Sixtieth anniversary of Soviet physics

The editors
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THE SIXTIETH ANNIVERSARY OF SOVIET PHYSICS

In commemoration of the sixtieth anniversary of the Great October Socialist Revolution, Soviet physicists have been looking back at their progress with some satisfaction. From its early years the Soviet state took energetic steps to develop the fundamental branches of physics and the results achieved were of major importance for applied research. This made possible the successful development of new industrial sectors such as radio engineering, aviation and optics. At that time the State Optics Institute was established and under its direct management our optics industry was created, which was of enormous significance for the development of instrument engineering, vital to science, culture and our national defense. At that time the Leningrad Physiotechnical Institute was founded which played an important part in developing Soviet physics and training scientists.

The Soviet state's concern for fundamental sciences led to the establishment of first class scientific schools for theoretical and experimental physics. And during the post-war years we were soon able to solve the problem of atomic weapons, which were so vital to the country in view of the cold war and the Western countries' monopoly of the atom bomb. It is important to note that from the very beginning of nuclear research great efforts were expended on developing the peaceful uses of nuclear energy: the first nuclear power station was put into operation in the Soviet Union, as was the first nuclear ice-breaker.

The high standards attained by Soviet physics in subsequent years were reflected in successes in outer space exploration, the launching of artificial satellites, space ships and so forth. At present, achievements in the physical and mathematical sciences are manifold and influence many aspects of Soviet life. The generous assistance given by the Party and the state to all these fields, the new large-scale approach in organizing scientific research and implementing results, as well as the enthusiasm of scientific and technical workers have enabled problems to be resolved quickly.

To celebrate the fiftieth anniversary of the Soviet state in 1967 this journal published a lengthy article in the October issue by our chief editor, Prof. É. V. Shpol'skiĭ, and entitled *Fifty years of Soviet physics*. It gave an extensive survey of the work of Soviet scientists in all major fields of physics. The last ten years have seen new and important successes.

For science ten years is a significant period of time during which basic changes occur: new trends appear and the nature of scientific problems changes depending on how each problem is resolved. To celebrate the sixtieth anniversary of our state the editors of *Uspekhi Fizicheskikh Nauk* (*Soviet Physics-Uspekhi*) would like to summarize the successes of Soviet physicists over the last ten years. These achievements are constantly being reflected in surveys published by this journal. This article therefore is to a large extent based on material published in *Uspekhi Fizicheskikhi Nauk* (*Soviet Physics-Uspekhi*).

Twenty years ago the Soviet Union launched the first artificial earth satellite. That event was the beginning of space research, to which Soviet science has made a signal contribution. The most striking fundamental research in the Soviet space program was the study of the planet Venus, made possible by the "Venera" (Venus) satellite series. The program provided practically all the information we possess about the planet: surface temperature, atmospheric pressure, composition of the atmosphere, luminosity in the lower part of the cloud layer and the atmosphere below the clouds, as well as the profile of the horizontal wind velocity up to a height of 50 kilometers.

A successful program was initiated in the Soviet Union for carrying out radioactive experiments in near outer space. The program includes creating artificial plasma clouds, exciting cosmic-plasma instabilities and creating artificial auroras with electron beams. The program is also concerned with the strong effect on certain elements in the upper atmosphere accompanied by a temporal change of its electric parameters. Important research has taken place into nonlinear phenomena which occur during the action of high-power radio waves on the ionosphere. Task-oriented research on the earth's magnetosphere is being conducted in the Soviet Union.

All these programs provide rich scientific information which is the basis for the ideas we form about the closest regions of space.

The launching of artificial satellites provided further opportunities to develop other scientific and technical fields. It led to the creation of extraterrestrial astronomy (gamma-ray, x-ray, ultraviolet, infrared, submillimeter and radio-frequency astronomy).

New research methods led to the rapid development of astrophysics. Thus satellites of the 'Cosmos' and 'Intercosmos' series conducted research into the size, structure and position of x-ray flares on the sun. The x rays from the flares were found to be polarized, indicating the dominant role played in the flare mechanism by directional beams of accelerated electrons. It was established that the x rays in the "quiescent" sun's corona are of thermal origin. By using orbiting stations, information was received on the influence of solar activity on the interplanetary magnetic field.

