

PERSONALIA

PACS number: **01.60. + q**

Georgiĭ Timofeevich Zatsepin (on his eightieth birthday)

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As his biographical particulars tell us, Academician Georgiĭ Timofeevich Zatsepin is 80 this year. He was born into the family of Timofeĭ Zatsepin, a well-known surgeon, in Moscow's ancient Arbat Quarter on May 28, 1917.

Zatsepin is the founder of a major scientific school which encompasses the theoretical and experimental physics of cosmic rays, neutrino physics, and astrophysics, extending far beyond the former Soviet Union and Russia and is of great concern in the countries of Europe, the Americas, and Asia. As before and in defiance of his recorded age, he feels young and is full of new scientific ideas and plans, is well-wishing, quick in his response to anything new, and surrounded by the youth to whom he devotes much attention.

Zatsepin has linked his carrier in science to the field of physics known as cosmic rays. He was among D V Skobeltsyn's favourite disciples and, as did his teacher, believes that "cosmic rays are undoubtedly one of the most intriguing phenomena of present-day physics, whose study has yielded many important results and is exceptionally attractive...". Zatsepin's range of scientific problems is exceptionally wide and diverse; he has proved both an outstanding experimental physicist and a generator of brilliant theoretical ideas usually borne out by experiment. He set out on his career as a scientist in the 1940s with a pioneering study in the Pamir Mountains into the then new phenomenon of extensive air showers (EAS). He grasped and formulated in the late 1940s the fundamentally new relationships involved in the evolution of extensive air showers, proceeding from the nuclear-cascade process he had discovered. Moreover, he derived the basic characteristics of the process, that is, the characteristics of the nucleon-cascade process at very high energies ($10^{12} - 10^{14}$ eV). In particular, he found that the inelastic interaction cross-section of a primary nucleon remained approximately constant; that upon an inelastic collision a primary nucleon would preserve about half its energy; that the inclusive cross-sections of pion production in the fragmentation region showed a scaling behaviour, etc. It was not until a quarter-century later that all of these characteristics were verified by accelerator experiments. At about the same time, Zatsepin came up with and developed a new technique for the study of EAS — the correlated hodoscope method. This technique was implemented on the extensive air shower arrays built under the guidance of Zatsepin and others at Moscow State University and in the Pamir Mountains. Concurrently, Zatsepin suggested and brilliantly developed a mathematical theory of the nuclear-cascade process.

In the early 1960s, Zatsepin launched a study into the muons and neutrinos that made up the penetrating component of cosmic rays. A neutrino laboratory was set up at the USSR Academy of Sciences' Lebedev Institute of Physics, where Zatsepin and his co-workers laid the foundation for two entirely new fields — neutrino astronomy and neutrino astrophysics. The laboratory developed solar neutrino detection techniques which made it possible to study the Sun by neutrino spectroscopy and to glean information about the nuclear fusion reactions taking place inside our natural luminary and supply the energy it needs. It was under Zatsepin's guidance that a new gallium-germanium technique was devised and developed. Likewise in Zatsepin's neutrino laboratory, methods were developed, for the first time in the world and twenty years earlier than in other laboratories, for the study of huge neutrino emission fluxes which accompany the collapse of stars.

In the mid-1960s, Zatsepin, together with V A Kuz'min, predicted what has come to be known as the Zatsepin-Greisen-Kuz'min effect. Its essence is in that when ultra-high-energy cosmic rays have a metagalactic origin, their

Uspekhi Fizicheskikh Nauk **167** (5) 571 – 572 (1997)
Translated by B V Kuznetsov

energy spectrum is cut off in the range $> 3 \times 10^{19}$ eV owing to their interaction with thermal radiation (3 K) of the Universe. This effect has invariably been taken into account in any further inquiry into the origin of ultrahigh-energy cosmic rays. At a time when giant arrays, such as the EAS-1000 and the Auger project, are being built, this theoretical work remains most important in the physics of cosmic rays as it rigorously limits the span of time over which ultrahigh-energy cosmic rays ($> 10^{19}$ eV) can exist in the Universe, and is, therefore, essential in identifying the sources of cosmic rays.

Another remarkable idea Zatsepin advanced (together with A E Chudakov) in the early 1960s concerned the possible use of the Cherenkov radiation of extensive air showers to detect sources of cosmic rays beginning from energies of the order of 10^{12} eV. His point was that even at such energies a considerable flux of optical photons is generated in the atmosphere, observable for tens of nanoseconds. This study decided the fate of ground-based high-energy gamma-ray astronomy and predetermined the present-day advances in the observation of galactical objects (such as the Crab) and extragalactic objects (Markar'yan-427).

In the late 1970s, the neutrino laboratory was reorganized into the Department of High-Energy Leptons and Neutrino Astrophysics (LVENA for short in Russian) as part of the USSR Academy of Sciences' Institute for Nuclear Research newly created on the initiative of Academician M A Markov. From that time, Zatsepin has invariably been the head of this department. With Zatsepin and Chudakov as scientific supervisors, the world's first Neutrino Observatory was built in the valley of the Baksan river, Northern Caucasus, intended to study muons and neutrinos of atmospheric and astrophysical origin. Currently, the United States and Russia are carrying out a joint experiment (SAGE) at the Neutrino Observatory involving the use of the gallium-germanium technique to observe solar neutrinos. To investigate various components of penetrating radiation below the ground, a team at LVENA has designed huge scintillation telescopes, the 'Collapse' now installed in the mines of Artemovsk and the LSD installed under Mont Blanc (jointly with Italy). Construction work is also under way on the LVD, a 2-kiloton scintillation-tracking detector, under Gran Sasso (jointly with Italy and USA).

More recently, Zatsepin and his co-workers have realized some results of fundamental importance. Using the gallium-germanium technique, they detected a deficit of low-energy neutrino radiation generated mainly by the p-p reaction of the Sun's hydrogen cycle, which cannot be attributed to a lower temperature inside the Sun. (Independently, this effect has also been noted by the GALLEX detector at Gran Sasso.) A theory has been formulated to explain the generation of atmospheric muons and neutrinos. It has been verified by experiments using both scintillation telescopes and the underground detector built under Zatsepin's guidance at Moscow State University on the basis of the new method of X-ray emulsion chambers.

Along with research into the generation of muons (their energy spectra and angular distribution), a study was undertaken to determine the inelastic interaction cross-section of muons with the production of hadrons in a range of energies substantially exceeding accelerator energies. A theory was formulated and verified by experiment to explain the production of the nuclear-active component of cosmic rays underground. Work is currently under way on a theory of ultrahigh-energy neutrino generation and methods of their detection.

Zatsepin's creative activity, encyclopedic erudition in physics, medicine, and history, and his striking memory attract many people to him, both young and old. For the last 15 years, Zatsepin has held the chair of cosmic rays at the Moscow State University, and it is very strange to see the figure "80" next to his name.

Good health to you, Georgiĭ Timofeevich!

We wish you as many happy days as there may be!

V L Ginzburg, V N Gavrin, N A Dobrotin,
V A Matveev, I V Rakobol'skaya, O G Ryazhskaya,
A N Skrinskiĭ, E L Feĭnberg,
G B Khristiansen, A E Chudakov