Petr Leonidovich Kapitza (on this eightieth birthday)

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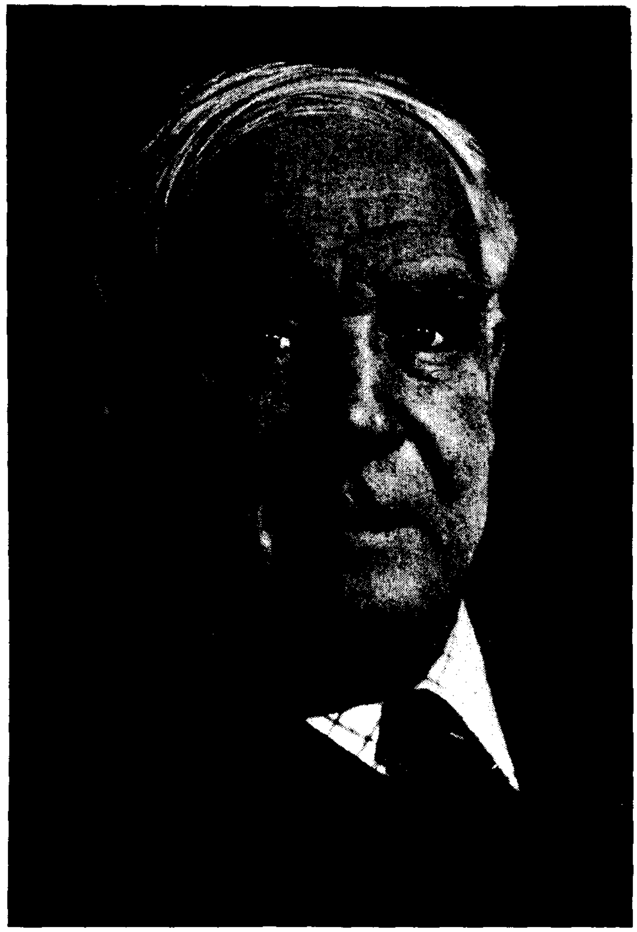
Petr Leonidovich Kapitza has celebrated his eightieth birthday. One of the foremost experimental physicists of our times, he made a substantial contribution to the development of the physics of magnetic phenomena, the physics and technique of low temperatures, the quantum physics of the condensed state, electronics, and plasma physics.

Kapitza began his scientific career in A. F. Ioffe's section of the Electromechanics Department of the Petrograd Polytechnic Institute, completing his studies in 1918. Here, jointly with N. N. Semenov, he proposed a method for determining the magnetic moment of the atom on the basis of the interaction of an atomic beam with an inhomogeneous magnetic field. This method was later used in the celebrated Stern-Gerlach experiments.

In 1921, Kapitza was dispatched to England to pursue his scientific studies; there he worked for a long time in the Cavendish Laboratory at Cambridge University, whose director at the time was E. Rutherford. In 1923, Kapitza conducted the first experiment in which a Wilson chamber was placed in a strong magnetic field, and observed bending of alpha-particle trajectories. In the course of these investigations, he found it necessary to create ultrastrong magnetic fields. He proposed an original method for eliminating the basic difficulty in the way of creating such fields, which consisted in severe overheating of the field coils. To prevent overheating, Kapitza proposed that short-lived magnetic fields be set up by passing a very large current through the coil; the coil could not heat up during the short time involved. Testing various current sources, he settled on a special motor-generator design. In this generator, the energy necessary for production of the magnetic field was accumulated in the form of kinetic energy of the rotor. Using this setup, Kapitza succeeded in producing a 320-kilooersted magnetic field with a pulse duration of about 10 milliseconds. This pulsed-field principle is now widely used in many laboratories. As technology developed, it became possible to use capacitors as energy accumulators, but Kapitza's result is still the record for the production of magnetic energy in a coil. He also developed original methods for measurement of various physical parameters in pulsed fields.

One of the basic results of Kapitza's investigations of the changes that take place in the physical properties of matter in strong magnetic fields was his discovery of the linear dependence of resistivity on magnetic field for various metals placed in very strong magnetic fields. This law, which he discovered in 1928, was not explained theoretically until 30 years later, when the complex topological structure of Fermi surfaces in metals was observed.

Kapitza's later scientific activity was associated with the physics of low temperatures. Here again, he began with a critical analysis of the methods that existed at the time for production of low temperatures and developed a new and original apparatus for the liquefaction of helium. In it, he succeeded in eliminating the need for preliminary cooling of the helium with liquid hydrogen. Instead, the helium was cooled in his apparatus by performing



work in a special gas-driven expansion engine. One feature of this piston engine was that the gaseous helium itself provided lubrication. Practically all of the helium liquefiers that are now built embody the principle proposed by Kapitza. The Mond Laboratory of the British Royal Society was built at Cambridge specifically for research in strong magnetic fields and at low temperatures, and Kapitza was named its director.

In 1934, Kapitza returned to Moscow, where he organized the Institute of Physics Problems, at which he continued his research on strong magnetic fields and the physics and engineering of low temperatures.

