PERSONALIA

Isaĭ Izrailevich Gurevich (on his eightieth birthday)

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Usp. Fiz. Nauk **162**, 189–192 (August 1992)

On 13 July 1992, I. I. Gurevich celebrated his eightieth birthday. Gurevich is an outstanding nuclear physicist, a scientist with an unusually high level of scientific intuition, a fortuitous combination in one person of an exacting experimentalist, theoretician, and excellent teacher. Gurevich is a Corresponding Member of the Russian Academy of Sciences.

Isaĭ Isidorovich (as his friends, colleagues, and students call him) was born on 12 July 1912 in Riga. His scientific career began immediately after his graduation in 1934 from Leningrad University, and in only a few years he had attained great success virtually simultaneously in two important areas of the then-new science of nuclear physics.

In 1935–1938 Gurevich, together with A. P. Zhdanov and A. N. Filippov discovered (independently of and at the same time as Blau and Wambacher) the splitting of the nuclei of photoemulsions by cosmic rays. This discovery proved the existence of strongly interacting nucleon particles in the cosmic radiation, and initiated a broad range of research studying the strong interactions of highly energetic cosmic particles with atomic nuclei.

Even earlier (in 1934) Gurevich began to study the physics of neutrons in connection with the study of the structure of heavy nuclei, and in 1937, that is, immediately after the creation of the Bohr theory of the nucleus (but before the discovery of a reliable method of neutron spectroscopy), he obtained a rule for the distribution of capture cross sections for thermal neutrons in a region of constant average spacing between atomic levels.

In 1938 Gurevich completed the most important publication in this series of experiments, in which he advanced the hypothesis of phase transitions in nuclear matter. This manuscript was highly regarded by N. Bohr, who personally presented it for publication. Now it is known that phase transitions in nuclear matter actually exist and are explained in the superfluid model of the nucleus by the existence of a specific pair interaction of nucleons.

It is clear from this survey of the early publications of Gurevich that already in the years before the war he had the reputation of being a highly-skilled specialist in the field of nuclear physics. Thus, it is not surprising that Ya. B. Zel'dovich and Yu. B. Khariton enlisted him in 1941 to complete one of their fundamental publications on the theory of the chain reaction of nuclear fission. In this publication, the authors estimated the critical mass of ^{235}U based on fast neutrons. Yu. B. Khariton, who understood its significance well, proposed to the coauthors that the manuscript not be published and that it be locked in a safe. Two years later, when work was resumed on the atomic problem, it played an important role.

ISAĬ IZRAILEVICH GUREVICH

When in 1943 Igor' Vasil'evich Kurchatov was officially named director of research on the use of atomic energy, he formed a small group of the best nuclear physicists in the country to work on the problem. Among them was Gurevich. He came to Moscow in September 1943 and immediately was included in the research. I. V. Kurchatov selected graphite as moderator and proposed an exponential experiment to measure its neutron characteristics. Gurevich derived an expression for the propagation of thermal neutrons in exponential experiments on the determination of diffusion length.

By 1943, it had become clear that a chain reaction was hardly possible in a homogeneous mixture of natural uranium and moderator due to the strong resonance absorption of neutrons by the main isotope ^{238}U. In the summer of 1943, the idea of a heterogeneous arrangement of lumps of uranium in the moderator was proposed, but a theory of the phenomena did not exist. Gurevich and Ya. B. Pomeranchuk

 0038-5670/92/080723-02$03.00

undertook a theoretical analysis of the problem. They understood that resonance capture would be reduced in a system of lumps when two effects coexist simultaneously: self-screening of strong resonances by the uranium, and the possibility of a neutron in the process of being slowed down slipping through the danger zone of absorption by being at that moment in the moderator far from a uranium lump. As a result, in 1943, the famous Gurevich–Pomeranchuk formula was obtained for the probability of a neutron avoiding resonance capture in lumps. At the same time, proceeding from clear physical concepts, Gurevich wrote a simple formula for the average geometric path of a neutron in a lump of arbitrary shape. The Gurevich–Pomeranchuk formula was published at the first Geneva Conference of the UN on the peaceful uses of atomic energy in 1955 (of course the authors were not allowed to go to this conference). It was then that the qualitative difference between the Gurevich–Pomeranchuk formula and Wigner's formula for resonance capture in lumps was noted, although both formulas had been confirmed experimentally. In a year it was found that the experiments were conducted in different ranges of lump diameters. The range of applicability of the Gurevich–Pomeranchuk formula was found to be much wider, and it is this formula which is in all textbooks on the physics of reactors.

