please, what is plotted along the axes?" In answer we heard: "Nothing is plotted along the axes." Wild laughter arose.

At these seminars Abram Fedorovich often reported on his trips abroad and recounted all the news in physics. I should mention that at that time many fewer physicists went abroad than do now and they brought back much news on each trip, especially Abram Fedorovich, who had extensive scientific contacts abroad. He always made very interesting reports both on the results of new work and about people with whom he met. Each of his trips abroad was completed with such a report and these reports were always extremely interesting.

Abram Fedorovich understood profoundly the importance of physics for engineering, which at that time was by no means recognized by everyone. It was for this reason that he created the Physicotechnical Institute and the Physicomathematical Department in the Polytechnical Institute, graduates of which were called engineering physicists. I too proudly carry this title.

Ioffe understood well that the time when physics would make enormous contributions to engineering was close at hand. Naturally, he himself sought to work in the field, which in his opinion, could make significant new advances in engineering. Continuing his work in the area of solid state physics, he worked on problems of the strength of solids.

It was well known that the strength of solids is actually much lower than the theoretical strength. All kinds of attempts were made to explain this fact. In particular, one interesting idea was an idea due to Griffiths, according to which microcracks were present on the surface of a solid, at whose tips stresses were concentrated. Griffiths thought that failure occurred much earlier in the presence of cracks than it would in their absence.

Abram Fedorovich decided to see if this was indeed the case and whether or not it was possible, by eliminating cracks on the surface, to obtain considerably higher strength. He chose rock salt as the object of his investigations. We stretched the specimen of rock

salt, simultaneously dissolving its surface, so as to eliminate in the process of dissolution the cracks forming on the surface. Abram Fedorovich chose, when possible, specimens of rock salt of good quality, which, it would seem, should not have defects within them. Thus fracture should occur, according to his expectations, at much higher stresses. And this was indeed the case. It turned out that in this state the salt does not want to fracture. It stretches and fractures only at stresses that are much higher than the stresses observed under ordinary conditions.

Abram Fedorovich then made further progress along these lines. He performed experiments with a salt sphere, which was first cooled to a very low temperature, and then rapidly placed, for example, into molten tin. In this case, maximum stresses occur inside the salt sphere, so that its hot surface begins to expand and stretches the inner part of the sphere. Thus Abram Fedorovich showed (these experiments were performed, as I recall, by his assistant Mariya Afanas'evna Levitskaya) that, under these conditions inside the salt sphere, cracks or other signs of failure do not appear in spite of the high stresses that arise there.

The path to practical application of these achievements of A. F. Ioffe was very difficult, but in many cases it was possible to overcome the difficulties and even within a comparatively short time. In particular, the strength of freshly obtained glass filaments, when covered with a very thin layer of some substance for protection from external actions, was greatly increased.

The room in which I worked with Viktor Nikolaevich Kondrat'ev was located next to the room where Abram Fedorovich worked as well as next to his study, so that I was able to see, more so than others, the carrying out of many experiments performed by Ioffe. I observed, for example, another very amusing effect (I don't know whether its details have ever been described or not: the nature of the effect was never understood). When specimens of rock salt were subjected to a stress, they stretched in jumps and weak clicks were audible, after each of which the specimen being stretched was elongated by an insignificant amount. These clicks once especially intrigued Paul Ehrenfest, who at that time was a guest of Abram Fedorovich, and he wanted to understand completely how this phenomenon occurs. But, as far as I remember, it was not possible to construct a rigorous theory of this phenomenon at the time.

Concerning Abram Fedorovich's idea on the increase in the strength of salt, I can mention the following event. The day on which the Physicotechnical Institute was founded was celebrated each year. On this day, there was a meeting of the scientific-engineering committee, at which a report was given on some important problem concerning either the work being performed at the Institute or work being performed in other countries. The committee met during the day, and a modest dinner for the staff members of the Institute with a small number of guests was organized at night. The dinner usually ended with a witty spontaneous skit. During one of these so-called "student parties," Yakov Grigor'evich Dorfman read a long poem (he wrote poetry very easily). This was a poem dedicated to Ioffe's work with rock salt, which ended with the following words:

I trust that soon
the salt express
will take me to
the Solvay Congress.

