

CONFERENCES AND SYMPOSIA

PACS numbers: 01.10.Fv, **01.52.+r, 01.65.+g**

90th ANNIVERSARY OF THE P.L. KAPITZA INSTITUTE FOR PHYSICAL PROBLEMS, RUSSIAN ACADEMY OF SCIENCES

History of P.L. Kapitza Institute for Physical Problems of the Russian Academy of Sciences*

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DOI: https://doi.org/10.3367/UFNe.2024.12.039868

Contents

Abstract. The establishment of the Institute for Physical Problems was a unique project of the Soviet government: it was set up for the scientific work of Peter Leonidovich Kapitza. The paper presents the history of the P.L. Kapitza Institute for Physical Problems of the Russian Academy of Sciences from its establishment in 1934 to the present day. It describes how the institute changed with changes in the country and how the structure, tasks, and topics of the institute's work have changed over the years of its existence. The most outstanding work of the institute's employers is presented, and the current state of the institute and the areas of its activities are described.

Keywords: Peter Kapitza, Institute for Physical Problems, Lev Landau, low-temperature physics, superfluidity, liquefaction of gases, history of physics in the USSR

1. Introduction

In December 2024, the P.L. Kapitza Institute for Physical Problems of the Russian Academy of Sciences (IPP RAS) celebrated its 90th anniversary. The institute was established in accordance with a decree of the USSR government dated December 23, 1934, signed by the Chairman of the Government V.M. Molotov. The uniqueness of the situation was that the institute was set up for the work of Peter Leonidovich Kapitza rather than for solving any specific scientific problems. The establishment of the institute was preceded by a number of events described at length in the literature [1–6]. Peter Leonidovich Kapitza, who worked in England with Ernest Rutherford, came to the USSR for his regular vacation. However, the country's political leadership, headed by Joseph Stalin, believed that at that moment science was necessary for the development of the country and decided not to let P.L. Kapitza go back to England; an institute was established for his full-fledged work in the country. Kapitza was not happy with this turn of fate: in England in 1933, the philanthropist Mond had already built a laboratory for him, which was equipped with the necessary latest equipment, but here, in the USSR, he had to start all over again. It should be noted that, while in England, Kapitza planned to return to work in the USSR in a few years and to use the time working in England to develop an instrument base in the USSR. So, in 1934, it was assumed that an intern would go to England with Kapitza for a year, who would master the work on a helium liquefier and, after returning to the USSR, build a similar one: at that time, there was no liquid helium in our country. A young staff member of the Institute of Chemical Physics (ICP) of the USSR Academy of Sciences, Aleksandr Iosifovich Shal'nikov, was chosen as an intern on the recommendation of A.F. Ioffe. He had all the documents for the trip in 1934 ready, but since the plans for the trip with Kapitza were cancelled, Shal'nikov decided to stay in Moscow to assist Kapitza.

By a decree of the Presidium of the USSR Academy of Sciences of March 22, 1935, Kapitza was appointed director of the future institute. Kapitza himself thought up the name of the institute, writing [7]: "This somewhat unusual name

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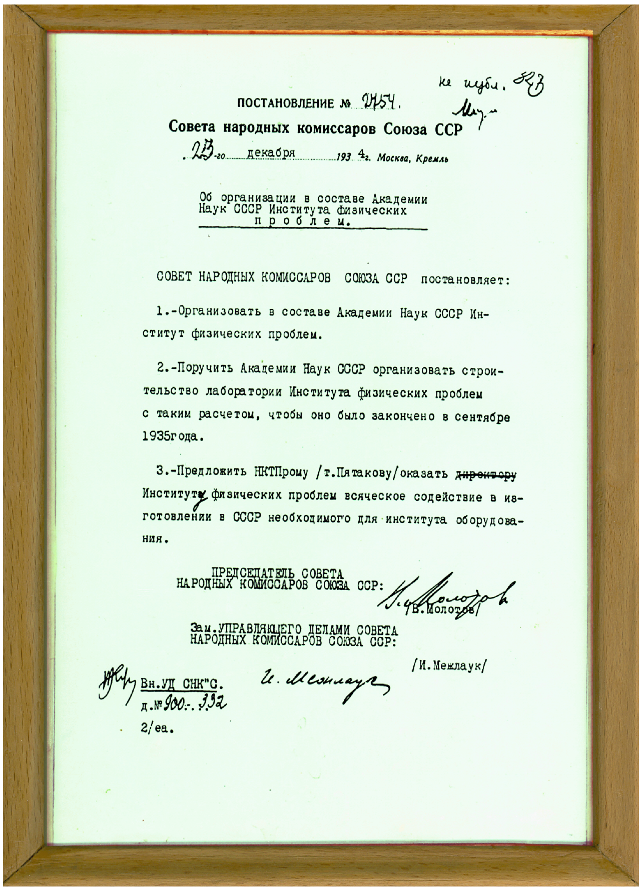
Received 18 December 2024
Uspekhi Fizicheskikh Nauk **195** (7) 748 – 758 (2025)
Translated by E.N. Ragozin

* Joint meeting of the Scientific Session of the Physical Sciences Division of the Russian Academy of Sciences and the Scientific Council of the Kapitza Institute for Physical Problems of the Russian Academy of Sciences, dedicated to the 90th anniversary of the Kapitza Institute for Physical Problems, Russian Academy of Sciences (December 18, 2024) (see *Phys. Usp.* **68** (7) 699 (2025); *Usp. Fiz. Nauk* **195** (7) 747 (2025)).



ПОСТАНОВЛЕНИЕ № 2754.

Совета народных комиссаров Союза ССР

23-го декабря 1934 г. Москва, Кремль

Об организации в составе Академии Наук СССР Института физических проблем.

СОВЕТ НАРОДНЫХ КОМИССАРОВ СОЮЗА ССР постановляет:

1.-Организовать в составе Академии Наук СССР Институт физических проблем.

2.-Поручить Академии Наук СССР организовать строительство лаборатории Института физических проблем с таким расчетом, чтобы оно было закончено в сентябре 1935года.

3.-Предложить НКТПрому /т.Пятакову/оказать ~~директору~~ Институту физических проблем всяческое содействие в изготовлении в СССР необходимого для института оборудования.

