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THE DEVELOPMENT OF PHYSICS IN THE USSR IN FORTY YEARS OF SOVIET POWER

TODAY our country is celebrating the fortieth anniversary of the great October socialist revolution. We are drawing up accounts, not only of the achievements of industry and agriculture, but also of the general growth of culture, and in particular of science. The progress of Soviet physics is of decisive importance in any review of the level of scientific culture in our country. Of all experimental sciences, it is physics which discovers the laws of material behavior which underlie the development of other natural sciences and of modern technology. The level which has been reached in the development of physics is thus an objective measure of the general growth of science and technology in the country. Of all experimental sciences, modern physics demands the most complicated and expensive equipment. Nowadays only a strong country, with widely diversified industry and a high level of technology, can achieve a successful development of experimental physics.

Even to the non-specialist it is clear that here in the USSR, after forty years of Soviet power, physics has risen to an exceptionally high level. The study of atomic nuclei is generally regarded as one of the most advanced parts of physics. Thanks to a succession of fundamental discoveries in recent decades, this branch of physics is being intensively developed. It has become an indispensable foundation for the technical utilization of atomic energy, both for peaceful purposes and for national defense. Soviet technology, with remarkable speed and success, found original solutions to the problems of designing thermonuclear weapons and of exploiting atomic energy for peaceful purposes. This would have been impossible, if there had not existed in the Soviet Union a massive and vigorous research effort in modern physics.

Soviet science recently achieved a new and outstanding success, the launching of the first artificial earth satellites. In this achievement also, the high level of our physics played an essential part.

A wide variety of scientific and physical research is carried out in the Soviet Union in a large number of institutes spread over the whole country. Our achievements in the fields of theoretical physics, nuclear physics, low-temperature physics, optics, semiconductors, solid state, theory of combustion, etc. are well-known to readers of this journal from the published reports of the members of these institutes. The continuous growth of Soviet physics is not only reflected in the increasing size of this journal, which has grown by a factor of 3 — 4 in the last five years. The USSR Academy of Sciences is also continually forced by the shortage of space in this journal to start new journals devoted to specialized parts of physics, for example crystallography, optics, metallurgy, technical physics, acoustics, electronics, etc.

If one tries to compare the volume of scientific work in physics before the revolution, 40 years ago, with the volume existing now, it is hard even to find a meaningful standard of comparison. One must remember that all physics in pre-revolutionary times was concentrated in the laboratories of a few institutions of higher education. In the cost of their equipment, all these physics laboratories taken together were equal only to a small fraction of a modern accelerator, such as the Synchrophasotron built at the Joint Institute of Nuclear Studies at Dubno on the Volga. This remarkable machine was put into operation this year, and it accelerated elementary particles to the record energy of 10 billion volts.

Of course, the large-scale growth of physical research in recent decades has occurred not only in our socialist country but also in the more advanced capitalist countries such as the United States and England. Both in capitalist and socialist countries, we observe the same nature encompassing us and we find the same laws governing the behavior of physical processes. But the organization of the same scientific work under socialist and capitalist governments is essentially different, and the difference becomes more and more evident as the socialist economy develops. The difference arises from the fact that under a socialist government science is regarded as the foundation upon which the material and spiritual culture of a country is built. This attitude towards science has two consequences. First, the encouragement of scientific progress is one of the basic responsibilities of the government. Second, the various branches of science are not developed independently as in capitalist countries, but in accordance with the general growth of the material and spiritual culture of the country. Under a socialist government the development of science must be planned and financed out of government funds according to a unified plan. We must admit that it has not been easy in practice to find a form of organization in which science could develop not independently but according to a reasonable plan, and to find a rational method of governmental financing of scientific institutes which could preserve the creative approach of a scholar to his work. In spite of the excellent work of our physicists, we still have to continue striving for improved forms of organization for scientific work, so that our scientists can work as purposefully and as productively as possible.

When one compares the organization of scientific work under socialist and capitalist governments, the question always arises of the difficulty of reconciling the freedom necessary for effective creative work with a rigidly constituted plan. When the Academy of Sciences began to develop a planned organization of scientific work, there was an attempt to make the plan completely rigid and detailed, and this difficulty became a real one. But time and experience provided the remedy. The basic task of a plan is to point to those fields and programs of scientific development which are at a given moment most important to the country. Today the most effective method of ensuring the coherent development of science is to encourage those scientific endeavors which have a close relation to applied fields, to technology, to industry, to medicine, to agronomy and other studies concerned with the national economy, or to problems of basic importance for the whole of science. The more practical lines of research receive a greater share of attention, material support, and encouragement; the government gives official recognition to such work by the award of Stalin and Lenin prizes, etc. The state tries all the time to guide scientists into tackling either major problems of the national economy or problems of basic scientific importance. Scientists are confronted with broadly defined questions, for example, the production of extremely pure chemical elements or of high-quality heat-resistant steels, the understanding of physical processes in semiconductors, various problems of modern power technology connected with the transmission of energy over large distances, etc. These questions are usually complex, they can be divided into many independent parts belonging to various fields of science and technology, but it is still necessary to attack them in a unified way. Physicists often are allotted the most difficult questions of all. In order to answer such questions, a physicist must concentrate upon the study of some definite field of knowledge within which he himself must search for a concrete line of attack. He retains a wide freedom for personal and creative initiative. Several institutes often are attracted to the same question, each working along a direction of its own choice.

