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In memory of Georgiĭ Borisovich Khristiansen

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Georgiĭ Borisovich Khristiansen, a professor of the Lomonosov Moscow State University (MGU), an outstanding authority on cosmic rays and high-energy physics, a full member of the Russian Academy of Sciences, passed away on August 4, 2000, at an age of 74. This is a heavy blow to the Russian science community.

G B Khristiansen was born in Moscow on May 31, 1927. He graduated from the physics department of Moscow University in 1950. G B Khristiansen had chosen the main thrust of his research effort already in his student years, when he began to study superhigh-energy cosmic rays at the high-altitude Pamir station of the Lebedev Physics Institute. The station was supervised by D B Skobel'tsyn and G T Zatsepin. In 1953, having completed the postgraduate course (supervised by D B Skobel'tsyn) at the Nuclear Physics division of the Moscow University physics department and defended his Candidate-of-Science dissertation, Khristiansen, together with S N Vernov, launched a new project: they designed and implemented a new, unique for that time, setup for studying cosmic rays in the energy range $10^{15} - 10^{17}$ eV by simultaneous recording of the electron, muon and hadron components of the extensive air showers (EAS) produced by such cosmic rays. On the basis of this setup, the division of superhigh-energy particles was created at the Institute of Nuclear Physics of MGU; Georgiĭ Borisovich headed it for nearly 40 years.

Even the first years of operation of the MGU EAS setup yielded a number of qualitatively new results on the space and energy structure of various components of EAS. The most spectacular result obtained by G B Khristiansen was the discovery of a kink in the energy spectrum of primary cosmic rays at about 3×10^{15} eV. In 1970 this result was registered with the State Committee on Inventions and Discoveries of the USSR Soviet of Ministers as a scientific discovery. At present the existence of this kink in the curve has been confirmed by the data of several tens of laboratories in many countries but the problem of interpretation of this kink remains a topical unsolved problem in cosmic ray physics; equipment is still being designed to analyze this feature. The kink problem was the leading light in the whole life of Georgiĭ Borisovich. During the last years he initiated a large-scale effort to analyze the experimental data accumulated over many years at the MGU EAS setup; an important result was obtained with high statistical accuracy for a significant but gradual mass increase in the composition of the primary cosmic rays in the vicinity of the kink for energies increasing from 10^{15} to 10^{17} eV. This result is in good agreement with the assumption of the kink energy being proportional to the charge of the primary particle.

G B Khristiansen insisted on the pre-eminence of experiment over theory but, at the same time, always stimulated the application of new theoretical models and constantly improved mathematical techniques to the analysis of experimental data. A detailed comparison of the collection of experimental characteristics of EAS with the predictions of theoretical models allowed G B Khristiansen to show that the extrapolation of the Feynman scaling of hadron interactions, which was popular at the beginning of the 1970s, from the ISR collider energies to the energy range of $10^{14} - 10^{15}$ eV was absolutely incorrect. This conclusion was arrived at six years before the SPS collider supplied experimental data that confirmed it.

One of the defining features of Georgiĭ Borisovich was a constant search for new unconventional research techniques that would allow him to get a novel approach to cosmic ray physics. Even at the very beginning of operations of the MGU EAS setup, Georgiĭ Borisovich initiated and guided the work on designing and applying, for the first time in this country, large-area scintillation counters for recording showers. It was possible, using large-area scintillation detectors with a resolving time of the order of nanoseconds, to determine the

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direction of the EAS axis, that is, the direction of arrival of the primary particle, by the time of impact of the EAS front on individual detectors.

Khristiansen used the MGU EAS setup to study the radioemission generated when an extended atmospheric shower passes through the atmosphere. He suggested a system of vibrators which, in combination with the EAS setup, recorded the radioemission of individual showers. The geomagnetic nature of this radioemission and its coherent nature at the frequencies of observation were proved. For the work on EAS radioemission, conducted together with physicists of Kharkov University, G B Khristiansen received the State Prize of the Ukrainian SSR in 1971.