ПРЕДСЕДАТЕЛЬ СОВЕТА НАРОДНЫХ КОМИССАРОВ СОЮЗА ССР: /В.Молотов/

Зам.УПРАВЛЯЮЩЕГО ДЕЛАМИ СОВЕТА НАРОДНЫХ КОМИССАРОВ СОЮЗА ССР: /И.Межлаук/

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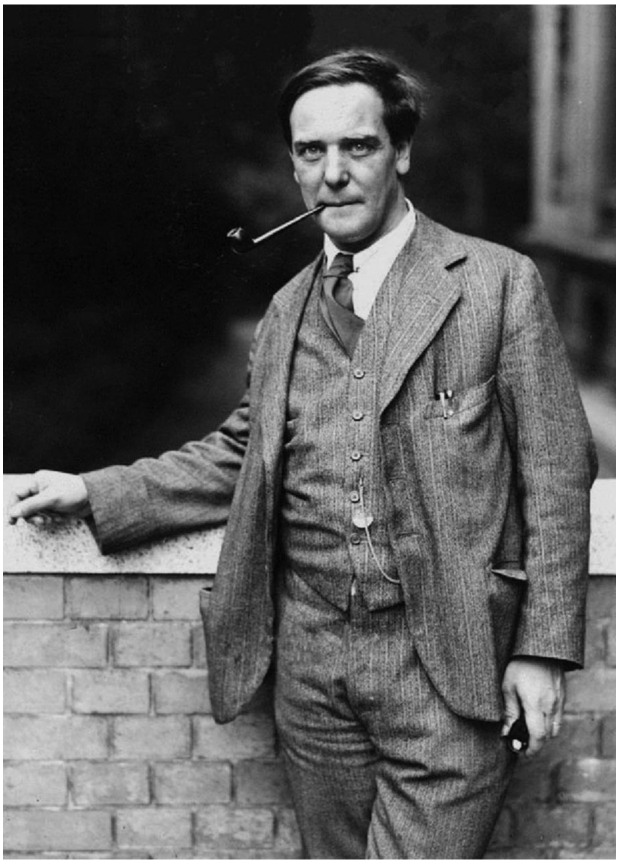
Resolution on the establishment of the institute, 1934.

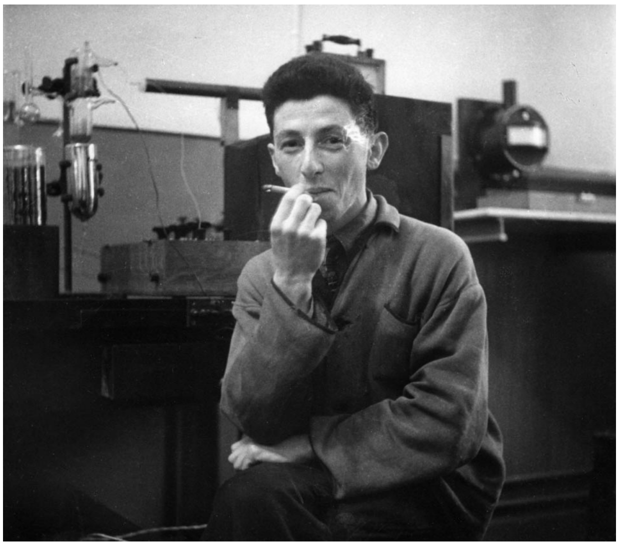


P.L. Kapitza, 1930s, IPP archive.

should reflect the fact that the institute will not be engaged in any specific field of knowledge, but will be, broadly speaking, an institute studying known scientific problems, whose range will be determined by the personnel, the scientists who will work in it." Kapitza identified three stages in the setting up of the institute: construction, installation of equipment, and organization of scientific work. The concept of the future institute was also defined: it should be small, with no more than eight scientific staff members, otherwise, Kapitza believed, the institute would be unmanageable. There would be no divisions in the form of structural units: laboratories or departments were not envisaged; the institute should be like one laboratory. In fact, it was to be set up following the example of the Mond Laboratory, which was built in Cambridge for Kapitza.

2. Construction of institute

The government decree on the establishment of the institute set very strict construction deadlines: September of the following year, i.e., it was necessary to build the institute 'from scratch' in less than 10 months, including the preparation of the institute's design. A site near the Kaluzhskii outpost on Vorob'evy hills was chosen. This site was far from the railways, and therefore possible noise and vibrations in this area were minimal. The institute was designed by experienced architects with the participation of Kapitza. A complex of three buildings was designed on the provided site: the main, administrative–laboratory building (now building 1), a residential building for employees, and a residential cottage for the director. The living quarters were designed in the English style: two-story apartments with fireplaces on each floor.



A.I. Shal'nikov, 1937, IPP archive.

When setting up the institute, starting with the stage of choosing its site, Kapitza was actively assisted by Shal'nikov. At first, Kapitza was critical of Shal'nikov's character. In a letter to his wife, Peter Leonidovich wrote: "... He is a nice guy, but his character is really nasty. He criticises everyone and scolds everyone except himself. If he is so used to scolding everyone, then he will certainly scold me too.... Of course, the art of living and working with people consists in finding all the good that is in a person in order to develop and use these traits for work....'' [8, 9]. But, after communicating for some time, Kapitza changed his opinion of him.

Since Kapitza had no housing in Moscow, in 1935, he lived in the Metropol Hotel, and Shal'nikov settled nearby, in the Budapest Hotel. For Kapitza, the main difficulty was adapting to Soviet conditions; sometimes he lost faith in the success of the enterprise. What could be resolved quickly in England, over the phone, here had to be somehow obtained, someone had to be persuaded, you had to argue your case etc. Kapitza writes: ''Shal'nikov helps a lot. He is not upset, apparently he has gotten used to such conditions....'' With his characteristic humor, Shal'nikov recalled those days like this: in the morning he would come to Kapitza at the Metropol, they would discuss current affairs, then Kapitza would say: ''Well, I'll go to these..., and you, Shura, go to the construction site.'' Kapitza would go to see the officials and bosses, and Shal'nikov would go to the construction site of the institute. One day it turned out that the builders did not know what a right angle was, ''nothing was built in a rectangular coordinate system. Everything was crooked and askew.'' Shal'nikov explained to the builders what a right angle was and how to do it. In the evening, he would return to the Metropol; Kapitza, after communicating with officials, returned gloomy, and without saying a word, opened the cabinet, took out some cognac, poured a glass, drank it, and only after that said, ''that's it, we're done with the evil spirits for today, Shura, tell me how things are at the construction site.''

