HIGH-ENERGY PHYSICS AND THE NATURE OF MATTER

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THE achievements of the present-day physical sciences (in the broad meaning of this term) are particularly striking in branches of two diametrically opposed scales; the investigations of the universe, the macrocosm, with all the battery of modern technological achievements, and the penetration into the region of the microcosm, i.e., the study of the laws of the subnuclear world beyond the limits of the rather well-known nuclear systems. The successful investigation of these extends to an unsurmised degree our knowledge of the fundamental laws of the world surrounding us; it leads to a quite specific knowledge of the most general and profound laws of the nature and the structure of space and time, such that the very thought of these possibilities is breathtaking. The keen interest of broad sections of society in these new fields of science is therefore understandable.

This issue of "Uspekhi" is basically devoted to one theme—the attainments, problems and goals of the field which leads to knowledge of the nature of matter. This field can be called, as was done above, the field of subnuclear physics; it is more frequently referred to as the physics of elementary particles or high-energy physics. Although the latter name is at first sight technical in nature, it is in fact of deep significance for the following reason: there is a quantum law according to which the smaller the object the larger the energy required for investigating its structure. Indeed, the elementary particles of physics and chemistry in the nineteenth century were the atoms; in gas-kinetic processes of energy exchange at normal temperatures (i.e. at $kT \sim 10^{-2}$ eV) they behaved like elastic spheres without structure. For the study of the structure of atoms, however, energies of several electron volts were required, since these are the separations between energy levels of the electron shell. At these energies there are still no sign of nuclear structure. In turn, to investigate the structure of the nucleus it was necessary to have at one's disposal energies on the order of millions of electron volts, since these are precisely the energies characteristic of nuclear spectroscopy. Finally, when progress in accelerator technology made possible the construction of facilities for energies up to 30 billion electron volts, a whole new world of particles, whose number started to grow explosively, revealed itself. We are at present still at the very beginnings of the path leading to a knowledge of the fundamental laws governing the phenomena of the world which surrounds us. The outlines of these laws are already indicated in the symmetry laws, so enticing in their harmony, which have been discovered in recent investigations of strongly interacting particles, and which are striking not only in their elegance but also in their amazing analogy with the laws of the spectroscopy of the electron shell which is also based on the elementary symmetries. Also there is the unexpected result of these symmetries, the hypothesis of the existence in nature of a special world of elementary particles, quarks, which are the structural units of protons and neutrons, i.e. constitute that "primordial matter" which man has sought from time immemorial. If this is confirmed, then the "indivisible" elementary particles, the proton and neutron, will meet the same fate as the "indivisible" atoms and nuclei met in their time. However, the same quantum law which governs the energies required for investigating small objects indicates that if we desire to proceed appreciably further in our knowledge of the nature of matter, it will become unavoidable to go from energies of tens of billions to energies of hundreds or even thousands of billions of electron volts. This issue of "Uspekhi" contains a number of articles by Soviet authors devoted to the problems of high-energy physics, as well as a translation of the collection "Nature of Matter. Purposes of High Energy Physics" published in the United States at the beginning of 1965. Although many of the short articles of this collection contain similar opinions concerning certain questions, each of the articles is colored by the personality of the author and is, thus, of independent interest. It is for this reason, that the editors considered a translation of the complete collection, including articles of similar content, advisable.

The comments of Soviet physicists concerning the problem of the nature of matter are not confined to the articles included in this issue; they will also be included in the following issues of the journal. In particular, an article devoted to a discussion of the possibility of observing "quarks" in nature by Ya. B. Zel'dovich, L. B. Okun', and S. B. Pikel'ner entitled "Quarks: Astrophysical and Physico-chemical Aspects" will appear in the next issue, and has not been included in the present issue for technical reasons.

In conclusion, it is not superfluous to note that by according such attention to high-energy physics, the editors do not wish to emphasize that this fascinating field should occupy the main place in the development of physics during the coming years. There are many problems, possibly no less important both for the development of basic science and also for its application to the national economy. It is sufficient to mention the vast and most important field of solid state physics which competes, by the way, with nuclear and elementary-particle physics in the number of articles devoted to it. The readers of "Uspekhi" are well aware of the fact that our journal accords equal attention to all these problems. Nevertheless, the attention accorded in this issue of "Uspekhi" to the problems of high-energy physics is justified by the alluring prospect of discovering the most fundamental laws of the world which surrounds us.

Translated by Z. Barnea