Aleksandr Mikhaĭlovich Prokhorov (on his sixtieth birthday)

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Aleksandr Mikhaĭlovich Prokhorov, one of the Soviet Union's foremost physicists, celebrates his 60th birthday in July of this year.

Prokhorov is one of the founders of a new field of science, quantum electronics. He is credited with pioneering work in a number of divisions of radiophysics, solid state physics, and radio spectroscopy.

All of his activity is characterized first of all by an appreciation of what is new: by the ability to advance ideas and design pioneering projects in which profound fundamental research is combined with the development of new techniques. The ideas advanced are distinguished by succinct scientific formulation, and the results are analyzed in explicit physical terms. Every investigation leads either to a new physical result or to an actual working model of a new device.

Prokhorov was born on July 11, 1916 at Atherton, Australia, into the family of a revolutionary worker who had fled to Australia in 1911 from Siberian exile. Prokhorov's family returned to the Motherland in 1923.

In 1939, on his graduation with distinction from Leningrad University, Prokhorov began graduate work at the P. N. Lebedev Institute of Physics of the USSR Academy of Sciences under the supervision of V. V. Migulin. During the Second World War, Prokhorov fought in the active army, was twice wounded, and returned to the Academy of Sciences Physics Institute after sustaining his second wound in 1944.

Working under the guidance of S. M. Rytov, he then carried out a series of fundamental studies in the physics of oscillations, first among which we should note work on the theory of frequency stabilization for the vacuum-tube oscillator.

Next, at the suggestion of V. I. Veksler, Prokhorov did an interesting study of the electron emission in a synchrotron, and became the first to demonstrate experimentally that the synchrotron can be used as a source of coherent electromagnetic oscillations in the centimeter wavelength band. These studies were the subject of his doctorate dissertation. At the same time, as head of a group of junior staff members of the Oscillations Laboratory, Prokhorov began work in a new area of physics: radiospectroscopy. These projects enjoyed the steady interest and support of M. A. Leontovich, who was then head of the FIAN Oscillations Laboratory.

Using radiophysical methods that were new to spectroscopy, Prokhorov obtained important data on the structure of a number of organometallic molecules and drew attention to the importance of using spectral lines to stabilize microwave-generator frequencies. Investigation of fundamentally new coherent centimeter-band electromagnetic-radiation sources, problems of frequency stabilization, and problems of improving the sensitivity of radiospectroscopic instruments were all closely interrelated in all of Prokhorov's activity, which prepared the soil for the ideas of quantum electronics.

In 1953, Prokhorov and N. G. Basov formulated the basic premises of a theory of a molecular generator and amplifier, and in 1955 they proposed one of the basic methods of obtaining inverted states—the auxiliary-radiation (pump) method in multilevel systems. The auxiliary-radiation method turned out to be unusually productive in quantum electronics. Its use led to the development of a fundamentally new class of low-

noise radio-receiving devices, the paramagnetic-crystal masers, and eventually to the lasers. Prokhorov's development of quantum paramagnetic amplifiers was the outcome of his extensive exploration of the field of electron paramagnetic resonance, which not only served as the physical basis for development of efficient quantum amplifiers, but was also of great importance for solid-state physics (EPR spectra and relaxation processes in crystals).

Many scientific and design organizations were called upon to work on microwave quantum amplifiers, and they revolved around Prokhorov and the team of scientists that he headed. The outcome of this project was the development of a series of quantum paramagnetic amplifiers of extremely high sensitivity. These amplifiers have been used extensively in radio-receiving systems for space communications and radio-astronomical observing stations, and have made it possible for our country to acquire important scientific results in the exploration of outer space. For example, use of quantum paramagnetic amplifiers in the systems used to communicate with the Venera 9 and Venera 10 interplanetary spaceprobes (1975) contributed to the success of these unique space programs by providing high-information-content communications and delivering high-quality pictures of the surface of Venus.

The advance of maser technology toward shorter wavelengths ran into serious difficulties in the design of the resonators, without which the operation of self-oscillatory electromagnetic-energy generators would be inconceivable. Prokhorov's fundamental proposal that a new type of resonator be used—an open resonator in the form of two parallel reflecting surfaces with dimensions much greater than the wavelength of the radiation—was of basic importance for further development of quantum electronics. This was a very important step in the further penetration of quantum electronics into the optical band. The open resonator has now become an indispensable part of the optical-band laser.

Immediately following development of the fundamentals of quantum electronics and a family of masers, a significant part of Prokhorov's research was brought to bear on the development of efficient lasers of various types with various applications (crystal and glass lasers, high-output gas lasers, lasers for thermonuclear research, technology, medicine, etc.,) and on their extensive use in physical research and practical applications. The study in which Prokhorov first showed that quantum generators and amplifiers have a maximum active-element length that limits the increase in radiated power with increasing length was of great importance. This conclusion proved to be highly important in the development of high-power laser systems.

In 1966, Prokhorov proposed and then built a new type of high-power gas laser—the gasdynamic laser, which is distinctive in that it converts thermal energy directly into coherent electromagnetic radiation. High radiated powers are obtained from lasers of this type by a single utilization of considerable masses of active medium.

In the mid-1960s, work on the high-temperature laser plasma was begun under Prokhorov's supervision, leading to the development of a new trend: laser thermonuclear fusion. It is in large part thanks to his efforts that research in this area was conducted on a broad scale at several of the country's scientific-research institutes, while the laboratory that he directed collaborated with various industrial organizations on the development of one of the most powerful neodymium-glass pulsed lasers, which was intended for use in controlled thermonuclear fusion research.