Aleksandr Iosifovich Shal'nikov was put on the staff on November 1, 1935 as a 'senior specialist of the institute.' In the archives of the institute, in his personal file, there is Shal'nikov's application for employment, which was written on a small piece of paper, with the resolution of P.L. Kapitza. So, A.I. Shal'nikov became the first research fellow at the institute.

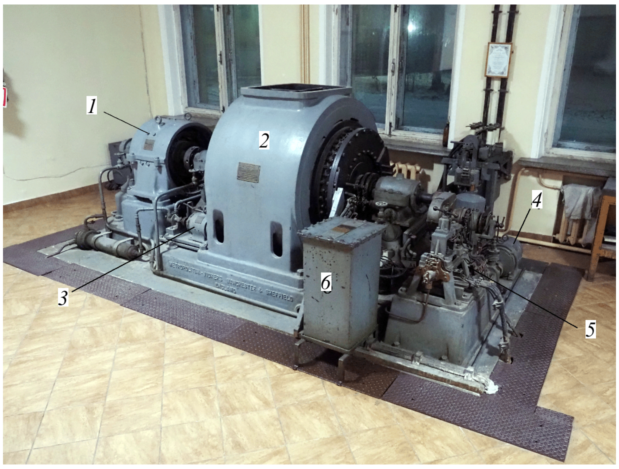
By September 1935, the main building was built. At the beginning of the year, Kapitza had set a condition for the authorities: either purchase the equipment from the Mond laboratory or manufacture similar equipment at factories in the USSR. On the second attempt, it was possible to agree on the delivery of the equipment from the Mond laboratory. The equipment began to arrive by the end of 1935. A lot was purchased: from small things like bronze foil to large installations developed by Kapitza: liquefiers and a generator for producing strong magnetic fields. On December 19, Kapitza wrote: ''The cargo has already arrived in Leningrad, loaded onto three platforms and sent to Moscow. They say it will arrive on the 22nd–23rd. They have already made arrangements with the heavy horses.'' Entry of December 21: ''The large generator was very picturesquely pulled by 15 horses. The heavy horses worked exceptionally well and harmoniously. You can't find fault with them.''

Arrival of equipment from England, IPP archive.

And on December 28, 1935, the newspaper *Pravda* published a note entitled ''The Institute for Physical Problems has been built.'' In 1936, a start was made on the installation of equipment, the most difficult being the electrical system. Each laboratory was provided with a large number of different electrical voltages: three-phase 380 V, single-phase 220 V, 12 V, direct voltage from battery packs, pulsed voltage with a stable frequency, etc.

Among the large installations, two liquefiers were mounted: of hydrogen and helium. The hydrogen liquefier was built according to the then common scheme: preliminary cooling of gas compressed to 180 bar with liquid nitrogen, and then liquefaction by the Joule–Thomson effect. The helium liquefier was built according to the scheme developed by Kapitza in the early 1930s in England. Its design was significantly simpler and more productive than the only helium liquefier known at that time by Kamerlingh–Onnes. In his design, P.L. Kapitza was the first to use the method of adiabatic gas expansion with the performance of mechanical work for the efficient cooling of helium; later, such designs were called expanders [10]. The method of cooling with the help of an expander was known earlier, but no one used it to liquefy helium due to the lack of suitable lubricant that worked at cryogenic temperatures. Kapitza came up with an ingenious solution: he used helium gas itself as a lubricant. The piston was a long body placed in a cylinder with a narrow gap. The piston length was chosen such that, during the piston stroke, only a small part of the gas managed to leak through the narrow gap without lowering the expander efficiency. At the same time, the productivity of the first version was up to 5 liters of liquid helium per hour versus 0.5 l/hour for Kamerlingh–Onnes. Furthermore, the system was a two-stage one: preliminary cooling was carried out by liquid air (Kamerlingh–Onnes had 6 stages, one of which was dangerous hydrogen). The liquefiers installed at the IPP in 1936 produced up to 7 l/hour of liquid hydrogen and up to 1.5 l/hour of liquid helium. This was the first helium liquefier in the USSR. Both liquefiers have survived and can currently be seen in the Kapitza Museum at the IPP RAS. The performance of the helium liquefier did not satisfy Kapitza, and a start was immediately made on the design of a helium liquefier with a performance of up to 5 l/hour.

The largest installation brought from England was a generator for producing super-strong magnetic fields in pulse mode [11, 12]. The generator was installed in the magnetic hall of the institute on a separate foundation (it is still located where it was mounted). The generator was developed by Kapitza (along with two assistants) in the late 1920s; the components were ordered from various enterprises in England. Schematically, the generator is a motor-generator bundle. Two additional small motor-generators were used to operate the installation: one to feed the DC electric motor that spun the heavy rotor of the generator, the other to feed the excitation windings of the main AC generator. In addition, two auxiliary electric motors were mounted on the



Motor-generator for producing strong magnetic fields, 1930: *1* — DC electric motor, *2* — main generator, *3* — oil pump, *4* — air compressor, *5* — assembly of contacts, *6* — smoothing capacitor.

platform: one to produce pressure in the oil line (to cool the bearings and to drive the emergency load shutdown), the second to drive the air compressor, with a pressure of about 6 atmospheres (compressed air was needed to blow off the electric arc when the contacts opened). The generator was started from an electrical panel located nearby. Before the experiment, all personnel left the room and all doors were locked with special latches. The experiment was controlled from a laboratory room located next to the solenoid; it was called the 'oscillographic room.' To control the experiment, Kapitza developed a device called a 'loop oscilloscope' (at that time, cathode-ray tubes were still in the development stage). The device was a falling photographic plate, during whose movement the parameters of the experiment were recorded on it by light beams, including the current through the coil. The experimenter pressed a button, a spring pushed the plate, and during the fall the plate closed the contacts, which closed the rotor of the generator on the solenoid by way of a relay system (the 'loop oscillograph' has been preserved and can be seen in the institute's museum). The generator contacts were synchronized with the rotor position, so the solenoid coil was connected to the generator when the output voltage passed through zero, and the solenoid was disconnected during the next zero-crossing (half of the sine wave). According to A.I. Shal'nikov [13], the parameters of the installation were as follows: single-phase generator power: 1500 kW; oil compressor: 6 atm; auxiliary generators (2 pcs.): 6 kW each; power supplied to the coil: up to 50,000 kW; rotor speed: up to 2000 rpm; closing time: ~ 0.001 s; rotor mass: 2.5 t; braking: by 10–15%: coil heating: up to 100 °C; field: up to 32.5 T.

Several units were purchased from domestic manufacturers, for example, an X-ray machine manufactured by Mosrentgen.