Artificial satellites are being used more and more in the economy. In recent years a series of meterological satellites has been launched in the Soviet Union. Tele-

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communications satellites have been greatly improved. The 'Salyut' spaceships have developed a multiband photography method, whereby pictures are taken simultaneously in different parts of the spectrum. The method enables us to gain much information about the state of the earth's surface and processes taking place there.

Space research has opened up unique opportunities for science and the economy. It has raised a number of important problems of physics in the fields of optics, radiophysics and geophysics, whose solution provides new basic information about the earth and the earth's atmosphere. The various applications of satellites depend upon precision methods and modern scientific apparatus. In the Soviet Union serious attention is given to space research.

The achievements of modern astrophysics result both from the methods used in extraterrestrial astronomy as well as from unique measuring instruments which meet modern technical requirements. Of particular importance here are the six-meter BTA telescope which recently began operating in the foothills of the Caucasus and the RATAN-600 radiotelescope which in a short period of time provided interesting information on relict-radiation fluctuations.

Relativistic astrophysics has been much developed in the Soviet Union. We have examined the physical aspects of superdense matter formation, neutron stars and so-called 'black holes.' We also predicted the x-rays produced when gas is compressed in the gravitational field of the superdense matter. As observation data reach us about x-rays in binary stars, a theoretical picture is formed, confirmed by the observations, of optic variability within such a system, and we thus learn more about the mass and the nature of superdense matter.

Soviet scientists have made a major contribution to the development of cosmology. A detailed theory of the relict radiation spectrum has been worked out, a theory of the formation of galaxies during the evolution of the hot (big bang) universe is in preparation and theoretical research has been conducted into phenomena in a superdense state of matter at the beginning of the modern stage of the expansion of the universe. The possibility in principle of the creation of small primordial black holes was noted, the quantum production of particles in a superdense state was studied, and detailed research was carried out into the evolution of normal stars. A special type of compact galaxy was discovered. The sun's fluctuations were studied and a new long-period type of fluctuation was discovered whose nature has not yet been clarified.

Over the past decade nuclear physics has been much developed in the Soviet Union; great efforts have been expended on studying the properties of atomic nuclei and the elementary particle interactions. Many unique installations have been put into operation, including first and foremost the Serpukhov proton accelerator, which until 1973 was the largest in the world with a proton energy of up to 76 GeV. In addition, isochronous cyclotrons, linear electron accelerators and reactors for studying nuclear reactions at low and medium energies were made operational. This enabled us to conduct successful experimental work over a wide range of energies. A number of new effects were observed in the behavior of atomic nuclei and in particle interaction, including the non-conservation of space parity in nuclear electromagnetic transition, the cluster structure of atomic nuclei, the identification of nuclei of antimatter (antihelium and antitritium), changes in the type of behavior of the total particle interaction cross sections in the range of energies of the Serpukhov accelerator (the "Serpukhov effect") and the clustering of secondary particles produced in inelastic processes. A new trend, relativistic nuclear physics, was put forward and developed.

Research with the Dubna unique IVR-1 pulsed reactor in 1968 produced ultracold neutrons, which had been previously predicted in theory, and this opened up a new trend in low-energy neutron physics. The theoretical and experimental principles of the producing ultracold neutrons were developed in the Soviet Union. Methods for scattering neutrons are widely used to study various structures.

Soviet and American scientists are the recognized leaders in developing methods to obtain and study the nuclei of super-heavy elements. Recently in the Soviet Union elements with atomic weights 105, 106 and 107 were synthesized and the chemical properties of elements from 102 to 105 were studied. The synthesis of new neutron-deficient isotopes pointed to a new regularity in the variation of the stability of heavy nuclei as a function of the number of protons and neutrons in the nucleus. A new class of nuclear reactions was discovered—deep-inelastic nucleon transfer—combining the properties of direct reactions and the decay of the excited compound nucleus. The theory of pion condensate in the nuclei has provided interesting predictions as to the possibility of a phase transition of the nuclei to a superdense state and of the possible existence of neutron nuclei. The microscopic theory of nuclei has been actively developed. With account taken of paired interaction between the nucleons as well as collective motions.