The lump arrangement of uranium led to a gain in avoiding resonance capture, but there was a simultaneous loss in the utilization of thermal neutrons. In 1944 Gurevich and Ya. B. Zeld'ovich formulated a one-velocity theory of the efficiency of utilization of thermal neutrons and introduced the concept of the lump effect of the first (internal) and the second (external) kind. Thus, in the formula for the coefficient of multiplication of neutrons in an infinite array, K_∞, two chief factors, φ and v, were defined. Following this it become possible to optimize K_∞ depending on the size of the lumps and the lattice constant (also taking into account a third factor—the fast fission factor, introduced by G. N. Flerov).

The pioneering work of a small group of remarkable scientists that included Gurevich created the theoretical basis for experimental research and design developments which were crowned by the start-up of the first domestic reactor in December 1946. Many of the Gurevich's ideas were far ahead of his time. For example, in 1946 he and G. N. Flerov proposed for the production of plutonium the use of a subcritical reactor (multiplier) controlled by a neutron generator. At that time it was difficult to construct a subcritical reactor due to the unavailability of enriched uranium. Forty-five years later this idea has again attracted the attention of specialists, but this time from the point of view of the nuclear safety of atomic energy.

Gurevich is one of the founders of a new method of studying condensed state of matter using muons. Now this method has been widely developed and is known as the μSR method. The experimental information obtained using this method makes it possible to study different properties of matter as well as the interaction of a single-charge particle (muon) with matter.

Under Gurevich's direction, experiments have been conducted to determine the diffusion coefficient of muons in metal, to measure the frequency of hyperfine splitting of a muonium atom in matter, to measure the contact magnetic field at a muon, to measure polarized conductivity electrons in a ferromagnetic substance, to study magnetic phase transitions using the muon method, and to study the properties of semiconductors and superconductors, etc.

In the study of muon diffusion in a crystal, it was found that the diffusion transition of a muon into a neighboring interstice is a quantum subbarrier process. The polaron energy associated with the Coulomb interaction of a muon and a nearby atom in the crystal lattice of a metal was measured. Especially elegant were experiments using the two-frequency precession method to determine the frequency of hyperfine splitting or the "dimensions" of a hydrogen-like muonium atom occurring as an impurity in dielectrics and semiconductors. These experiments, as well as experiments to measure the diffusion coefficient of a muon of muonium, were the origin of many experiments in a large number of laboratories all over the world. Studies of magnetic substances are probably the most natural area of application of the μSR method. The dynamics of muon spin in a magnetic substance is the result of the effect both of constant magnetic fields of the magnetically ordered state of the metal, and of variable fluctuating fields. Experiments to study superconductivity using the muon method are currently concentrated on the study of high-temperature superconductors. Muon experiments are virtually the only method of determining the depth of penetration of the magnetic field into a ceramic superconductor. In the 1970s and 1980s, Gurevich headed the laboratory of elementary processes of the I. V. Kurchatov Institute of Atomic Energy, at which studies of the properties of elementary particles are being conducted. This physics differs substantially from reactor physics, but the common thread is Gurevich's desire to study the fundamental properties of matter.

Under Gurevich's direction, this laboratory has conducted a series of experiments using the accelerators at Serpukhov and CERN to search for particles with a magnetic charge—Dirac monopoles. The proposed method has not required special time at the accelerators, and at the same time has made it possible to use virtually the full intensity of proton beams with long exposures of a target-trap. No magnetic monopoles have been detected, but record limits on their mass and production cross section have been obtained.

Subsequently the direction of research has shifted to the area of neutrino physics. In 1982, the laboratory personnel were the first in our country to record the interaction of reactor antineutrinos with protons, and a year or two later a significant portion of the world's statistics on neutrino events was collected at the detectors of Gurevich's laboratory. These studies are being conducted along a broad front: under study are the characteristics of the interaction of an antineutrino with a proton, deuteron, and electron. An antineutrino flux has been detected at record distances, and the world's best limits on the parameters of neutrino oscillations, the magnetic moment and charge radius of the neutrino have been obtained. Implementation of the neutrino program continues to this day. In particular, an experiment with "terrestrial" neutrinos is being used to verify hypotheses explaining the "deficiency" of solar neutrinos.

On this day of celebration all the friends, colleagues, and students of Isaĭ Isidorovich Gurevich congratulate this outstanding physicist and remarkable human being on his birthday and wish him many creative years to come.

Translated by C. Gallant