In the basement of the building, seven separate internal foundations were installed: concrete blocks on rubber pads with natural frequencies from 100 to 500 oscillations per minute for the placement of vibration-sensitive equipment.

Early in 1937, the installation of scientific equipment was completed, and on February 22, P.L. Kapitza wrote to V.I. Mezhlauk (deputy chair of the government): "today we have liquid helium, so the laboratory can be considered complete. We are all very happy about this" [1].

3. Pre-war period (1937–1941)

The first thing that had to be done after the completion of construction was to recruit employees. Kapitza approached this issue very carefully. In 1936, O.A. Stetskaya was hired as deputy director. One of the best glassblowers, A.V. Petushkov, moved from N.N. Semenov to the IPP, and employees for other departments were carefully selected. As for research staff, by the end of 1936, there were only three: P.L. Kapitza, A.I. Shal'nikov, and P.G. Strelkov [14].

After a lengthy selection procedure, Lev Davidovich Landau, who worked in Kharkov, was invited to the institute as a theorist. Landau filled out an application and was hired at the institute on February 8, 1937, but he was arrested in the spring of 1937. The story of Landau's arrest and his release through the efforts of Kapitza is well known and described in the literature [1, 15]. At the institute, in early May 1937, Kapitza had to issue an order: "L.D. Landau is to be excluded from the list of staff members of the institute," and after Landau's release, an order was issued at the end of April 1938 to reinstate Landau on the staff list.

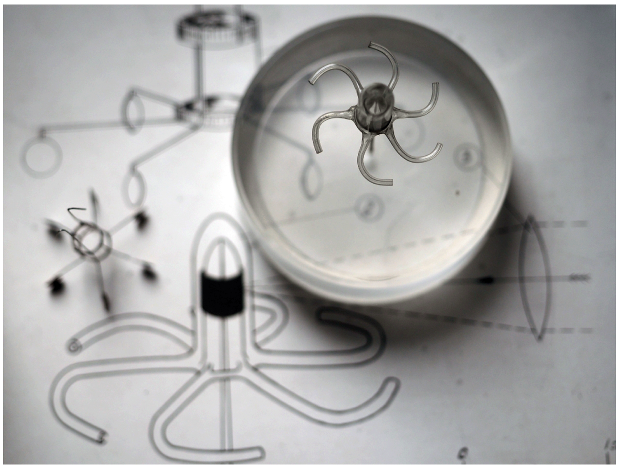
By the end of 1938, the institute already had five research associates: L.D. Landau and N.A. Brilliantov were added to the previous three. Hired later, in 1939, was the theorist E.M. Lifshitz, Landau's colleague from Kharkov [16].

The year of 1938 saw the publication of the first experimental work performed at the IPP on superconductivity and other topics.

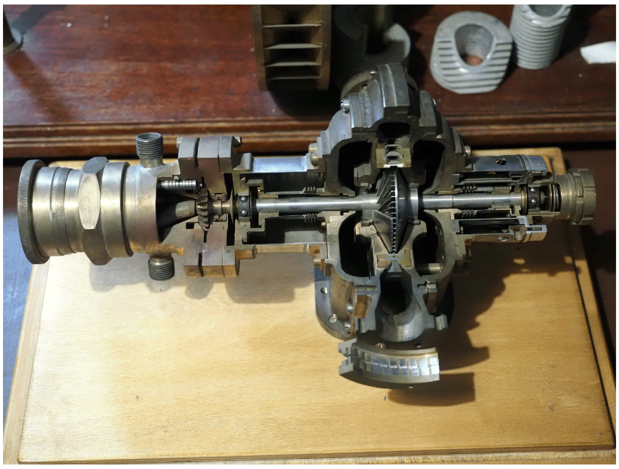
In 1938 and 1939, two papers signed by Kapitza were published that determined the scientific topics of the institute for many years to come. One, a paper in the journals *Dokl. AN SSSR* (in Russian) [17] and *Nature* [18] (in English), was short, only one page (it was submitted to the editors in 1937), where Kapitza described his experiments on the viscosity of liquid helium, called helium-2. In this paper, P.L. Kapitza first referred to the phenomenon he had discovered as superfluidity and pointed out the analogy of this phenomenon with superconductivity. It should be recalled that superconductivity was discovered by Kamerling–Onnes in Leiden in 1911, and, despite the fact that 26 years had passed, there was no explanation for this unusual phenomenon. Kapitza's discovery gave hope for a possible solution to the phenomenon of superconductivity. Kapitza suggested that Lev Davidovich Landau take up the unusual phenomenon he had discovered.

Kapitza reported the second study in 1938 at a session of the Academy of Sciences. In 1939, the study appeared as a paper [19], where Kapitza analyzed different methods of obtaining oxygen, including by rectifying liquid air, and proposed his own method of obtaining liquid air: using a turboexpander. There were attempts to use a turboexpander before Kapitza: at that time, steam turbines were used as expanders, but their operation was ineffective. Kapitza in his work proposed his own design of a turboexpander, providing a calculation of the shape of the blades and nozzles of the turbine. Not only did Kapitza propose his version of the turbine, but he also described an installation manufactured in the IPP workshops with a performance of up to 30 l/hour of liquid air using a turbine of his design, the rotation speed of the turbine being more than 40,000 rpm.

The advantage of Kapitza's installation for liquefying air is obvious: for the effective operation of a piston expander, a pressure of about 200 atm is required, while for a turbo expander only 6 atm is needed, with a higher efficiency of the



Kapitza 'spider.'



Kapitza turboexpander (demonstration model).

turbo expander. In the late 1930s, war broke out in Europe, and the need for oxygen increased greatly, so Kapitza's invention appeared to be very timely.

In addition to scientific work, L.D. Landau devoted much time to teaching. Together with his colleague E.M. Lifshitz, he planned to write a course on theoretical physics. The first volumes were published in 1939 ('The Classical Theory of Fields' and 'Statistical Physics').

In the pre-war years, A.I. Shal'nikov was actively engaged in thin films, including the study of their superconducting properties. Kapitza continued to work on engineering problems related to cryogenic technology. As for superfluidity, Kapitza conducted several experiments and published papers on the thermal conductivity of liquid helium in a superfluid state. He came up with a demonstration experiment, the so-called 'spider,' which, according to his idea, should clearly demonstrate the 'superfluidity' of helium. This 'spider' became the symbol of superfluidity, and later, in 2005, the Nobel Committee asked the IPP RAS to make a copy of the 'spider' for the Nobel Museum.

