# Fifth All-Union School of Inelastic Interactions at High Energies (Bakuriani, Georgian SSR, January 25–February 4, 1977)

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The All-Union School of Inelastic Interactions at High Energies, held annually in Bakuriani for the last five years, has become one of the most representative USSR schools on problems of elementary-particle physics and quantum field theory. A distinguishing feature of this school was and remains the fact that it is devoted primarily to discussions of problems at the forefront of both accelerator physics and cosmic-ray physics. In this respect, the Bakuriani school is unique. Personal contact between physicists working in these two related regions is undisputedly of mutual benefit from the point of view of both better mutual understanding and optimal planning of new experimental research.

At the same time, the scope of the school is not narrow. Its program encompasses an annually increasing large circle and fundamental and most timely problems of elementary-particle physics as a whole. There is no need for proof of the great benefit to its participants. The success of the school is due to a considerable degree to its well-knit and planned organization. Besides general lectures, the program provides for time for more restricted theoretical and experimental seminars held simultaneously. As a result, it is possible to relax the usual restrictions on the time for discussions of problems of great interest to at least some of the participants.

By tradition, the attention in the Fifth Bakuriani School was focused on strong interactions of particles at high energies. This included the following topics: asymptotic behavior of the total cross sections and the pomeron structure, the properties of elastic and inelastic diffraction processes, the energy dependence of the multiplicity, scale invariance and correlations in inelastic processes, deep-inelastic scattering, interactions of particles and of nuclei with nuclei, as well as methodological experimental problems.

The experimental situation in the case of total cross section has changed little recently, but new theoretical premises have been developed, based on the assumption that the bare pomeron is located somewhat to the right of unity ($\alpha_p(0)>1$). Experimental data in the region of acclerator energies are best described if $\alpha_p(0)-1\approx 0.07$. Questions dealt with in the school included the intrinsic consistency of this approach from the point of view of satisfaction of the unitarity relation in the $s$ and $t$ channel, as well as the energy dependence that can be expected for the average multiplicity, within the framework of this scheme. It was reported that attempts at a more detailed description, in this manner, of the experimental FNAL and CERN data on elastic scattering can encounter a number of difficulties unless one foregoes the assumed imaginary character of the scattering amplitude and the simple exponential structure of the pomeron vertex.

An interesting communication reported the results of the latest experimental and theoretical investigations on inelastic diffraction processes at high energies (in particular, their characteristic features in the theory with $\alpha_p(0)>1$). A study of the inclusive distributions in these processes has shown that they have a rather complicated structure, and in particular that the distribution in the square of the momentum transfer depends not only on the mass of the produced system, but also on the angle of the scattering of the secondary particles. It was noted that many properties of these reactions can be understood within the framework of the Drell-Hiida-Deck model.

Discussions were held on scale invariance and inclusive production of resonances in multiple processes. It can now be regarded as firmly established that at accelerator energies there is no scaling in the central region. This agrees with the results of earlier experiments with cosmic rays at higher energies. In the fragmentation region, scaling holds with accuracy ±5%. As to resonance production, owing to the large sampling and the difficulty of the analysis, the interpretation of the experimental data is ambiguous, although a number of workers state that the resonances can be had for up to 90% of all the secondary pions.

A moot point is that of large-scattering angles. The parton (quark) model and quantum electrodynamics lead here to substantially different predictions. Attention was called to the fact that the experimentally observed degree of the decrease of the inclusive cross section of hadrons with large transverse momenta ($\sigma\sim q_T^{-8}$) in the absence of an increase of the average $q_T$ with increasing $q^2$ poses certain difficulties to chromodynamics, at least when it comes to describing the experimental data at present-day energies.

At the same time it was demonstrated in a number of lectures that, on the one hand, the quark model is capa-

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ble of satisfactorily describing a large group of experimental data on hadron physics and, at the same time, the results of the experiments on the deep-inelastic $ep$ scattering and $e^+e^-$ annihilation are satisfactorily explained within the framework of quantum chromodynamics.

A number of lectures were devoted to multiple production of particles on nuclei and to methods of calculating the cross sections for the interaction of heavy relativistic particles with one another.

Much attention was paid to the question of the existence of Feynman scaling on nuclei. The dependences of the structure functions and momentum spectra in hadron-nuclear interactions on the hadron energy and on the atomic number of the target nucleus, obtained with accelerators and in cosmic rays, were considered.