I must say that the Solvay Congresses were not mentioned here accidently. Abram Fedorovich had a great deal of prestige abroad and often participated in these congresses.

I want to say a few words about the people with whom Abram Fedorovich began to work. I won't say anything about students such as Petr Leonidovich Kapitsa and Nikolaĭ Nikolaevich Semenov, who was A. F. Ioffe's main assistant when the Physicotechnical Institute was being created, since one can talk forever about them. Yakov Grigor'evich Dorfman, whom I mentioned above, was an outstanding individual, who besides physics, knew Latin and Greek extremely well. He also wrote poems in these languages and read them, translating them into the Russian poetic form. He was an exceptionally erudite and extremely highly cultured man. His works in the area of magneto-optical phenomena are well known. He later published several very good books on the history of physics.

Petr Ivanovich Lukirskiĭ was an outstanding experimentalist. He was a professor at the university and a very engaging man, so much so that when he recounted anything, he often added in the excitement of the story something that could not have actually happened. Along these lines, the following statement was once published in the "Phrases" section of the humoristic journal "Physikalische Dummheiten" published at the university: "Where does the habit of believing Petr Ivanovich Lukirskiĭ come from? There is no such habit of believing Petr Ivanovich Lukirskiĭ."

I am obliged to Petr Ivanovich Lukirskiĭ for a very vivid recollection. It was in a conversation with him that I first understood that there is an apparent violation of the law of conservation of energy in the emission of beta particles. Actually, we all know that beta particles are emitted with different energies, i.e., transitions with the same initial and final states produce beta particles with different energies. Physicists now clearly understand what is going on. For nonphysicists, it is worthwhile to explain the situation.

Over the course of many years, while the problems of wave mechanics and all the new models developed by Bohr, Heisenberg, and others were being vigorously discussed, some enthusiastic physicists considered that since everything is so complicated and incomprehensible, perhaps the law of conservation of energy doesn't exist at all. This was discussed completely seriously in scientific journals. Special experiments were set up to make a check. And, then, there is this phenomenon of beta emission that worried physicists.... Physicists calmed down only when Pauli invented the neutrino, which carries away the missing part of the energy. The law of conservation of energy was rehabilitated.

But once again, restoring the interconnection of the times, I must say that a new point of view has recently appeared. When Pauli introduced the concept of the neutrino, he introduced it as a massless particle that moved with the speed of light. And this is what everyone always believed. And then, following Karl Marx, who said that everything must be doubted, the physicists began to doubt: perhaps the neutrino does, in fact, have a mass? Here in the Soviet Union experiments were performed which showed that the neutrino does indeed have a mass, a very small mass, but the mass nevertheless is there. As soon as the first publications on this question appeared, a chorus immediately arose: "And why strictly speaking shouldn't the neutrino have a small mass? Nothing catastrophic occurs in this case."

Ivan Vasil'evich Obreimov was another assistant of A. F. Ioffe. He was a very interesting man and a very shrewd and well-educated physicist. Once together with Viktor Nikolaevich Kondrat'ev we encountered in some paper the term "sinusoidal lattice." We had never before encountered such a term in any book that we had seen. Then we told Ivan Vasil'evich about it and asked him to explain to us what a "sinusoidal lattice" is. Ivan Vasil'evich went up to the blackboard and right there on the spot explained to us in all detail all of the subtleties of this lattice.

Let me say a few words about Paul Ehrenfest, who was a close friend of Abram Fedorovich and the only person with whom Abram Fedorovich used the familiar form of address. Their friendship was long-standing, dating from their German times when Ioffe worked with Roentgen. Ehrenfest was a professor for some time at the university in St. Petersburg. To describe him, I can mention, as an example, the following event (I know this from Abram Fedorovich). Ehrenfest was distressed by the way in which scientific degrees were conferred at that time in Russia. The Master's and Doctoral degrees involved examinations. These exams had a completely fantastic extent. A knowledge of literally all of physics was required. This was very difficult because the examinations were conducted by a committee of professors who posed detailed questions.