The development of both solid and gas high-power lasers required broad physical research on the interaction of their radiation with optical materials, including active crystals, glasses, and metallic mirrors. Here, calling upon many academic and industrial establishments, Prokhorov scored significant successes in the discovery of new physical phenomena, the development of a theory of this interaction, and the creation of efficient production technologies for radiation-stable materials and elements.

The extensive research on the effects of powerful laser radiation on gaseous, solid and liquid targets that has been done in recent years under Prokhorov's supervision has led to the discovery of a whole series of new physical effects. Among them, we should note first of all the discovery of the multifocus structure of wave pencils propagating in nonlinear media and nonthermal resonant excitation of molecules by infrared radiation, which causes them to dissociate (this effect can be used to initiate chemical reactions with lasers and in isotope separation). A number of effects that arise on the interaction of strong laser radiation with solid and liquid media were predicted and later observed (laser generation of ultrasound in an absorbing medium, "slow burning" of plasma near the target, etc.).

In addition to the work having a direct bearing on quantum electronics, Prokhorov always devoted a great deal of attention to the organization of new research in various fields of physics. Thus, back in 1960, he initiated the development of our country's first special-purpose installation for the production of ultrastrong constant magnetic fields. Its startup formed the basis for organization of the FIAN's magnetic research center, whose wealth of possibilities is being used to advantage by many organizations. A number of fundamental studies have been carried out on this installation, an example of which is determination of the band structure of tellurium.

Also pioneering was the work that Prokhorov directed with the object of mastering the submillimeter wavelength band. Development of new quasioptical-measurement techniques made it possible to build special apparatus superior to the best foreign spectrometers operating in this wavelength band.

Special note should be taken of the development of a new scientific-engineering trend in our country—integrated optics and fiber-lightguide optical communications—which was also undertaken under Prokhorov's direction. This trend promises a revolution in com-

munications techniques and in the processing of large blocks of information. In an extremely short span of time, Prokhorov succeeded in coordinating the efforts of several institutes and developing low-loss fiber lightguides.

Having devoted a great deal of attention in recent years to the development of research in solid-state physics, Prokhorov attaches particular importance to the developement of new high-quality materials of importance not only for physical research, but also for technology. Thus, our country has developed a new trend in materials technology under Prokhorov's direction: the creation of pure high-temperature single crystals, glasses, and ceramics, which are exceptionally important in power engineering for the design of efficient MHD generators, in metallurgy, in optical communications, and in quantum electronics. A technology developed in the academic institutes for such materials has been turned over to industry.

As a subtle experimental physicist, Prokhorov has always given much attention to the development of the experimental base, and in recent years in particular to the large-scale introduction of automation and computer facilities into the physical experiment and into production practice. Prokhorov attaches much importance to the training of scientific cadres. He is skillful in the selection of talented young people and their training and can be a demanding and at the same time unusually understanding taskmaster, fostering a creative and comradely atmosphere in the team. It is difficult to overestimate the contribution that Prokhorov has made to the development of the FIAN, of which he is a director. His ideas, methods, and creative assistance have, in a word, influenced the work of all of the institute's laboratories.

The service rendered by Prokhorov in organizing research and coordinating scientific-research progress in the physical sciences are generally recognized nationwide. As scientific director of work on various complex problems, Prokhorov has successfully directed the efforts of Academy of Sciences scientific research teams in industry in the implementation of projects of great national-economic importance. Thanks to his talents as an investigator and organizer, the research trends that he has headed in the USSR are in the vanguard of world science. In his position as Academician-Secretary of the Division of General Physics and Astronomy of the USSR Academy of Sciences, Prokhorov has shown skill in organizing teams of scientists and highly qualified specialists, both for the solution of specific pivotal problems that are of high priority at the moment and for the development of basic research as a whole. He gives a great deal of attention to the development of science in the Union Republics, enjoying exceptionally high authority in the Republic Academies.

Academician A. M. Prokhorov is a scientist with extremely broad scientific horizons, whose interest and knowledge go far beyond the limits of the field of science with which he is directly concerned. It is this quality that has made him successful in directing the work of the "Great Soviet Encylopedia," of which he is Editor-in-Chief.

A. M. Prokhorov, outstanding Soviet Scientist and Communist, has won distinction for his high-minded social activity, citizenship, and patriotism. He was elected a Corresponding Member of the USSR Academy of Sciences in 1960 and a full member in 1966. He was elected to the Presidium in 1971 and in 1973 was made Academician-Secretary of the Division of General Physics and Astronomy of the USSR Academy of Sciences. Prokhorov's election to the Academy of Sciences and Arts in Boston, the Hungarian Academy of Sciences, and the Hungarian Physical Society and his honorary doctorate degrees from the Universities of New Delhi and Bucharest attest to his high personal authority as a scientist.

The title of Hero of Socialist Labor has been conferred upon Aleksandrov Mikhaĭlovich Prokhorov for his outstanding service to Soviet science. He has been awarded three Orders of Lenin and the Order of Peace and Friendship of the Hungarian People's Republic. He is also a Lenin and Nobel Prize Laureate.

Everyone who is personally acquainted with Prokhorov recognizes his exceptional vigor and dedication to his work, the sharpness of his mind, his sense of humor, and his great humanity. Taking note of his sixtieth anniversary of his birth, we wish him preservation of these qualities for many years to come.

Translated by R. W. Bowers