The experiments show that for heavy nuclei (Fe, Cu, Pb), in a wide range of primary energies (up to thousands of GeV), the structure functions of the leading hadrons are independent in the fragmentation region of the incident particle on the energy within a 15% error. The asymmetric emission of mesons in the c. m. s. in $pp$, $\pi p$, or $Kp$ reactions of the exclusive or semi-exclusive type (and even in inclusive spectra in the reactions $\pi p$ and $Kp$), originally observed in experiments with cosmic rays, makes it possible in certain accelerator experiments to classify events by type of the exchange processes. In particular, events were singled out with $\rho$ and $\pi$ exchange, and also diffraction effect for the incident pion and target proton.

In one lecture, observation of new unusual particles were reported, generated by cosmic-ray neutrinos in an underground experiments in mines in India. The last of the registered events contains two triplets of charged particles emitted each from a single center. The Hindu physicists propose that they have registered the decays of a new heavy lepton with mass larger than or of the order of 2 GeV and with a lifetime $\tau \sim 10^{-8}$ sec.[1)]

Another discussed experiment was performed in cosmic rays by the "Pamir" collaboration using the largest x-ray emulsion chamber now in existence (its area is about 0.1 hectare). The results offer evidence that the transverse momentum of pions, from accelerator energies up to $10^6$ GeV, increases quite little (by 1.5–2 times) with increasing energy. At the same time, the characteristics of the longitudinal development of the nuclear-cascade process in the atmosphere demonstrates either that the fraction of the heavy particles in the primary cosmic rays increases at energies higher than $10^6$ GeV, or that scaling is violated in the hadron fragmentation region.

During the school session, a discussion was also held of certain assumptions concerning the investigations of multiple production at ultrahigh energies. The physicists of the Georgian SSR have proposed to register for this purpose muons with energy higher than 100 GeV, produced in the upper layers of the atmospheres.

Lectures were delivered reporting experiments on the search of charmed particles in strong interactions in processes of the $\nu p$ and $\bar{\nu} p$ type, and also on the search for anomalous $\mu^+e^-$ events in the $\bar{\nu} p$ reaction. In addition a project was reported of deep-water investigations of inelastic interactions of muons and neutrinos of ultrahigh energy.

In accord with tradition, the program of the school included lectures and seminars on the general problems of elementary particle physics and quantum field theory. The lectures on these subjects included: ideas pertaining to solutions that are nonanalytic in the coupling constant and the status of perturbation theory, the possible special role of exclusive groups and the corresponding mathematical formalism in the theory of elementary particles, oscillations of neutrinos if their mass is not zero, the elementary length, new soliton-like solutions of nonlinear equations, certain empirical relations between cosmological parameters and the fundamental constants of the physics of the microworld, and also seminars devoted to topological expansion in quark dual models and the theory of the relativistic string, the restructuring of vacuum in intense gauge fields, leptons in $SU(3)$ theory of weak and electromagnetic interactions.

Most timely was a discussion of the status of the heavy lepton observed in experiments on $e^+e^-$ annihilation. Considerable interest was attracted by a lecture on the prospects of developing a new generation of accelerators. On the whole, it can be now stated with assurance that the Bakuriani School of Inelastic Interactions at High Energies has proved itself fully. Its significance transcends now the modest tasks undertaken by its founders. Outstanding service in this respect was rendered by the management of the Physics Institute of the Georgian Academy of Sciences and its staff, who participated directly in the preparation and organization of the school.

The school attracts annually a large number of actively concerned working physicists from the largest scientific centers of our country: The Physics Institute of the USSR Academy of Sciences, the Institute of High Energy Physics of the USSR Academy of Sciences, the Joint Institute of Nuclear Research, the Institute of Theoretical and Experimental Physics, The Leningrad Institute of Nuclear Physics, The Physics Institute of the Georgian Academy of Sciences, the Erevan Institute of Physics, the High-Energy Physics Institute of the Kazakh Academy of Sciences, and many other scientific institutions.

A tragic event which cast a dark pall on the mood of the school, was the death of the great Soviet physicist Professor Vladimir Borisovich Berestetskii immediately after his arrival in Bakuriani. Vladimir Borisovich suffered from a long and heavy illness. His death is an irreplaceable loss to all who knew him and studied under him.

[1)]See, e.g., Pramana 5(3), 59 (1975).

Translated by J. G. Adashko