In 1941, L.D. Landau published his first paper [20] on the theory of superfluidity. To explain the phenomenon of superfluidity, Landau was the first in the world to use macroscopic parameters in the equations of quantum physics, such as the density of a matter and the viscosity of a matter. As a result, a new discipline in quantum physics appeared — quantum macrophysics — and liquid helium in a

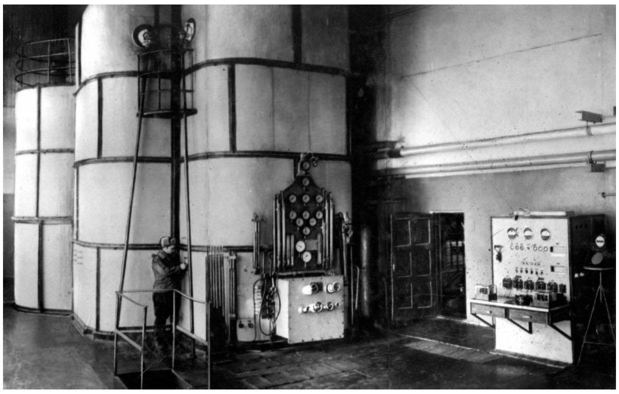
L.D. Landau (right) and E.M. Lifshitz, IPP archive.

superfluid state came to be referred to as a quantum liquid. In this study, Landau first proposed a two-liquid model of helium. In the same paper, Landau made preliminary calculations for the case of superconductivity, proposing a similar model of two types of electrons: 'normal' and 'superconducting.' The scientific world gained hope to solve the phenomenon of superconductivity. For this work, Landau received the 1962 Nobel Prize in physics.

As for the organization of scientific work at the institute, in March 1941, Kapitza issued an order on attendance at work without registering the arrival or departure time for three employees: Shal'nikov, Landau, and Lifshitz. Later, this rule was extended to all scientific staff members and remains in force to this day.

4. Wartime (1941–1945)

Literally immediately after the onset of the war on the eastern front, in July 1941, an order was received to evacuate the institute to Kazan. Kapitza and a small group of cryogenic engineers remained in Moscow. The country needed pure oxygen, and Kapitza actively engaged in the development of an industrial installation for oxygen production. In 1941, a start was made on the design and manufacture of two TK-200 installations with a performance of 200 kg of liquid oxygen per hour. The installation was made at the first autogenous factory in Moscow and was assembled on the territory of the IPP. In April 1943, the TK-200 was accepted by the government commission. And a little later, a large group of IPP staff members received government awards for this work. To coordinate work on providing the country with oxygen, an interdepartmental committee 'Glavkislorod' was set up, with P.L. Kapitza appointed as its head. In the summer of 1943, the institute returned to Moscow. Work began on the design and manufacture of a more powerful oxygen unit, the TK-2000 (oxygen performance: 2000 kg/hour). The unit was assembled and launched in Balashikha in February 1945. For the work performed, the institute was awarded the Order of the Red



TK-2000 oxygen plant, 1945, IPP archive.

Banner of Labor, and Kapitza was awarded the title of Hero of Socialist Labor. Another 28 employees of the institute also received awards for this work [21].

In addition to work on oxygen, the institute's staff members carried out other work related to the country's defense. The institute's archive contains a letter of thanks from the headquarters of long-range aviation for work on studying the operating principle of the German MV-1000 magnetic bomb. To safely study the fuse operation, the entire structure was cooled with liquid nitrogen. Work was performed on separating a mixture of toluene and benzene (N.A. Brilliantov and V.P. Peshkov), and work was carried out on introducing new domestic bacterial filters into industry (P.G. Strelkov and N.E. Alekseevskii). Other work on consulting and assisting industry was also carried out.

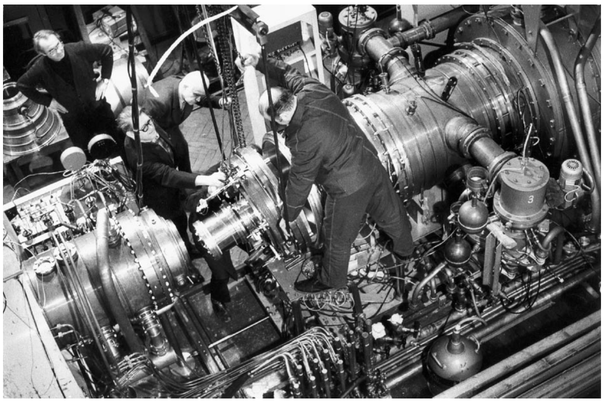
In November 1942, a theoretical department was set up as part of the institute, and L.D. Landau was appointed head of the theoretical department. During the war, the theoretical department conducted work on combustion hydrodynamics (Landau), continued work on developing the theory of superfluidity (Landau), and prepared the book *Continuum Mechanics* for publication (Landau, Lifshitz). Ya. Smorodinskii engaged in the theory of proton collisions with protons and light nuclei.

In addition to scientific work, the institute also had to deal with economic matters: its archive contains information about its vegetable garden and the expected vegetable harvest in 1942.

5. Post-war period: atomic project, A.P. Aleksandrov

In 1945, the country's leadership realized the necessity of implementing work to make an atomic bomb. To execute this task, the Special Committee consisting of nine members was set up in August 1945. Member of the government L.P. Beria was appointed head of the Special Committee, and two scientists were included in the committee: I.V. Kurchatov and P.L. Kapitza. Kurchatov was responsible for making the bomb itself, and Kapitza was assigned work on related issues (including isotope separation).

Kapitza refused this work and stated the reasons for his refusal in a letter to Chair of Government Stalin. Kapitza believed that it was wrong to repeat the American way of making an atomic bomb, and there were also complaints about the head of the project Beria, who was considered incompetent in physics and had a poor communication style with subordinates. The conflict between Kapitza and Beria



Installation of the plasma setup in the Physics Laboratory, 1984. Photo by V. Gende-Roth, IPP archive.

has been described in detail elsewhere [1]. As a result of the conflict, the country's leadership decided to remove Kapitza from all work. On August 17, 1946, Chair of Government Stalin signed a resolution to remove Kapitza from the post of director of the IPP, and it was decided to appoint A.P. Aleksandrov as the director of the institute. In his memoirs, Anatolii Petrovich wrote that he really did not want to occupy this position and made an attempt to influence this decision in a peculiar way. When he learned about his appointment to the post of director of the IPP and was summoned to Beria, he decided to play a scene in front of L.P. Beria, pretending to be a drunkard. So, on the way to Beria, Anatolii Petrovich stopped in a store, bought some vodka, poured some on his clothes, drank some, as he wrote, for courage, and in such a 'fragrant' form stepped into Beria's office. Beria's first words were "we know everything about how you poured vodka on yourself," adding that these tricks do not work, and handed Aleksandrov a decree appointing him director of the Institute for Physical Problems of the USSR Academy of Sciences.