At the beginning of the 1970s G B Khristiansen proposed a new and promising approach, later known as the technique of the pulse shape of Cherenkov radiation, which made it possible to reconstruct the individual cascade curve of a shower and, at the same time, to find its energy. The experimentally observed height distribution of maxima on the cascade curve yields an upper bound for the range of primary particles at superhigh energies. At the same time, this distribution can be used to determine the nuclear composition of the primary radiation. The pulse shape method generated lively interest and was applied to study the Cherenkov radiation of EAS in virtually all laboratories of the world where EAS was an object of research.

In addition to work on cosmic rays of superhigh energies and their interaction with matter, G B Khristiansen guided experimental research in other areas. For example, a detailed analysis of the spectrum of energy release by muons in the ground layer of 40 m.w.e. was carried out. It was found that in the energy release range from 1 to 10 TeV the spectrum was characterized by an exponent which was less by four mean-square errors than that predicted by the theory based on the traditional notion of the spectra of single muons. The nature of this anomaly remains unexplained until this day.

G B Khristiansen played an important role in the design and development of new EAS setups in various research institutes of this country, where superhigh-energy cosmic rays were studied. For instance, in the 1960s work started on a giant (at that moment) new EAS system near Yakutsk, which would analyse cosmic rays in the energy range of 10^{17} – 10^{20} eV. Georgiĭ Borisovich joined this effort and the research using this system with his characteristic energy and vigor. He selected a team of talented young graduate students from Moscow institutes and created a young research group for the Yakutsk EAS system. It is on this system, under G B Khristiansen's supervision, that his EAS Cherenkov radiation pulse shape technique was implemented. This method made it possible to determine the position of the shower maximum as a function of the primary energy in the 10^{15} – 10^{18} eV range, as well as of the inelastic interaction cross section of primary protons at 10^{16} eV. In addition, it was possible to measure averaged cascade curves for a given position of the maximum.

In 1970 an EAS system was constructed at the Samarkand University. Georgiĭ Borisovich was again active in designing and launching it, and again he was surrounded by young physicists, who formed later the nucleus of a new research organization. G B Khristiansen's ideas and his style of research are still alive on Uzbekistan's soil.

The work on superhigh-energy cosmic rays brought a Lenin Prize to G B Khristiansen in 1982 and an MGU Lomonosov Prize, in 1989.

At the end of the 1980s the attention of cosmic ray physicists turned more and more to extremely high energies (above 10^{19} eV). This was connected with the problem of microwave background cut-off of the cosmic ray spectrum and the potentialities of neutron and proton astronomy. G B Khristiansen channeled his prodigious enthusiasm to guiding the work on designing and building a new EAS-1000 system of area 1000 km^2 for studying cosmic rays with energies in the range 10^{19} – 10^{21} eV. The project of creating this setup was included in the State Program for Science and Technology.

Georgiĭ Borisovich started his pedagogical career very early and devoted much effort to training young physicists. He created a number of new courses at the nuclear physics division of the physics department of MGU for students majoring in cosmic ray physics. G B Khristiansen paid much attention to training new generations of researchers, to communicating with graduate, postgraduate and postdoc students both at the physics department and at other institutes, and not only in this country but beyond its borders as well. His students carry on successful work in various fields of physics; he has founded a new school in cosmic ray physics at superhigh energies. Though a strict and demanding supervisor, Georgiĭ Borisovich was at the same time an exceptionally sensitive and responsive person, ready to help people even if he knew them only slightly. G B Khristiansen was elected a corresponding member of the Russian Academy of Sciences in 1990 and a full member in 1997.

Georgiĭ Borisovich also left an important trace as deputy chairman of the Science Council on Cosmic Ray Problems, Russian Academy of Sciences, organizing and coordinating work on cosmic ray physics in this country and also organizing regular international conferences on cosmic rays. He was also a member of the Commission on Cosmic Rays of the UNESCO International Union of Pure and Applied Physics.

The memory of Georgiĭ Borisovich Khristiansen will live in the hearts of his students and followers.

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