The inclusive approach idea has had a substantial influence on experiments to study particle interactions at high energies. Experiments with the Serpukhov accelerator established scale invariance of the cross sections of inclusive processes. A strong correlation was found to exist for secondary particles in inelastic hadron processes. The study of the elastic scattering of protons by protons revealed that the radius of strong interactions increases with energy. This had been proposed in theory. Much material has been gathered on reactions initiated by various initial hadrons and this made possible detailed comparisons with theoretical conclusions and *inter alia* to check the detailed predictions of the reggeon model. New data have been obtained on the formation and classification of heavy hadrons. A meson $h(2030)$ with a spin of 4, the highest among known mesons, was discovered. The existence was predicted of bound and resonant nuclear-like states for the nucleon and anti-nucleon.

Pioneering work on the observation of ρ-meson production in e^+e^- collisions has contributed greatly to our understanding of the physics of electromagnetic interactions of particles. The constants that characterize the electromagnetic properties of protons were measured—the coefficients of magnetic and electric polarizability. For the first time ever, total photo-absorption cross sections were measured at energies up to 40 GeV, a feat made possible through the creation of electron-photon beams in the Serpukhov proton accelerator. The creation in that accelerator of a neutrino beam combined with the spark spectrometer and one of the largest bubble chambers in the world (SKAT) was of equal importance for the physics of weak interactions.

Together with the study of neutrino interaction processes in accelerators, the development of neutrino astronomy has also been emphasized in the Soviet Union. The Academy of Sciences neutrino station which is under construction is the only multipurpose low-background laboratory in the world where the penetrating component (neutrinos, μ-mesons) of cosmic radiation will be studied, in particular the solar neutrinos. On the whole the main thrust of the nuclear-physics aspect of cosmic-ray physics now involves ultrahigh energies not yet attainable by the most powerful accelerator in the world. The results of experiments on artificial earth satellites, on mountains (in particular, the "Pamir" experiment) as well as research into extensive air showers have shown that scale invariance of some properties of hadron collisions is valid up to energies of 10^5 GeV. At higher energies of noticeable change takes place in the characteristics of the strong interaction.

Important results were obtained also on the cosmophysical aspect of cosmic rays. Many important results came from the study of the earth's outer radiation belt. The energy spectra of primary cosmic rays up to energies of 10^{19} eV were measured. Research into the eleven-year cycle of galactic cosmic rays led to the discovery of new facts concerning solar processes. The theory of the origin of cosmic rays, which is closely linked to radio and gamma astronomy, continues to be successfully developed.

Great progress has been made over the last ten years in our theoretical understanding of particle interactions at high energies, and the contribution here made by Soviet physicists has been very significant. In particular the pioneering work on the analysis of higher orders of perturbation theory in a weak interactions has greatly influenced the development of physics. Recently much work has been done on a traditional problem: the search for a unified field theory such as monopoles, instantons, and "bubbles." The recovery of spontaneously broken symmetry at high temperatures was predicted and the cosmological consequences of that prediction were pointed out. Supersymmetry theories were put forward and developed. Great progress was made in the quantization of the Yang-Mills fields and in our understanding of the far-from-trivial properties of these fields, which are the basis of so called asymptotic freedom.

Soviet physicists, virtually at the same time as a number of foreign physicists, put forward a useful idea about the 'color' of quarks, the basis of quantum chromodynamics, whereby several rules pertaining to weak and electromagnetic hadron interactions were explained. Great success has been seen in building formal apparatus for the quantum theory of gravitation and in study of non-local field theories. Composite hadron models have been further developed. Quark theories have been widely used to describe specific processes (quark counting rules, charmonium properties), models with a large number of quarks, etc. The quark-lepton analogy was used to develop the hypothesis of the two types of neutrino and the appearance of neutrino oscillations. The possibility has been studied of searching for mirror-odd neutral currents by using atomic spectroscopy methods. In the theory of strong interactions at high energies, the Regge scheme and the reggeon-diagram technique were evolved. A description of multiperipheral inelastic processes was given. Interest in thermodynamic-type models was renewed and ideas on the quark-parton particle structure were used. Soviet scientists analyzed the cosmological consequences of the hypothetical existence of free fractional-charge quarks, and important arguments were obtained in favor of the theory of the quark confinement. Cosmological arguments allowed conclusions to be drawn about the masses of muonic-neutrinos and of hypothetical new types of neutrinos.