Ehrenfest could see that this impeded progress: instead of being occupied with scientific work, people were expending enormous efforts and great amounts of time on detailed study of questions that no one was interested in. Each problem should be studied in detail when this is required by the work at hand, and the students should have a firm understanding of the foundations of physics. At a conference where this question was discussed, Ehrenfest delivered a heated speech indicating that this horrible custom should be eliminated. He was so upset for the people who were subjected to this ordeal that he could no longer restrain himself and at the end of his speech he burst into tears.

Ehrenfest was a good pianist. Sometimes, during the evenings, when we assembled in the library, mainly for discussions, Ehrenfest sometimes sat down at the piano and played. Abram Fedorovich teased him sometimes because Ehrenfest very much liked Strauss' waltzes. "You're playing that sentimental nonsense again," said Ioffe. As for himself, Ioffe liked serious music.

During his stay in Leningrad, Ehrenfest gave a series of lectures to the staff at the Physicotechnical Institute. He was a very sociable person. Many staff members came to his lectures. Among them there was a student at the Polytechnical Institute, who could not permit himself the luxury of wearing shoes during the summer and so he walked barefoot. This was in 1924, a difficult time, and many students survived by earning extra money as dock workers. But there were also students who did not know how to earn extra money and as a result they lived very poorly. This did not shock anyone especially, but Ehrenfest was very distressed to see that this fellow walked around barefoot in good and bad weather. He tried to persuade him in every way: "Listen, allow me to buy you a pair of shoes." But the fellow, naturally, not being able to accept such a gift, always refused. Ehrenfest tried to convince him for a long time, but was not successful. The fellow finally found a way to earn enough money to buy shoes.

More on Ehrenfest. At one of the seminars, at which he was present, a newly received paper on the so-called Bose-Einstein statistics was being discussed. It was not getting through to Ehrenfest; he simply could not understand it. And here at the seminar he began to worry, saying: "This is not correct. Einstein did not think this through. Bose led him astray. I shall go and prove to him that this is not so." Actually everything came out to be "just so" and was correct. This can happen to anyone; no one understands everything immediately. As is well known, even Einstein in his time did not understand Aleksandr Aleksandrovich Friedman's work on the expansion of the universe.

With this I shall end my recollections about the people of the older generation, who were part of Abram Fedorovich's inner circle.

Abram Fedorovich believed in the power of physics. He deeply believed in the fact that anything that does not contradict the laws of physics can be done. In particular, once during one of his trips abroad he arrived at the conclusion that it is possible to make extremely compact storage batteries and wrote about this to his wife. In this letter he writes that he has thought of a way to make a compact storage battery, which would provide enough energy for a small airplane to fly from Leningrad to Moscow. With this example I wanted to show that Abram Fedorovich always thought about the engineering applications of physics. His work on thin insulation, to which he devoted several years of his creative life, was also motivated by such concerns. Many workers at the Institute worked on this idea and believed in it.

A great deal of attention was devoted to this work for a long period of time. The well-known company Siemens also was interested in thin insulating films. The Siemens company performed extensive research, which resulted in higher quality insulators. As a sign of its gratefulness, the company sent Abram Fedorovich an automobile as a present. But, nevertheless, Abram

Fedorovich was not able to achieve his goals.

Abram Fedorovich had a very broad range of interests. At seminars and in discussions on the most diverse problems, he would often state some completely new idea, a completely new approach to physical phenomena.

I recall the following. There was a drought one year and Abram Fedorovich proposed the following idea at one of the discussions: soot should be deposited from aircraft on glaciers feeding rivers, which would lead to more intense melting of glaciers and increase the amount of water in rivers fed by these glaciers. I should point out that this idea was forgotten and it later reappeared in print. From time to time I encounter for the second time such "inventions," although I remember well that I first heard about them from Abram Fedorovich.

Long before any discussions on the energy crisis, Abram Fedorovich began to worry that a great deal of energy is consumed for heating houses. In this connection, he stated the idea that houses should be made large and without windows, and they should be artificially illuminated on the inside (physics makes it possible to replace daylight by electric light with a nearly identical spectrum). Then, very little energy would be required to maintain an appropriate temperature in the house (the heat losses in this case would be much lower).