After being appointed director of the IPP, A.P. Aleksandrov carried out the necessary changes at the institute to organize work on the atomic project. By Aleksandrov's order of August 30, 1946, four laboratories were set up at the institute: the Laboratory of Low-Temperature Physics (headed by A.I. Shal'nikov), the Laboratory of Molecular Physics (headed by A.P. Aleksandrov), the Laboratory of New Measurement Techniques (headed by P.G. Strelkov), and the Laboratory of Technical Applications (headed by M.P. Malkov).

The legal inconsistency was that at that time Kapitza was still formally the director. The Presidium of the USSR Academy of Sciences had the privilege of appointing and dismissing directors of academic institutes. In order to implement the government decree, the Presidium of the USSR Academy of Sciences quickly organized a commission to review P.L. Kapitza's activities in the field of oxygen. They concluded that he had done poor work in creating oxygen installations, and only on September 20, 1946 did the Presidium of the USSR Academy of Sciences issue a decree to remove Kapitza from the post of director of the Institute for Physical Problems of the USSR Academy of Sciences for his poor work in making oxygen installations and to appoint Aleksandrov to the said post. At the same time, Kapitza was dismissed from the institute without explanation (a handwritten note was added to the decree of the Presidium of the

USSR Academy of Sciences on the dismissal: "do not indicate the reason for dismissal") [22].

Aleksandrov tried to preserve the scientific topics of the institute, but some of the work was performed within the framework of the atomic project. For example, in the order of the Council of Ministers No. 19332rs of 01.12.1949 ([23, see p. 609]), it was directly stated: "In order to clarify the possibility of using amethyl in the alpha phase... to require the performance of scientific research and experimental production work... at the Institute for Physical Problems of the USSR Academy of Sciences...." The phrase seems somewhat mysterious: a code was used, and amethyl meant plutonium-239.

After the successful test of the atomic bomb on August 29, 1949, by the Resolution of the Council of Ministers of the USSR No. 5070-1944ss/op of October 29, 1949 ([23, see p. 530]), a large group of project participants were rewarded. Among them was A.I. Shal'nikov, "who developed and implemented the technology of anti-corrosion coating of plutonium." Among those receiving an award was L.D. Landau, for developing the theory of simulating the efficiency of an atomic bomb. In 1953, Shal'nikov received the Stalin Prize for developing methods for extracting and processing tritium after testing the RDS-6 thermonuclear bomb.

In total, Landau received three Stalin Prizes for his work on the project (in 1946, 1949, and 1953), and in 1954 he was awarded the title Hero of Socialist Labor [24]. It is necessary to note the paradox of the Stalinist system. It is well known [23] that the lists for awards prepared by Beria were personally checked by Stalin. L.D. Landau was a special person for Stalin: it is unlikely that he forgot his youth [25] and certainly remembered that Landau was arrested in 1938 and was still under investigation, but, despite this, he nominated the defendant Landau for high awards (the investigation into Landau's case was closed only in 1990).

A.P. Aleksandrov [26] did not visit the institute often: he spent a lot of time at the facilities, and in 1948 he was appointed part-time deputy head of Laboratory 2 (now the Kurchatov Institute). He delegated many matters at the institute to Shal'nikov, who effectively became the scientific director of the IPP in those years.

In addition to work on the atomic project, the institute continued, whenever possible, to work on traditional topics, such as superfluidity and superconductivity. The penetration of a magnetic field into a superconductor and the intermediate state of superconductors were intensively studied, the theory of superfluidity continued to be developed, and work began on the use of the helium-3 isotope at low temperatures.

In 1950, L.D. Landau and V.L. Ginzburg published their phenomenological theory of superconductivity [27], which later came to be known as the Ginzburg–Landau theory [28]. In this theory, the authors, without touching on the nature of superconductivity (it was not yet known), described the properties of superconductors based on the theory of second-order phase transitions and Landau's theory of superfluidity. At first, the world community did not pay much attention to this work, but since the late 1950s it has become popular in the scientific world [29], since it provided a good description of many unusual superconductor properties.

As for P.L. Kapitza, he had no formal relation to the institute during this period, was evicted from the institute cottage, and lived in a dacha on Nikolina Gora, trying not to go beyond the dacha plot. However, Aleksandrov, with the help of the President of the USSR Academy of Sciences S.I. Vavilov, managed to organize Kapitza's work at the dacha, formalizing it as work "according to an individual plan." Financing for Kapitza's work at the dacha was also provided directly from the USSR Academy of Sciences. A staff member of the institute, S.I. Filimonov, was seconded to the dacha to help Kapitza, and some equipment was supplied. In fact, a laboratory was equipped at the dacha, which Kapitza also called the IPP — "the (Individual) hut for Physical Problems." Kapitza's main topics were high-frequency oscillations, high-voltage discharges, and the nature of ball lightning [30]. In particular, he developed a powerful (over 100 kW) high-efficiency cw electromagnetic oscillator at a wavelength of 20 cm called 'nigotron' (named after the place of invention: Nikolina Gora).

In 1951, the name of the institute was changed: according to the Resolution of the Council of Ministers of 25.01.1951 No. 224 "On perpetuating the memory of the President of the USSR Academy of Sciences, Academician S.I. Vavilov," added to the name of the IPP was "named after S.I. Vavilov." S.I. Vavilov was the president of the USSR Academy of Sciences and a worthy scientist, but he had nothing to do with the IPP. One can only assume that this was a small act of revenge on Beria.

Changes in the life of the country and the institute began to occur after the change of the country's leadership in 1953. As is well known, Beria was arrested in July 1953. Almost immediately after these events, the laboratory at Kapitza's dacha received the official status of "Physical Laboratory of the USSR Academy of Sciences," and on August 28, 1953, Kapitza was appointed its head. A little later, in September 1953, Kapitza was accepted back onto the staff of the IPP.