The new methods of electron cooling and charge-exchange injection are very promising for accelerating high energy particles.

In the Soviet Union methods have been developed by which positrons and mesons may be used in chemical and biophysical problems and a new trend, 'meson chemistry,' has been created.

The use of nuclear energy sources and accelerator technology has been very important in nuclear research of the past decade, as well as nuclear physics methods in other fields of science and the national economy. Pioneering work has been conducted in the Soviet Union on the uses of synchrotron radiation in certain fields of biology and chemistry. Neutron activation analysis is now used more widely in biology, medicine, chemistry, applied geophysics and geochemistry, and in the metallurgical, oil and gas industries. The USSR has successfully developed a technique of using multiply charged ions to manufacture nuclear filters which have proved extremely effective in the chemical and electronic industries and in medicine. A set of methods has been developed and is being used whereby the structure of thin surface layers and impurity distribution in various materials can be determined by using orientation phenomena such as channelling and the shadow effect. Apparatus has been developed for the x-ray radiometric multi-element analysis of matter.

Particle and charged-ion accelerators are being used in the national economy as highly efficient flaw detectors. Bombardment with accelerated electrons enables the parameters of semiconductor devices, integrated circuits and capacitors to be stabilized. Methods used to sterilize medical preparations and instruments are based on this kind of bombardment. It is also used for radiation treatment of tissue, for activation analysis, and much more besides. Proton and pion beams are used to treat cancer patients. The economic gain from using acclerators in the economy amounts to several million rubles a year. Thus nuclear physics gives a good economic return for the money invested in it.

Soviet physics has been very successful in developing quantum electronics, which began in 1954 with the inauguration of the first microwave maser. By the late fifties the USSR had made microwave-band quantum paramagnetic amplifiers with intrinsic noise reduced to a record low, which could therefore receive extremely weak radio signals.

Particularly rapid progress in quantum electronics is attributable to the advent of lasers. Soviet physicists played a major role in developing semiconductor, gas-dynamic, electroionization, and excimer lasers, metal-vapor lasers, and photodissociation and chemical lasers. Coherent lasers with tunable frequency, namely parametric generators and dye lasers as well as injection semiconductor heterolasers have been developed in the Soviet Union.

Over the past ten years lasers have become more widely used as sources of monochromatic radiation which makes precision physical investigations possible. The use of lasers has led to great progress in optical spectroscopy, and in this field Soviet physicists have propounded and realized many new ideas. They have also made a great contribution to the development of non-linear optics. The Soviet Union has created effective frequency multipliers for the optical band; the effects of self-focussing and of the multifocus structure were discovered, as well as the phenomenon of inversion of the light wave front in induced scattering. IR receivers with upward frequency conversion were built.

One of the most recent trends in modern spectroscopy is laser spectroscopy. Soviet scientists have developed new methods for laser spectroscopy, viz., saturation spectroscopy, non-Doppler two-photon spectroscopy, and the separate-fields method. These methods provide maximum resolution in the measurement of radiation wave lengths. Progress in laser spectroscopy has led to the development of stable frequency lasers, which are the most stable radiation generators. The use of lasers as sources of high temperature plasma has fostered progress in x-ray spectroscopy and in multi-charged-ion spectroscopy. Lasers have made possible practical holography for obtaining three-dimensional color images, for developing memory systems, etc. Various methods of laser technology and laser medicine have been developed. In recent years Soviet scientists have found new ways of using laser radiation to stimulate chemical reactions (laser chemistry), for separating isotopes, and for obtaining ultrapure substances. Soviet physics has made great progress in applying lasers to metrology, meteorology, and optical communication. The appearance of lasers has led to new approaches in various scientific fields and laser physics has stimulated by the same token the development of other fields of science and physics.