The USSR is still far from the end of the search for methods of organizing science as the foundation of a planned socialist economy. The form of organization, especially for the specialized branch institutes, is mainly determined by the administrative structure of industry. We have learned by experience that the structure of our economy changes continually. The change is certainly now in the direction of democratic centralism. A massive reorganization of the economy in this direction is now in progress. The basic idea of the reorganization is that the central authority should retain only general supervisory functions, such as the development and promotion of new techniques and the broad coordination of the economy of the whole country. The detailed management of industry is handed over to regional organizations. From this reorganization of the economy a reorganization of scientific work will inevitably follow. The detailed planning and organization of the actual work will be more and more concentrated in the working organs of the scientific institutes themselves, for example in committees of scientists. Broad scientific planning, dealing with the general problems of the growth of a socialist culture on a national scale, will be handled centrally by such organizations as the Academy of Sciences, Gosplan, and other departments of the central government. The planned organization of science which has been achieved in the Soviet Union is already producing greater efficiency and better utilization of scientific manpower and equipment.

When we consider the contact of science, and in particular of physics, with the practical problems of national life, we find that this contact is already far more effective in the Soviet Union today than in the most advanced capitalist countries. This explains the rapid pace at which Soviet scientists and engineers solved the most difficult problems of nuclear technology, jet-propulsion technology, aviation, radio, metallurgy, power technology, etc. Although the Soviet Union is still some way behind the United States in the production of some important items, the USSR has held and still holds the record for the speed at which scientific and technical problems have been solved and the results put into practical operation. This can be explained only by the close and friendly contact between science and technology, which is possible under our government. It is possible mainly because in our socialist country there is only one all-powerful landlord, and that landlord is the people. Under capitalism, where industry is in private hands and companies are often competing against one another, scientific organizations are largely left to their own devices. The coordinated activity of all scientific and industrial resources, which is naturally and simply achieved in a socialist country, is under capitalism impossible.

The rate of growth of Soviet physics, and of all branches of science, is nevertheless influenced by our contacts with foreign science. We all believe that the basic task of science is the understanding of nature, and the basic purpose of this understanding is the conquest of nature for the benefit of mankind.

Scientific truth is one, and the more rapidly it is discovered and the more intensively science is developed the greater the benefit to all mankind. Nowhere in the history of human culture has international cooperation given such great benefits to humanity as in the field of science.

We are very happy that in all these years our journal has not only been widely read here in the Soviet Union but has also had a wide foreign circulation. We welcome the recent appearance of the "Journal of Experimental and Theoretical Physics" overseas in an English translation.

International professional contacts between scientists are valuable not only to progress in science. Understanding between scientists leads also to understanding and trust between countries. Peaceful coexistence, so necessary for happy and prosperous human life, is impossible without trust between peoples. Physicists more than anybody else should now be concerned for peace, since they have the responsibility before mankind for putting into our hands weapons of annihilation which if carelessly handled could lead to misery on an unprecedented scale.

Translated by F. J. Dyson
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INVESTIGATION OF THE THERMAL PROPERTIES OF SUPERCONDUCTORS
1. TIN (DOWN TO 0.15°K)

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Measurements have been made of the thermal and thermometric conductivities of several samples of tin in the range from 0.15 — 4°K. These make it possible to determine the specific heat of tin down to 0.15°K. It has been found that, below 0.45°K, the specific heat is due to the lattice and varies according to Debye's law, with $\Theta_D = 202 \pm 3$°K. Above 0.45°K, the specific heat of the electrons appears, which depends on temperature as $c_{es} = A(T) \times \exp(-\alpha T_c/T)$. The free energy of the superconducting electrons below 3°K, determined on the basis of these measurements, can be represented as $F_{es} = BT^n \exp(-\alpha T_c/T)$, where $B = 8.7 \times 10^{-4}$ joules/g-mole-deg, $n = 2.5 \pm 0.5$, $\alpha = 1.35 \pm 0.1$. The thermal conductivity of tin below 0.3°K for all specimens is due to the heat transfer by the phonons; one of the samples exhibited a reflection effect of the phonons from the mirror surface. For higher temperatures, the thermal conductivity of the electrons varied for all samples as $K_{es} = \text{const} \cdot \exp(-\beta T_c/T)$, $\beta = 1.45 \pm 0.05$. The results are discussed from the point of view of the presence of an energy gap in the excitation spectrum of superconductors.

As is well known, the analysis of data on the thermal properties allows us to obtain a number of indications concerning the energy excitation spectrum in solids. We can obtain the most definite conclusions in this case on the basis of the analysis of the specific heat of bodies over a wide range of temperatures,