Georgiĭ Timofeevich Zatsepin (On his seventieth birthday)

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The prominent Soviet physicist Academician Georgiĭ Timofeevich Zatsepin, laureate of both Lenin and State Prizes is reaching his seventieth birthday.

Zatsepin was born on 28 May 1917 into the family of a well-known surgeon. In 1941 he graduated from the Physics Faculty of the Moscow State University and starting with 1944 he began working in the Physics Institute of the Academy of Sciences. Under the guidance of his teacher, D. V. Skobel'tsyn, he traversed the path from a young graduate student to one of the deepest specialists in cosmic-ray physics unusually quickly. The subject of the experimental investigations of the young physicist became the extended atmospheric showers (EAS). Under the severe conditions of the high-altitude station of the Physics Institute of the Academy of Sciences in the Pamir Mountains he carried out his principal experiments. He discovered the nuclear cascade in the EAS and in studying its development already in 1949 he obtained the characteristics of the elementary interaction event which he finally formulated in the course of the subsequent several years: 1) the cross-section for the interaction of protons with the nuclei in the atmosphere is approximately constant right up to energies of $E \sim 10^{15}$ eV; 2) the high energy nucleon retains in the nuclear interaction approximately one-half of its initial energy; 3) the most energetic of the pions produced carries away on the average 15% of the energy of the primary nucleon. This was an astonishing discovery for the theory of those years when the conviction reigned that all cross-sections decrease at high energies, and the proton loses its energy in a collision in a catastrophic manner. Accelerator physics needed almost a quarter of a century to see this picture of the interaction at high energy.

Somewhat later Zatsepin (and independently N. L. Grigorov) discovered that the energy distribution of the most energetic secondary pions is a function of only the ratio of the pion energy to the energy of the primary nucleon. More than ten years later this regularity was observed in accelerator experiments and has been named "scaling."

Characteristic of Zatsepin's style is the intertwining of experimental and theoretical ideas. The fate of one of them has turned out to be very interesting. In 1955 Zatsepin noted that the ultrarelativistic nuclei of cosmic rays can be split under the action of photons of solar light. The idea that low energy photons can bring about reactions as a result of the relativistic transformation of energy in going over into the rest system of the incident particles obtained wide application in the 1960s when the cosmic background (relict) radiation was discovered. In particular in 1968 Zatsepin showed that protons with an energy higher than $3 \cdot 10^{19}$ eV undergo strong slowing down in the intergalactic medium as a result of the production of pions in collisions with relict photons.

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This phenomenon has been given in the literature the name of the "Greisen-Zatsepin effect."

Since the early 1960s the principal field of Zatsepin's scientific activity became muon and neutrino physics in cosmic rays. He made proposals of large-scale underground experiments, being in advance by 15–20 years of the appearance of similar proposals abroad. The scale of the proposed detectors had no precedence in the physics of those years. In order to carry out work on these projects a special laboratory was created in 1963 (in 1971 it became part of the Institute of Nuclear Investigations of the Academy of Sciences of the USSR). Work began on construction of a complex of underground laboratories at the Baksan neutrino observatory, and also of a laboratory in the salt mine in the city of Artemovsk.

The problems undertaken by the underground detectors at first included the detection of atmospheric neutrinos and the detection of solar neutrinos by the chlorine-argon method. Under the direction of G. T. Zatsepin the young team of scientists in the laboratory developed the method of detecting low-energy neutrinos, analyzed the background and sought methods of screening from external radiations, and undertook a search for new methods of detecting solar neutrinos. In particular, in 1965 a proposal was made in the laboratory to use a gallium-germanium detector with a low threshold for recording neutrinos which was sensitive, in contrast to the Cl–Ar method to the main portion of the solar neutrino flux.

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In 1965 Zatsepin found one more important problem of neutrino astronomy: he discovered the possibility of detecting a neutrino burst arising in the collapse of stars in our galaxy. Under Zatsepin's direction the laboratory began the development of a 100-ton scintillation detector "Kollaps." A discussion began of mounting a world net of detectors to search for collapsing stars.