I can recall many proposals by Ioffe, which were later rediscovered. Reading about some "new idea," I would recall that Abram Fedorovich mentioned it 30 or 40 years ago. He suggested many new ideas and many of them were taken up and realized immediately or much later. Ioffe was very concerned that physics contribute as much as possible to engineering.

Abram Feodorovich attached enormous significance to dissemination of physics in the country. He organized a number of institutes in different cities, placing outstanding scientists as directors: I. V. Obreimov, I. K. Kikoin, and G. V. Kurdyumov. All of them later became Academicians. They contributed a great deal to the extensive development of physics in the USSR, working a number of years in the outlying districts and creating strong scientific organizations there.

In 1928, Ioffe did a very unusual thing. He organized a floating conference of physicists. The purpose was to encompass the largest possible number of people and to raise as much interest as possible in physics. To do so, he was able to organize a conference in the following form: the conference opened in Moscow, where several reports were given; then many of the participants got on a train and reached Nizhnii Novgorod, where they boarded a ship going down the Volga. There were many foreign guests at the conference. P. A. M. Dirac, P. Debye, and R. Pohl and many others were present. The ship stopped at every university town. A one or two day conference with a series of reports was conducted at each university.

In this manner, we finally reached Tbilisi. The entire operation was very well thought out, since it was impossible to collect such large audiences in one spot, as Abram Fedorovich was able to do. This type of conference was an enormous event for the instructors and students at these universities. They could hear and see many well-known physicists. Abram Fedorovich himself translated a large number of reports by foreign physicists. I was especially impressed when he tackled the translation of a report by Philip Frank, who was well-known as one of the best and subtlest specialists on the theory of relativity. I was even somewhat concerned for Abram Fedorovich because he was more of an experimentalist than a theoretician so that he simply never dealt with all the subtleties of the theory of relativity. Nevertheless, Abram Feodorovich brilliantly translated the very complicated statement made by Frank.

I shall allow myself a small diversion. During this trip, Viktor Nikolaevich Kondrat'ev and I became good friends with the son of R. E. Millikan, who was also a young physicist. When we reached Tbilisi, we decided to show the younger Millikan the exotic Caucasian sights and slightly shock his imagination. We found out from physicists, whom we knew in Tbilisi, where the most interesting tavern was in Tbilisi, and we took him there. The tavern was divided into small sections, each containing a small table. We wanted to surprise him with Caucasian cooking and wine, but Millikan and we ourselves were astounded by something very different. On the walls of this tavern in Tbilisi, we saw portraits drawn in a somewhat exotic style. The tavern was long and there was a continuous succession of portraits along its long walls. When we studied these portraits carefully, we saw that they were portraits of writers, philosophers, and scientists. It was very surprising to seem them in a tavern. Millikan jumped up and said: "Look, this is Darwin! Who would think that one could see a portrait of Darwin in a Georgian tavern?" This aroused in him a very deep respect for Georgia.

I also want to mention the following. Abram Fedorovich played a very great role in the organization and development of nuclear physics in the Soviet Union. I believe that his role here has been underestimated. He immediately and actively supported Igor' Vasil'evich Kurchatov and A. I. Alikhanov, when they proposed that work on nuclear physics be commenced at the Physicotechnical Institute. I should mention that this was not an easy thing to do. In those years, Abram Fedorovich was strongly criticized for the inadequate output of applied work at the Physicotechnical Institute. To organize at this time work on nuclear physics, which was then viewed as something very abstract, not having any practical applications, was very difficult and required great civic courage. Nevertheless, Ioffe understood profoundly that nuclear physics is a branch of physics which cannot help but have practical applications. In addition, he was convinced that serious progress in the area of fundamental sciences cannot help bearing practical fruits.

In spite of all difficulties, Abram Fedorovich obtained permission to organize a division of nuclear

physics. For some time he himself headed this division, and this accelerated its development. After six months, he appointed Igor' Vasil'evich as the head of this division.