Recent years have seen the rapid development of integrated optics. Glass fibers with unprecedentedly low losses have been created in the Soviet Union and structures have been discovered which make reversible recording of optical information possible. By using semiconductor lasers with electron excitation, a television image can be reproduced on a screen up to 10 m^2 in size.

Successful research has been conducted in the field of luminescence. In recent years luminors have been developed which transform infrared and microwave radiation into visible light, and on their basis the 'Radiovizor' instrument was developed.

Soviet scientists have made much progress in the field of statistical electrodynamics, especially research into the propagation of radiation in the atmosphere and in the ocean. This was prompted by practical problems in man's activities under water and in outer space, as well as by ecological studies. A general theory of coherent properties of radiation in fluctuating media was developed. An electrodynamic approach to the interpretation of photometric and radiation concepts, including the theory of radiative transfer, has provided a basis for developing the theory of the optical field in scattering media (including an experimental check on this theory).

Using this theory, the laws governing the ways in which the properties of a medium affect the optical-field structure were explained, as was image transfer in heterogeneous media. This made it possible to develop new methods of long-distance optical sounding of the atmosphere and ocean, including from outer space (e.g., for meterological purposes) and has made it possible to elucidate the properties of atmospheric air and natural waters as optical media and of their optical structure.

Research into solid state physics occupies a very important position in the Soviet Union. This field has seen much progress over the past decade, and Soviet scientists have made a major contribution to its development. An elegant effect predicted, discovered by Soviet physicists, is connected with the condensation of exitons into drops of metallic electron-hole liquid in semiconductors. At present physicists in many countries are engaged in research into this effect.

Theoretical research into the theory of phase transitions has been successful in the Soviet Union. The phenomenological similarity theory has been particularly useful, and established a correlation between temperature dependences of various quantities in the region of strong fluctuations. Soviet physicists established the fundamental fact that crystal anisotropy and long range forces exert a strong influence on the behavior of matter in the region of strong fluctuations. The theory of long polymer chains and of phase transitions in such a system has been developed in the Soviet Union.

Recent intensive research has been conducted in the Soviet Union into the states of solids at high and ultrahigh pressures (~1 megabar) both in static and dynamic (shock wave) conditions. The first progress in this direction is due to the indication that such substances as diamond, silica, hydrogen and others become metallic at high pressures.

Soviet scientists have developed a theory and conducted experiments into coherent phenomena occurring in interactions between solids and resonant γ radiation. A number of new effects connected with the polarization of nuclear spins in crystals when electrons are optically oriented have been discovered and studied.

As for the physics of metals, we have developed methods for studying cyclotron resonance on non-extremal orbits. This has made it possible to determine the Fermi surfaces of a large number of metals with a high degree of accuracy. Considerable success has been achieved in theoretical calculations of stable structures of simple metals and of their phonon spectra.

Of great importance is Soviet research into the properties of antiferromagnets and weak ferromagnets in external fields as well as research into nonlinear processes in antiferromagnets. A precision method of studying antiferromagnetic materials has been developed, based on birefringence.

Research into heterojunctions in semiconductors has been started and radiation accompanying plastic deformation of semiconductors was observed; the formation of a dielectric exitonic phase in molecular crystals was discovered, and others. Great progress has been achieved through the use of developments of solid-state physics in the economy. A wide range of semiconductors using heterojunctions has been created. Electron and nuclear paramagnetic resonance methods, first discovered in the Soviet Union, have gained wider use in modern devices.

For the first time ever Soviet physicists proved the possibility of obtaining p- and n-type semiconducting diamonds by the implanation method. This served as a basis for developing semiconductors with unique properties. By using natural diamond, the first spectrometric nuclear radiation detector in the world has been developed, and its use led to great gains in the national economy.

A leading school was established in our country devoted to the study of the superconducting and superfluid states of matter. Following a well-established tradition, the contribution of the Soviet school of superconductivity and superfluidity and the progress in these branches of physics were substantial in the last decade.