In addition to the main direction of his scientific and organizational activity associated with the preparation of underground neutrino experiments, Zatsepin in the 1960s and 1970s obtained a number of interesting experimental and theoretical results in neutrino and muon physics.

He became an organizer and active participant of the large experiment of the Moscow State Unviersity on detecting muons with the aid of x-ray emulsion cameras. An experiment was mounted to measure the muon spectrum at very high energies.

Of Zatsepin's theoretical work during these years one should note the calculations that have become classical of the spectra of atmospheric muons and neutrinos taking into account the production and decay of π and K mesons, and later of charmed hadrons. For the first time the problem was solved of the absorption of muons in the ground taking into account fluctuations in energy losses.

In 1959 Zatsepin for the first time called attention to the possibility of measuring the energy of high-energy muons by observing showers created by electron-positron pairs. This method has now become the most promising one for measuring the energy of muons of superhigh energies.

The name of Zatsepin is indissolubly associated with the birth of high-energy gamma-astronomy. The appearance in 1961 of an article on the possibility of searching for local gamma-sources using the Cherenkov radiation of showers produced by gamma-quanta in the atmosphere led to the construction of Cherenkov gamma-telescopes.

In the 1980s Zatsepin and the division headed by him completed work on the construction of neutrino detectors. This refers first of all to the 60-ton gallium-germanium detector for recording solar neutrinos. It is expected to be put into operation by the end of 1987. Behind him now is the tremendous work not only on the detector, and not only on the construction of a low-background laboratory in which the detector has been successfully installed, but also on educating a group of experimenters who entered the laboratory as students. An optimal chemical procedure has been found for extacting individual germanium atoms formed under the action of solar neutrinos from metallic gallium with an efficiency not lower than 95%. The gallium-germanium detector is only the first step along the path of the program planned by Zatsepin for neutrino spectroscopy of the sun. Work is being conducted in the laboratory on constructing a lithium-beryllium neutrino detector and a chlorine-argon experiment has been prepared with a mass of the detecting material of 3,000 tons, i.e., five times larger than in the unique experiment of Davis. It is intended to be put into operation by the end of the present five-year plan.

The single module 100-ton scintillation detector "Kollaps" began working in the salt mine of the city of Artemovsk. In addition to its regular program of monitoring the collapse of stars during the 1980s the cross-section for the production of hadrons as a result of the interaction of muons with nuclei was measured with the aid of this detector and it was shown that the cross-section for the photoproduction of hadrons on nuclei derived from this remains constant up to an energy of $3\cdot10^{12}$ eV. The muon spectrum was measured using this installaion up to an energy of $1\cdot10^{13}$ eV. Up to still higher energies exceeding $3\cdot10^{13}$ eV the muon spectrum was measured with the aid of x-ray emulsion cameras of the Moscow State University installation.

In 1985 under Zatsepin's guidance work was completed on constructing a system of scintillation detectors which culminated in putting into operation of the 90-ton Soviet-Italian telescope underneath Mont Blanc. The beginning of its operation signified the addition of a third telescope devoted to the observation of neutrino bursts from collapsing stars. The low level of the background in the central detectors enables one to raise the question of recording in them solar neutrinos using the neutrino-electron scattering effect. This possibility will be further developed in the joint Soviet-Italian detector which will be constructed in the Grand Sasso laboratory.

Zatsepin became one of the initiators and participants of the large scale experiment "Pamir" on the study of interactions at an energy up to 10^{16} eV with the aid of x-ray emulsion cameras. In this experiment the discovery was made of the change in the characteristics of the elementary event of the interaction of hadrons at energies of the incident particles up to 10^{16} eV, which considerably exceeds the energies in accelerator experiments.

Zatsepin's work in the field of neutrino astrophysics and cosmic rays has been deservedly acknowledged internationally, and for a number of problems it determined the development of world physics.

Zatsepin created a school of specialists working both in his laboratory and in many other scientific centers of the USSR. Among them there are both young physicists and well-known scientists. Zatsepin also works with students being the head of the chair for cosmic rays at the Moscow State University.

In congratulating Georgiĭ Timofeevich Zatsepin on his seventieth birthday we wish him health and further successes in his many-sided scientific activity.

Translated by G. M. Volkoff