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Georgiĭ Borisovich Khristiansen (on his seventieth birthday)

May 31, 1997 marks the seventieth birthday of Georgiĭ Borisovich Khristiansen, a noted scientist, the Corresponding Member of the Russian Academy of Sciences, an authority in the physics of cosmic rays and high energies, and head of the Department of Superhigh-Energy Particles in the Research Institute of Nuclear Physics, Moscow State University (NIIYaF MGU for short in Russian).

He was born in Moscow into the family of Boris Aleksandrovich Khristiansen, a mathematician, and Nina Nikolaevna Goryainova, a secondary-school teacher. Khristiansen chose the core of his scientific interests as early as the late 1940s. While still a student and then a post-graduate of Moscow State University's Faculty of Physics, he watched superenergetic cosmic rays at FIAN's Pamir station high in the mountains under the guidance of G T Zatsepin and D V Skobel'tsyn. After he received his candidate degree in 1953, Khristiansen started an experimental study of extensive air showers (EAS) produced by cosmic rays, using a setup of his own design on FIAN's territory in Moscow. The study became known at once owing to two results: a strong suggestion that there should be a knee in the integral energy spectrum of cosmic rays at an energy of about 3×10^{15} eV, and a precision measurement of the lateral distribution function of shower particles at short distances from the axis of an extensive air shower.

Beginning in 1955, Khristiansen applied himself, on the instructions of S N Vernov and G T Zatsepin, to building a new array, unique at the time, known as MSU EAS array, with a surface area of 0.05 km^2, intended to study cosmic rays with an energy of $10^{15} - 10^{17}$ eV by simultaneously intercepting the electron, muon, and hadron components generated by such cosmic rays. Extremely exacting to himself and to his assignment and ever looking for new approaches, Khristiansen strongly influenced his younger associates in their work and their scientific thinking.

The MSU EAS array built under Khristiansen's guidance was highly praised by the leading physicists N Bohr, W Heisenberg, H Yukawa, and P Blackett when they visited Moscow State University in the early 1960s.

Studies done on the MSU EAS array in 1950s – 1960s yielded several fundamentally new findings about the lateral and energy structure of the various EAS components. The most striking result obtained by Khristiansen (for which he received a doctor's degree in 1964) was the discovery of a knee, that is, a fast change (over half an order of magnitude in energy) in the exponent of the differential energy spectrum of primary cosmic rays at an energy of about 5×10^{15} eV, deduced from data on the differential EAS spectrum in the number of particles, and from the dependence of the muon average number on the total particle number in a shower. This result evoked a vivid interest in the scientific community. The existence of the knee was confirmed by several dozen laboratories in many countries of the world (Japan, the United States, Great Britain, France, and Western Germany, to name but a few). The study of this unusual phenomenon is still going on worldwide, including the now modernized MSU EAS array with a surface area of 0.5 km^2, which has an underground muon detector 40 m^2 in area, and a magnetic spectrometer ($MDM = 1000$ GeV s^{-1}, $\Omega = 0.1$ m^2 ster). In recent years, Khristiansen and his co-workers made a very important observation in this unit: the mass of primary cosmic rays gradually but significantly increases in the vicinity of the knee, with the energy changing from 10^{15} to 10^{17} eV. This observation agrees closely with the diffusion model which presumes that the knee energy is a function of the Larmor radius, and hence, of the charge on a primary particle.

Georgiĭ Borisovich Khristiansen

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During the construction and operation of the MSU EAS array, Khristiansen suggested and developed new methods for the study of superhigh-energy cosmic rays. Under his guidance, large plastic scintillation counters (with a surface area of 0.5 m^2 each) were made and used for the first time in this country. With them, it became possible to determine the direction of the extensive air shower axis from the relative time of particles arrival at the various detectors.

In connection with an analysis of experimental data on high-energy muons (> 10 GeV) in extensive air showers with a fixed number of particles, Khristiansen suggested and developed a new method for studying the mass composition of primary cosmic rays from fluctuations of the muon flux. This method yields a rigorous result and demonstrates a sensitivity level when used in conjunction with advanced computers.

Prompted by G A Askar'yan's idea about the Cherenkov radio emission of a negative electron excess in EAS, Khristiansen proposed a new experimental method to study radio waves. Implemented on the MSU EAS array, the new method proved that the radio emission is of geomagnetic origin and has a coherent character, and that the lateral distribution of the modulus of the electrical vector of radio waves can be a good measure of the position taken up by the maximum in the cascade curve of a shower.