6. Kapitza's return, Institute for Physical Problems, and Physical Laboratory

In January 1955, the Presidium of the USSR Academy of Sciences issued a decree appointing P.L. Kapitza as director of the IPP of the USSR Academy of Sciences. A little later, in 1958, the USSR Academy of Sciences issued a decree canceling the 1946 decree as incorrectly assessing Kapitza's activities as director of the IPP. So, Kapitza was completely rehabilitated. He did not return to the institute alone, but together with the Physical Laboratory. An unusual situation arose: at one site, with one address, two independent scientific organizations appeared: the IPP of the USSR Academy of Sciences and the Physical Laboratory of the USSR Academy of Sciences; they had a common director, accounting, workshops, supply department, and other services, but each of them had its own academic council and its own theoretical department, and each held its own seminars.

One of the small laboratory buildings, which currently houses the Kapitza Museum, was rebuilt for Kapitza to live in. And the cottage house, where Kapitza's family had previously lived and then Aleksandrov and his family, was turned into a laboratory and a place for student practical training.

With Kapitza's return, life at the institute began to return to the way it had been before his departure. The procedure of signing purchase orders, admission to postgraduate school, and other rules introduced by Kapitza became as they had been before. A physics seminar was held again, to which anyone could come, and speakers could come from different institutes; the seminar itself was called 'kapichnik' [31].

A.F. Andreev and V.-A.S. Borovik-Romanov, 1995, IPP archive.

Teaching activities would also continue. The IPP became a basic department of the MIPT in the specialty 'low-temperature physics and engineering,' and P.L. Kapitza became its chair, and, until his last days, personally attended the defense of diplomas by students of his department.

The institute also began to have a cultural life: Kapitza loved painting, with the result that exhibitions of artists' works would be held periodically. Such exhibitions caused some nervousness among ideologists at the level of district committee secretaries. Kapitza made attempts to calm the party secretaries, but this was not always successful. Artists of various genres were also invited to perform, and movie screenings were organized.

After Kapitza's return, work on the atomic project was cancelled, work on low-temperature topics was actively resumed, and work on plasma and ultra-high frequencies continued in the Physical Laboratory. A new generation of research staff came to the institute, carefully selected by P.L. Kapitza himself. They comprised the experimenters Borovik-Romanov A.S., Keshishev K.O., Zavaritskii N.V., Parshin A.Ya., Prozorova L.A., Khaikin M.S., Sharvin Yu.V., and Edelman V.S., the theorists Abrikosov A.A., Andreev A.F., Kaganov M.I., and Fomin I.A., and others. Together with the older generation (Shal'nikov, Alekseevskii, Landau, Lifshitz, Khalatnikov, Migdal, and others), a great deal of beautiful and interesting work was done.

Theoretical work on superconductivity continued. Landau suggested to his young colleague A.A. Abrikosov study the behavior of superconductors in a magnetic field. Abrikosov, using the Ginzburg–Landau theory of superconductivity, predicted that a magnetic field should penetrate type II superconductors with the formation of a vortex structure, which was called the 'Abrikosov lattice' [32]. For this work, Abrikosov would receive the Nobel Prize almost 40 years later. More recently, the existence of the Abrikosov lattice was confirmed experimentally. Landau's student A.F. Andreev would theoretically predict an unusual reflection of electrons from a superconducting boundary [33], and this phenomenon would be called the 'Andreev reflection' worldwide, which would also be confirmed experimentally.

L.D. Landau would receive the 1962 Nobel Prize for his work on superfluidity; unfortunately, after a car accident, he would not be able to return to work. This was the only case in the practice of the Nobel Committee when the prize was not awarded in Stockholm: Landau received the prize in a hospital in Moscow. Later, in 1978, P.L. Kapitza would receive the Nobel Prize for his work on the superfluidity of helium performed in 1938.

In 1964, some of the theorists moved to work at the newly established institute, which was called the Institute of Theoretical Physics. At the same time, some of the theorists continued to work with Kapitza (Landau, the Lifshitz brothers, Pitaevskii [34], et al.).

Among the applied areas that the institute worked on was cryosurgery. Shal'nikov developed instruments using liquid nitrogen for local freezing of subcortical structures of the brain located at a depth of up to 90 mm from the outer surface of the brain. For this work, he was awarded the USSR State Prize in 1985.

In the 1950s, in Shal'nikov's laboratory, a start was made on studying the properties of crystalline helium, and in the 1970s, A.F. Andreev and A.Ya. Parshin predicted the behavior of a helium crystal as a 'quantum crystal' by analogy with a quantum liquid. One of the properties of a quantum crystal was predicted — a new type of surface wave — crystallization waves [35], which were successfully observed in the experiments of K.O. Keshishev and A.Ya. Parshin. For this work, the institute's staff members received the 1986 Lenin Prize.

In the 1970s, work began on the design of an ultralow-temperature facility to obtain temperatures below 1 mK using adiabatic demagnetization. The work was carried out by Yu.M. Bun'kov and V.V. Dmitriev. In the 1980s, record low temperatures of 0.12 mK were achieved in the working chamber; this record has not been broken in our country to this day, and the facility itself can be considered the coldest point in Russia (there are only a few similar facilities in the world) [36].

7. Institute after 1984

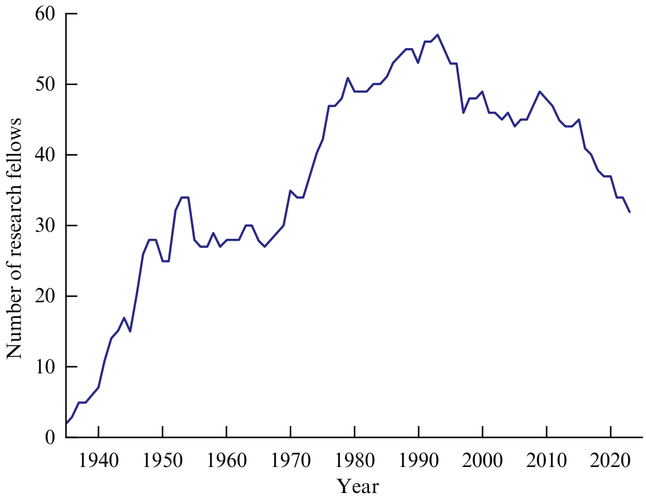
After the death of P.L. Kapitza in 1984, his deputy of many years, Academician V.-A.S. Borovik-Romanov, was appointed director of the institute, and A.F. Andreev was appointed deputy director.