Abram Fedorovich organized a special seminar on nuclear physics, which was a very lively seminar. He proposed interesting experimental ideas at the seminars, and some of them came to life much later. In particular, I will describe the method for observing particles with the help of a Wilson cloud chamber, which for a long time remained the basic instrument of nuclear physicists. This chamber, as is well known, operates periodically: during the times of expansion. Abram Fedorovich was literally tormented by the thought of how to improve the Wilson chamber and almost at every seminar he said that the chamber must be able to fix particles at any moment in time, and not only in separate short time intervals. He suggested various ideas. One of his ideas reduced to the following: to create a mixture of air with water vapor, which would be injected through a nozzle into the chamber so that some region of the chamber would contain supersaturated vapor. This vapor must be systematically removed, new vapor must appear in its place, etc. We now know that chambers providing for continuous detection of particles were finally created. Abram Fedorovich, at the very beginning of Soviet nuclear physics, gave a great deal of thought to the development of experimental methods and did a great deal to accelerate the solution of this problem.

Abram Fedorovich Ioffe himself directed the international congresses of physicists, which occurred twice in Leningrad and to which a large number of foreign scientists were invited (J. Perrin, F. Joliot-Curie, P. Auger, and many others). Although at that time I no longer worked at the Physicotechnical Institute, as I recall, I was interested in nuclear physics. I had to participate in editing a collection of papers, published after one of these conferences, so that I had a great deal of contact with Abram Feodorovich along these lines. I could see his preoccupation and the effort he applied to the development of nuclear physics, from which he himself already completely withdrew.

I had the good fortune to work with Igor' Vasil'evich Kurchatov for many years. Igor' Vasil'evich appeared at the Physicotechnical Institute in 1925 together with his good friend Kiril Dmitrievich Sinel'nikov, whose sister he later married. Their appearance at the Institute became a memorable event. At that time the Physicotechnical Institute was full of very energetic and lively young people. Nevertheless, the arrival of Igor' Vasil'evich and Kiril Dmitrievich was very noticeable. Both of them were tall and well built. Igor' Vasil'evich was very handsome, temperamental, and lively, and immediately won universal liking and attention. He engaged in experimental work with a furious passion and it was evident very quickly how bright a light he was in our science. I will not recount his work. A great deal has been written about it. I shall try to recount the events which have not been adequately discussed.

As is well known, Igor' Vasil'evich abruptly switched from solid state physics to nuclear physics. This change surprised many of us. It was indeed a very sharp and abrupt change. His work on ferroelectric crystals was elegant and beautiful, an example of true classical research. It is amazing how rapidly he entered the new field. He was able to identify the crucial problems, which had to be addressed, collected the equipment, and engaged in a serious experiment. As a result of his work and the work of other physicists, primarily at the Physicotechnical and Radium Institutes, Soviet nuclear physics began to develop rapidly. Alikhanov and Artsimovich worked intensely. Very quickly, in 1933, a large conference was convened in Leningrad on nuclear physics to which a number of well-known foreign scientists were invited. At this conference, Soviet scientists already could appear with original work and carry on discussions with foreign colleagues as equals. Igor' Vasil'evich actually became the leader of this branch of science in the Soviet Union. In 1933, at the conference that I mentioned above, Soviet physicists presented a number of very good papers, which were highly praised by their foreign guests. Here I shall take the opportunity to recount the following episode. The guests were assigned scientists who were supposed to help them so that they would feel free in an unfamiliar country with a strange language. I was very lucky because I was assigned for some time to Frederic Joliot-Curie, who also participated in this conference. When I asked him what he would like to see in Leningrad, Joliot-Curie surprised me by asking me to show him a pair of metallurgical and machine building plants. He had a metallurgical education and continued to be interested in these problems. I took him to two plants. Compressors were manufactured at one of them. He walked around the plant and was very interested in all the details of the technology. He evidently knew it very well and he asked questions, which the engineers answered with interest and excitement. He was delighted by the quality of the castings of machine beds. He praised this section highly and the engineers were very happy that their work was praised by such an outstanding scientist. His knowledge of machine building and metallurgy surprised me.