Beginning from the mid-1960s, Khristiansen did much to help with the construction of new arrays in the Ukraine, Georgia, Yakutia, and Uzbekistan. This was especially true of the arrays in Yakutsk and Samarkand. Working in Moscow State University's Research Institute of Nuclear Physics, he developed, with S N Vernov's support, the greater part of the equipment for the huge array with a surface area of 20 km^2 in Yakutsk. Khristiansen gathered a young research team of Moscow college graduates, who were largely responsible for the successful startup, operation and observations at the new array which remains one of the world's largest even today.

Khristiansen has taken a special interest in the Cherenkov radiation of extensive air showers. He came up with a new method, the Cherenkov pulse shape method, which makes it possible to locate the maximum in the cascade curve and the energy of an individual shower. With this method, an absolute energy calibration of observable showers was carried out up to the energy of 3×10^{19} eV, the manner in which the position of the shower maximum varies with the primary energy in the range $10^{15} - 10^{18}$ eV was determined, and the cross-section of the inelastic 'soft' interaction of primary cosmic rays with the nuclei of air atoms at an energy of 10^{16} eV was measured.

The method was accepted and came into wide use both inside and outside the Soviet Union. In particular, it was used on the Samarkand University array built under Khristiansen's guidance. There, the existence of a knee in the primary spectrum was proved for the first time when the Cherenkov radiation of EAS was observed on a clear, cloudless sky.

In his studies, Khristiansen was especially careful when he chose an hadron interaction model for superhigh energies, which he did by drawing upon the fundamental findings acquired on particle accelerators and in cosmic-ray experiments (EAS and X-ray emulsion chambers). Six years prior to works on the SPS collider, Khristiansen and his disciples concluded that it was improper from the viewpoint of experiment to extrapolate the Feynman scaling to energies in the range $10^{14} - 10^{15}$. And yet the model of quark-gluon strings accords well with observable data on extensive air showers up to the energy of 10^{17} eV. The choice of the hadron interaction model played an important role in the study of the mass composition of primary cosmic rays with energies in the range $10^{15} - 10^{17}$ eV.

In the late 1980s, physicists engaged in studies of superhigh-energy cosmic rays showed a progressively greater interest in the range of extremely high energies (higher than 10^{19} eV). This was concerned with possibilities offered by the neutron and proton astronomy. At the time Khristiansen was at the head of works on design and construction of a new EAS-1000 array (with a surface area of 1000 km^2) for studying the cosmic rays of extremely high energies $10^{19} - 10^{21}$ eV. At the present time, an international collaboration has been set up, which includes Moscow State University's Research Institute of Nuclear Physics, the Institute of Cosmic Physics and Astronomy (Yakutsk), Durham University (Great Britain), Kiel University (Germany), and Lodz University (Poland). An engineering design has been drawn up for an EAS-1000 array to be built near Volgograd, and a prototype of the EAS-1000 featuring the latest advances in electronics is operating at Moscow State University.

Khristiansen belongs to Academician D V Skobel'tsyn's school which has always been proficient in both experiment and theory. Khristiansen's work is widely known. He is an acknowledged authority in the physics of cosmic rays and high energies both inside and outside Russia. His achievements in science won him the 1982 Lenin Prize, the 1971 State Prize of the Ukrainian SSR, and Moscow State University's 1989 Lomonosov Prize. In 1990, Khristiansen was elected a Corresponding Member of the USSR Academy of Sciences.

Khristiansen's activity as a scientist and an organizer has always extended far beyond the confines of Moscow State University's Research Institute of Nuclear Physics where he heads the Department of Superhigh-Energy Particles. For many years, he has been the deputy chairman of the Scientific Council on 'Cosmic Rays' problems, formerly of the USSR Academy of Sciences, and now of the Russian Academy of Sciences, and has contributed much to promote the study of cosmic rays. Khristiansen has been very active in arranging various international and national conferences. He is a member of the commission on cosmic rays of the International Union of Pure and Applied Physics. He is putting considerable effort into the training of specialists in cosmic rays in this country. Many doctors and candidates of science in Moscow, Yakutsk, Samarkand, and Khar'kov call themselves his disciples. For more than 30 years now Professor Khristiansen has been lecturing to students at the Faculty of Physics of Moscow State University.

Now that Khristiansen is facing the task of building the EAS-1000 array in the present extremely strenuous economic conditions, we wish him new strength and great success in this challenging undertaking whose significance for science here and worldwide is difficult to overestimate.

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