Since it was difficult to continue work on high-temperature plasma in the Physical Laboratory without its leader Kapitza, this research was stopped. The Physical Laboratory ceased to exist as a separate organization within the USSR Academy of Sciences; it was merged with the Institute for Physical Problems. One of the most successful projects of the Physical Laboratory — work on the development and operation of the Microtron accelerator, headed by S.P. Kapitza — continued within the framework of the IPP of the USSR Academy of Sciences. This work enjoyed direct practical applications in three areas: X-ray flaw detection, treatment of tumors in medicine, and gamma-activation analysis of substances. The last was successfully carried out at the institute.

In 1985, in accordance with the resolution of the Presidium of the USSR Academy of Sciences, the P.L. Kapitza Museum was set up at the institute in the cottage house where P.L. Kapitza lived. More recently, in 1989, the Presidium of the USSR Academy of Sciences issued a resolution on perpetuating the names of P.L. Kapitza and S.I. Vavilov. As a result, the institute became known as the P.L. Kapitza Institute for Physical Problems, and the name of S.I. Vavilov was assigned to the State Optical Institute.

V.V. Dmitriev near his setup with record low temperatures (0.12 mK), 1994, photo by the author.

A.F. Andreev and S.P. Kapitza, 2010, photo by the author.



Number of research fellows by year.

The year 1991 saw changes in the country, and along with these changes, problems in science were emerging, which are well-known: a virtual lack of funding and the departure of many staff members to other areas or the departure of research staff to work in other countries. One of the management's tasks in those years was to preserve the institute and organize work under the new conditions. In 1990, Borovik-Romanov left the post of director and A.F. Andreev, an academician of the Russian Academy of Sciences (in 1991–2013, he was vice-president of the Russian Academy of Sciences), was appointed director.

A.F. Andreev managed to preserve the work of the institute. To do so, he changed the structure of the institute: scientific laboratories and the theoretical department were abolished. In fact, the institute became structurally the way P.L. Kapitza conceived it in 1935. Andreev preserved the scientific traditions laid down by Kapitza in the management of the institute.

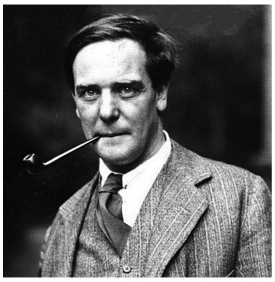
Due to the general trend of the Russian government to purchase all equipment abroad, the design bureau that existed at the institute, whose main task was the development of cryogenic equipment, had to be abolished. No funding was allocated for in-house developments. As a result, equipment that was traditionally manufactured in-house, such as dilution cryostats and transport Dewar vessels for helium, had to be purchased abroad.

Major changes in the organization of work of RAS institutes occurred as a result of the RAS reform in 2013. Funding for the institute in some areas was stopped, including funding for the museum and the MIPT Department. In those same years, officials introduced such requirements for postgraduate work that its presence in a small institute became impossible, although it had existed since the establishment of the institute. The MIPT began to pursue a policy of organizing alternative departments on its territory in Dolgoprudny, which led to an outflow of students from the basic departments. As a result, the basic department of the MIPT at the IPP RAS, which had existed for many years, actually ceased its activities, despite the fact that formally it still exists today.

In 2017, Academician V.V. Dmitriev became director of the IPP RAS. The new director continued the work and management style laid down by A.F. Andreev.

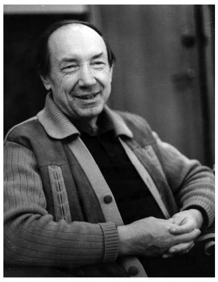
The institute continues work related to low-temperature research. It continues to pursue basic research (theory and experiment) [37–39], and there is applied work as well. The main areas of basic research are the study of the magnetic properties of new materials, new types of superconductors, and the properties of superfluid helium-3.

Recent years have seen the revival of developing cryogenic equipment at the institute; life has shown that not everything can always be bought abroad, as officials once believed. Among the institute's successful work in this area is the development of a portable autonomous cryostat with an operating temperature down to 0.1 K [40], which was



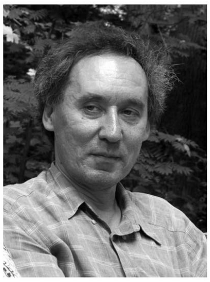
Kapitza
Peter Leonidovich
(1935–1946, 1955–1984)

Aleksandrov
Anatolii Petrovich
(1946–1955)

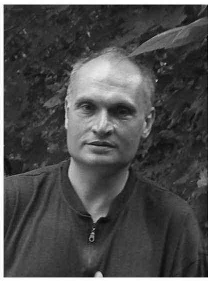


Borovik-Romanov
Viktor-Andrei Stanislavovich
(1984–1990)

Andreev
Aleksandr Fedorovich
(1990–2017)



Dmitriev
Vladimir Vladimirovich
(2017–2022)



Kleev
Andrei Igorevich
(since 2022)

Heads of IPP RAS with years when they headed institute given in parentheses.

designed to operate in concert with a large telescope for cooling high-sensitivity bolometers [41].

In addition to scientific work, the IPP RAS is a co-founder of three scientific journals: *Zh. Eksp. Teor. Fiz.* [42] (English version: *JETP*), the main physics journal of the RAS, *Pis'ma v Zh. Eksp. Teor. Fiz.*) [43] (*JETP Letters*), (and *Pribory i Tekhnika Eksperimenta* (*Instrum. Exp. Tech.*). Currently, the institute is a basic department (specialty: low-temperature physics) of the Faculty of Physics of the National Research University Higher School of Economics (HSE); students successfully complete their internships at the institute, and lectures are given on the specialty. HSE postgraduate students carry out their scientific work.

During the existence of the institute, the principles laid down by P.L. Kapitza in the organization of scientific work have proven their effectiveness. Over 90 years, prominent schools of science have formed at the institute: the schools of Kapitza and Landau, which are the foundation of the style of scientific work at the institute. Although the team of staff members is small (20–40 scientists, entire staff of about 100 people), it has been possible to organize scientific work in such a way that many interesting and key studies are performed both in the field of fundamental physics and in applied areas during the existence of the institute. The work of its staff members has been marked by state awards: several Lenin and State Prizes were received, and L.D. Landau and P.L. Kapitza were awarded the title of Heroes of Socialist Labor. The institute has also received international recognition: three works of the institute were awarded Nobel Prizes. We hope that the scientific staff of the institute, relying on the existing historical and scientific background, will continue productive work in the field of basic and applied physics along with the training of qualified young scientists.

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