Nuclear fission was discovered several years after the conference at which Soviet nuclear physicists seriously entered the international arena. Igor' Vasil'evich and his laboratory began to study all the related problems with great vigor. Simultaneously, together with Yakov Borisovich Zel'dovich, at the Institute of Chemical Physics we busied ourselves with a number of calculations of neutron-nuclear chain reactions. A close-knit group formed, in which we all met often. Our institutes were practically next door to each other. Igor' Vasil'evich, Georgiĭ Nikolaevich Flerov, Yakov Borisovich Zel'dovich and Isaĭ Isidorovich Gurevich actively participated in the discussions of all problems. This was a time of very high pressure work, it was felt that something new and important was beginning.

I want to recount an amusing fact. One of our outstanding scientists, whom I deeply respect, in a conversation on these subjects began to talk about the fact that to solve our problems it is necessary to create an enor-

mous institute (this was in 1939). He began to fantasize what could be done with the problems that we were all studying on an experimental-theoretical level. He drew a quite precise picture of what was soon begun first in the United States and then in the Soviet Union. However, at the time he was talking in an ironic tone. It seemed to him that in general this was still a fantasy. It is remarkable how important it is to have the courage to go beyond the familiar ideas. Even a man to whom the program of action was completely clear did not present it as a program. On the contrary, he referred to it as a joke. This was most likely due to his enthusiasm for the problems on which he himself was working. Nevertheless, this shows that sometimes an understanding of the problem is not in itself sufficient. Courage is required to give up ingrained ideas.

The work that was unfolding in the Physicotechnical Institute and at the Institute of Chemical Physics in Leningrad was quickly supported by the formation of a special uranium committee, chaired by Academician Khlopin, in the Academy of Sciences. Igor' Vasil'evich and I were among the young physicists on the committee. Kurchatov at the time worked with a fantastic energy. Aside from direct work in the laboratory at Physicotechnical Institute, he worked closely with the Radium Institute, worked on its cyclotron, and conducted enormous organizational work in preparation for construction of a cyclotron at the Physicotechnical Institute. One can imagine how complicated this work was in the years before the war.

When the war began, everyone knew that Igor' Vasil'evich was at the forefront of military science. His work on demagnetization of ships, which he conducted together with A. P. Aleksandrov, was urgent work. His departure to Sevastopol' was a great risk.

Soon enormous work began on nuclear science and technology, which the government assigned to Igor' Vasil'evich. Here I want to describe the following episode. In 1943, electrons were conducted to the Academy of Sciences. Two candidates were nominated for academician in the physicomathematical division, while there was only one place. The situation was such that it was necessary to elect Alikhanov. Abram Feodorovich Ioffe understood well that it is impossible not to elect Igor' Vasil'evich. Abram Feodorovich considered that Igor' Vasil'evich was no weaker than Alikhanov, although some people thought that Alikhanov achieved greater results. In addition, Abram Fedorovich already knew that Igor' Vasil'evich was facing gigantic work and the title of Academician would be very useful in this work. He appealed to the government with an urgent request to provide one more additional place. In this manner, both Alikhanov and Kurchatov were elected.

It is amazing with what energy and skill Igor' Vasil'evich began to form an enormous group, which had to solve all problems facing Soviet physics in the immediate future. One of his most important qualities, which helped him accomplish this, was his exceeding benevolence. This quality attracted to him not only the minds, but also the hearts of people. This is extremely important for great and difficult work.

IGOR' VASIL'EVICH KURCHATOV

Igor' Vasil'evich was deeply engrossed in the problems involved in the construction of nuclear reactors. All this is described in detail in appropriate books, so that I will not enter into details. A remarkable characteristic of his work was his penetration into all aspects of the problem.

Igor' Vasil'evich's style was clearly evident in his work on nuclear reactors. This work was always conducted under continual observation. Literally every corner of the complex crisscrossing of pipes and wires of which a reactor consists was examined with the greatest of care. This required colossal effort, and because of it the difficult commissioning period passed well and smoothly. The first reactor, started up in the Soviet Union, was the reactor at the Institute of Atomic Energy. The reactor was started up with the help of a small control panel. Igor' Vasil'evich was always specially attracted to this panel. When the large reactor was started up, he took the control panel from Moscow to the location of the reactor.