Thus, a theory was developed of the dynamic intermediate state of a superconductor, and this state was experimentally observed for the first time. The phenomenon of paraconduction—the growth of the conductance of a normal metal as a result of superconducting fluctuations as the superconducting transition is approached—was predicted and theoretically studied. A theory of quasi-one-dimensional superconductors has been developed and serves as an important step in the investigations of superconductivity at high temperature. Theoretical research on high-temperature conductivity is carried out on a broad front.

Interesting results were obtained in the investigation of the properties of He^3, one of the quantum crystals that are principally new objects in solid state physics. It was observed that He^3 is cooled on going from the liquid to the solid state. This effect allows temperatures down to 0.002 °K to be obtained. The superfluidity of He^3 was predicted and was subsequently observed by American scientists. Research into the thermal conductivity of solid helium has been very important in the Soviet Union. The continuation of this research in the USA led to the discovery of second sound in helium. Soviet physicists have developed the theory of the diffusion of impurities and vacancies in quantum crystals. This theory has been proved experimentally by investigations of He^3. The theory of the properties of He^3 near the λ point has been further developed.

Much research is being conducted into the properties of plasma in the Soviet Union. In particular, this is part of the research on controlled thermonuclear reactors. Soviet scientists have made a substantial contribution to the physics of collective phenomena and of plasma instability and turbulence. Their efforts helped to create modern hot-plasma physics.

The Soviet thermonuclear program of research proceeds successfully. 'Tokamak,' the most promising thermonuclear reactor system, was created in the Soviet Union. The T-10, one of the largest tokamaks, was built in the Soviet Union. The T-10 research program will be an important step towards resolving the thermonuclear problem.

In the past ten years, laser-driven thermonuclear fusion has been successfully developed. This is a new step towards achieving a controlled thermonuclear reaction using laser radiation. Soviet scientists are making a significant contribution to this research; they were the first to put forward the idea of laser-driven fusion and they did pioneering theoretical and experimental work to prove the viability of the new trend. A powerful laser installation with energy of 10^3 joules for spherical irradiation of thermonuclear targets was set up in the Soviet Union for the first time ever, and a technology for making these targets has been developed. In addition the first experiments on the laser compression of matter have been conducted and thermonuclear neutrons were obtained.

Another field came to light in our thermonuclear fusion program, namely the initiation of a thermonuclear reaction using relativistic electron beams. Great success was achieved in obtaining nuetrons as the result of a thermonuclear reaction induced by an electron beam.

The development of plasma physics has led to our understanding of several phenomena taking place in cosmic plasma. Over the past ten years the achievements of plasma physics have been used to construct a general picture of the activity of solar-plasma (protuberances, granules, solar wind, the earth's magnetosphere), of the formation of interstellar clouds, of the interaction between cosmic rays and plasma, etc. The theory of laboratory magnetic traps was used to establish a theory of the radiation belts. The concept collective phenomena in a plasma provided an explanation for the sun's radio waves and other sources of cosmic radio waves, particularly pulsars. Extension of the concept of collective interactions to include gravitating systems has led to new ideas about the dynamics of stellar systems and galaxies. Soviet scientists have greatly contributed to these branches of physics.

The description of plasma in the language of self-consistent fields and collective phenomena has been transferred to related fields of physics. The last decade saw the rapid development of solid state plasma physics. The work of Soviet scientists is highly important in this field, for they produced a picture of the wave properties of solid-state plasma in an external field.

The plasma approach is being successfully used in large-current electronics where there is a strong interaction between the charged-particle currents and their own electric and magnetic fields, and the plasma is used either to cancel the charge for slow-wave generation. This approach has helped create a fundamentally new technology. In recent years superpowered microwave generators (up to 1 GW per pulse) have been built in the Soviet Union using powerful electron beams. The physics of cyclotron-resonance masers has been developed and powerful electron accelerators and electron-beam sources have been created.