In the field of low-temperature engineering, Kapitza developed a new method for liquefaction of air with a low-pressure cycle using a special high-efficiency expansion turbine. Kapitza's radial expansion turbine with its high, 80–85% efficiencies set the pace for the worldwide development of large modern installations for liquefaction of air to produce oxygen using low pressure only. In the Soviet Union, powerful air-separating units using low pressures and producing from 10 000 to 65 000 cubic meters of oxygen per hour are in operation or being built. The industrially developed Western countries produced about 53 billion cubic meters of oxygen in 1970 in low-pressure air-separator units, i.e., using

Kapitza-type expansion turbines. About half of the oxygen produced is used in ferrous and nonferrous metallurgy. In addition to its applications in metallurgy, oxygen is widely used in the chemical industry and in rocket technology.

Kapitza's work on ultrastrong fields and liquefiers is that of a rare combination of the major scientist and the engineer in a single individual. Kapitza was one of the first physicists to use large modern machines in the laboratory and at the same time to put the most recent achievements of physics directly into practice. This marked the beginning of a process that has now been fully developed and is a characteristic feature of the contemporary scientific-technical revolution.

In low-temperature physics, Kapitza began a series of highly elegant experiments to study the properties of liquid helium. A result of these experiments was his 1937 discovery of the superfluidity of helium. He showed that the viscosity of liquid helium flowing through narrow slits at temperatures below 2.19°K is but a fraction of the viscosity of even the lowest-viscosity liquid, that it is apparently simply zero; hence his designation of this state of helium as superfluid. In studying the anomalous properties of liquid helium, Kapitza performed a series of extraordinarily subtle and lucid experiments that demonstrated the quite extraordinary properties of liquid helium at temperatures below 2.19°K.

Kapitza's research on the properties of liquid helium is a shining example of the approach of the true experimental physicist to solution of a complex problem. Reading his papers, we derive an esthetic satisfaction from following him step by step through one new experiment after another to his fundamental discovery of the coexistence in helium of two fluids with totally different properties and the ability to move counter to one another.

In the course of these studies, he also established the following important fact: when heat is transferred from a solid to liquid helium, a temperature discontinuity whose magnitude increases sharply with decreasing temperature appears at the interface—the so-called Kapitza jump.

Late in the 1940's, Kapitza turned his attention to a totally new range of physical problems—those involved in the creation of powerful continuous microwave generators. He succeeded in solving the complex mathematical problem of electron motion in magnetron-type microwave generators. On the basis of these calculations, he built microwave generators of a new type—the planotron and nigotron. The nigotron develops a record power of 175 kW in continuous operation. In studying these powerful generators, Kapitza encountered an unexpected phenomenon—when a helium-filled flask was placed in the beam of electromagnetic waves emitted by the generator, a very bright discharge appeared in the helium and the walls of the quartz flask melted. This suggested to Kapitza that it might be possible to heat plasma to very high temperatures by the use of microwave electromagnetic oscillations. He attached a chamber in the form of a microwave resonator to a nigotron. Admitting various gases (helium, hydrogen, deuterium) into this chamber under pressures of 1—2 atm, Kapitza observed that a filamentary discharge appeared in the gas at the center of the chamber (where the microwave intensity was highest). Applying various plasma-diagnostics methods, Kapitza showed that the temperature of the plasma electrons in this discharge was about a million degrees. These studies, which Kapitza is still pressing vigorously, opened a new path to the solution of the thermonuclear reactor problem and enabled him to complete calculations for such a reactor.

Kapitza is more than a prominent scientist; he is also a major scientific organizer. As director of the Institute of Physics Problems, a member of the Presidium of the USSR Academy of Sciences, and the editor-in-chief of the country's leading physics journal, he devotes much effort to concrete scientific-organizational activity. As in his scientific work, he is also an innovator here, a foe of bureaucratic management methods and a seeker after the most progressive methods of organizing the administration of a mechanism as subtle as that found in a creative scientific workforce.

Kapitza has always given much attention to the training and selection of young people who are capable of creative scientific work. He was one of the promoters of the Moscow Physico-technical Institute (MFTI), and is the Chairman of the Coordination Council of this Institute. Kapitza himself invariably chairs the sessions of the State Examination Commission for MFTI students who have done their undergraduate work in the Institute of Physics Problems. He also receives every examination in application for admission to graduate work and prepares a set of problems for each examination.

In addition to being a major scientist and an outstanding organizer of science, Kapitza has been a prominent social activist. All aspects of the development of human society excite him. He was a member of the Soviet National Committee of the Pugwash movement of scientists for peace and disarmament and participates actively in this movement. He has often taken a stand on questions of the future development of human society, especially in connection with such pressing problems as disarmament, pollution of the environment, and the ecological crisis.

Kapitza is still full of vigor and creative plans. He works in his laboratory very day in spite of the heavy demands of his scientific-organizational and social affairs.

On his eightieth birthday, all of Kapitza's friends and colleagues join in wishing him, from the bottom of their hearts, new creative joys and successes in his many-faceted activity.

Translated by R. W. Bowers