The extremely intense work had its effect on Igor' Vasil'evich's health. His health broke down somewhat, but he continued to work indefatigably. When the main work necessary for the development of nuclear power and the defense of our country was completed, Igor' Vasil'evich turned with great passion to realization of controlled thermonuclear fusion, proposed by a group of

Soviet scientists. A great deal of progress was soon made. Igor' Vasil'evich believed that progress must be made very rapidly. He deeply believed that the time was not far off when thermonuclear energy would become a powerful and almost inexhaustible source of energy for mankind. He applied great efforts to the organization of this work, which also required large and expensive installations as well as new efforts. Industry had to be attracted to construct these installations. Igor' Vasil'evich, with his wonderful ability to attract people, was able to create here as well enormous new groups, which engaged in this work. He felt that the work on thermonuclear fusion must be used to reduce the tension that appeared in the world after many years of the Cold War, following the ill-fated speech by Churchill in Fulton. Igor' Vasil'evich was able to convince the leadership of our party and the government of the importance of taking appropriate steps. We know well that during a state visit to England in 1956 Igor' Vasil'evich described to amazed British scientists at Harwell the research performed in the Soviet Union on problems of thermonuclear fusion. Such work was also being performed in the USA and in Britain, but was strictly classified. Kurchatov's appearance had great political consequences. We can firmly assert that Igor' Vasil'evich was not only a great scientist and a great organizer of science, but he was also an outstanding politician. In particular, his appearance at Harwell turned out to be a turning point in the history of relations between Soviet physicists and physicists in capitalist countries.

Igor' Vasil'evich had a wide range of interests and extensive scientific interests. He was disturbed by the situation in biology, as were many other scientists. Many of us remember well that after Lysenko dominated biology for a long time, his influence decreased somewhat. Later, Lysenko's influence again increased, and this greatly disturbed Igor' Vasil'evich. Together with the then president of the Academy of Sciences Nesmeyanov, Igor' Vasil'evich made a special appeal to the government pointing out the necessity of developing a number of branches of biology. He partially solved this problem in his own way by creating a special biological section at the Institute of Atomic Energy.

In the last years of his life, Igor' Vasil'evich devoted more and more time to work on thermonuclear fusion. Several days before his death, he was in the Ukrainian Physicotechnical Institute. He was able to gain the support of the Central Committee of the Communist Party in the Ukraine for construction of new buildings and installations in Khar'kov. He returned from the Ukraine encouraged by the fact that another serious center will be created and a solution of one of the biggest and most difficult problems confronting physicists will be that much closer.

Igor' Vasil'evich also devoted a great deal of attention to the development of fundamental research. With his direct participation, the problem of constructing a large accelerator in Serpukhov, which for many years was the most powerful accelerator in the world, was solved, an Institute of Nuclear Physics was organized in Novosibirsk, and a large center for nuclear studies was created in Dubna.

Igor' Vasil'evich literally burned with creativity up to the last moments of his life. He died suddenly during a scientific discussion.

Two months after Kurchatov's death, I saw Abram Feodorovich Ioffe for the last time. There was a general meeting of the USSR Academy of Sciences. I had to talk to him about some problems related to the application of semiconductors. I wanted to ask his permission to set up some experiments along these lines at his Institute.

Abram Fedorovich lived at the Moscow Hotel. We agreed that I would visit him. This was in April. For Abram Fedorovich, Igor' Vasil'evich's death was an enormous blow. Usually, when a conversation started up on some physical subject, Abram Fedorovich came alive and immediately entered into the discussion. This time was different: we exchanged several remarks and he quieted down and began to talk about Igor' Vasil'evich. He liked and valued him a great deal. I could see that Abram Fedorovich could not concentrate on our conversation. He continuously returned to recollections of Kurchatov and our last meeting was sad from beginning to end. Abram Fedorovich died the same year in October 1960.

Translated by M. E. Alferieff