The development of fundamental plasma physics has had a favorable effect on applications of plasma physics. Plasma has found several uses in metal smelting and welding, and also as a source of radiation. Over the past decade magnetohydrodynamic energy conversion has been further developed. The most powerful open-type MHD generator in the world (20 MW) is in operation in the Soviet Union and explosive MHD generators have been developed and are being successfully used as pulsed electric-power sources. These generators deliver up to hundreds of megawatts of power and are used for geophysical research. Plasma chemistry has gained practical uses over the past ten years. Reliable plasma engines using a plasma stream for a jet have been developed. These engines develop a thrust of several grams and are used for space ships and for other technological purposes.

Modern plasma physics is a very highly ramified and fast developing branch of physics. It has produced ideas which have proved extremely useful for other related branches of physics. Soviet scientists occupy a leading place in many fields of modern plasma physics and their work is promoting the development of fundamental physics research in the field as well as many technological and applied uses.

The development of applied research, such as gas lasers or thermonuclear plasma, as well as research into the upper atmosphere and outer space, increased the need for more information about atomic-particle collisions and interactions. This has resulted in the rapid development of many branches of atomic physics, to which Soviet scientists have made a signal contribution. One new trend in the physics of atomic collisions was initiated by Soviet research and it relates to processes accompanying the crossing of the energy levels of the inner electron shells in collision between atoms and ions. Soviet scientists have made a great contribution to the atomic collision theory, to the theory of the elementary processes of atomic-particle collision, and to the theory of physical kinetics of weakly ionized plasma.

The farsighted policy of the Party and the Soviet state as well as the serious attention which they have always given to the basic sciences is the reason why Soviet physics enjoys a leading position in the world today. The high standard attained in physics is important for the other sciences for two main reasons. Firstly, the use of the methods and approaches of physics as an exact science in other related sciences has always helped to develop the latter. Secondly, the new instruments and a fundamentally new technology which has been created by physics open up new possibilities for the other sciences and stimulate their development.

In Soviet physics, joint research with scientists from the socialist countries as well as France, the USA and other capitalist countries has become a tradition. International scientific links allow resources and human efforts to be saved and also promote better understanding between scientists of various countries. International links with Soviet physics, which are increasing every year, are a striking demonstration of the peace-loving policy of the Soviet state.

The development of fundamental physics has had a decisive impact on the creation of progressive technology in the Soviet Union. Over the past decade the Party's specific line on the strategic use of science as a productive force has been clearly outlined. In the resolution adopted by the 25th Congress of the CPSU entitled "Main guidelines for the development of the economy of the USSR for 1976–1980" there is a special section called "The development of science." It is stated there that Soviet physics aims to "further promote research and open up fundamentally new ways and possibilities to transform the productive forces of the country and to create technologies for the future."

The physical sciences are called upon to "develop theoretical and experimental research in the fields of nuclear physics, plasma physics, solid-state physics, low-temperature physics, radiophysics and electronics, quantum electronics, mechanics, optics, and astronomy in order to speed up scientific and technological progress, especially thermonuclear energetics, and to perfect and develop new methods of energy transformation, to create and broadly apply fundamentally new techniques, new structural, magnetic, semiconducting, superconducting and other materials and technically valuable crystals."

At this new stage of scientific development the problem of the efficiency of scientists and scientific organization becomes highly important. All-inclusive planning and the practical application of scientific results in the economy become of paramount importance. Long-term comprehensive research programs on the most important scientific and technical and fundamental problems of modern physics are being developed. Effective ways of linking science to various fields in the economy are being found and put into practice on a large scale. The role played by the Academy of Sciences of the USSR is being enhanced as a center for theoretical research and a place where all scientific work throughout the country is coordinated.

Soviet science approaches the 60th anniversary of the Soviet state in the prime of its life. Its potential is huge. The program for its development is becoming more task-oriented. It is being organized to attain maximum effectiveness. Scientists have responded enthusiastically to the Party's appeals. There is no doubt that Soviet science, including physics, will attain new and greater heights and will fulfill the task allotted to it by history and the Party, namely to become a mighty weapon for transforming the productive forces of society in an age of mature socialism.

Translated by J. Mitchell