Fourth workshop on inelastic interactions at high energies (Bakuriani, Georgian SSR, 25 January–4 February 1976)

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The workshop on the physics of inelastic interactions at high energies was held at Bakuriani for the fourth year in a row. The basic objective of the workshop is to bring physicists working on cosmic rays and accelerators together in order to give them an opportunity to discuss both general problems bearing on the appearance of new experimental results and on the development of a theory of inelastic processes, and also methodological problems in the design of experiments. In our view, the success of the workshop has far surpassed even the most optimistic hopes of its organizers. It is, in fact, the only All-Union workshop in this division of physics.

In addition to the general lectures and seminars, time was set aside at the workshop specifically for concurrent sessions of experimental and theoretical seminars and for sessions of the Scientific Council of the USSR Academy of Sciences on the composite "Cosmic Rays" problem.

The range of problems that have traditionally been discussed at the workshop is very broad. First of all, of course, there are those bearing on the energy behavior of the total cross sections and average multiplicity in hadron-hadron and hadron-nucleus collisions. Experimental data obtained on accelerators at energies up to those of the ISR at CERN have made it possible to approximate the behavior of the total cross sections both with a function that increases logarithmically with

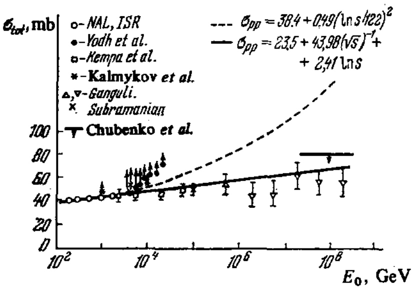

FIG. 1. Cross section of nucleon-nucleon interaction vs. energy. Data for energies above 2×10^3 GeV were obtained by converting the cross sections of interactions of nucleons with air nuclei. The results obtained by Yodh *et al.* depend on the type of primary spectrum (the data given correspond to the assumption that the exponent of the primary proton spectrum $\gamma = 2.7$).

energy and as a maximum permissible increase in accordance with the law $\ln^2 s$ (s is the square of the energy in the c.m.s.). The results obtained in cosmic rays at energies in the range from 10^3 to 10^6 GeV and reported at Bakuriani strongly support logarithmic extrapolation, whereas as the known limit approximation $\sigma_t(\text{mb}) = 38.4 + 0.49 \ln^2(s/122)$ runs above the experimental data (Fig. 1). We note that the errors of measurement of the total cross sections in cosmic rays due to errors in determining the spectrum of the primary radiation have recently been reduced by study of fluxes incident on the instrument at various angles. According to data from extensive atmospheric showers, the average multiplicity increases as a power-law function E^a of the energy E, where $a \approx 0.25-0.5$ (Fig. 2). All of these results confront the theory of strong interactions with major problems, since asymptotic constancy of the cross section and a logarithmic increase of the average multiplicity were until recently regarded as the soundest hypotheses. The workshop heard a report on an attempt to modify the Regge scheme, which leads to an asymptotic increase of the total cross section of the type $\ln^2 s$ and a slow increase in the average multiplicity with a small exponent, $a \lesssim 0.07$. In light of experimental results on inelastic processes, there was active discussion of the problem of the existence of scaling of inclusive produced-particle rapidity distributions (at present-day energies, we note a rise of these distributions in the central region and, instead of the expected plateau on the distribution, the Gaussian-function approximation is found, on the whole, to be valid); considerable attention was given to the production of resonances (experiments thus far indicate a rather indefinite fraction of pions from decay of the resonances; it varies from 10 to 80%), and to the production of particles with large transverse momenta (evidence indicating a "two-jet" structure of these events has been obtained).

The problem of secondary-particle clusterization was considered in a number of papers, both on the basis of the well-known experimental results and reduction methods and using new methods of analysis (for example, the rapidity interval method and an interference method that makes it possible to determine the dimensions of the clusters and their lifetimes).

Attempts at intuitive geometrical interpretation of the particle-interaction region were reported in the context of generalization of the impact-parameter method for inelastic processes.

Various types of theoretical multiple-production models were reflected in the papers on multiperipheral processes (in particular, the possibility of unitarization of a multiperipheral model was discussed), on statistical and hydrodynamic approaches (where the quasiclassical condition and entropy increase continue to be the most acute problems), and on the parton model.

Much attention was devoted to hadron-hadron interactions, where the results reported included weak dependence of the principal characteristics on the nucleus atomic number A, nuclear multiplicity scaling, a difference in the angular distributions of particles produced on light and heavy nuclei, and the problem of the so-called "young" (just produced) particles.

Among other things, the results obtained by Georgian physicists at the Tskhra-Tskaro mountain station near Bakuriani were discussed in detail; here we can trace the atomic-number dependence of the number of particles produced in various rapidity intervals at primary energies up to 1 TeV.

Hydrodynamic and parton models have been used in theoretical description of hadron-hadron interactions. We should note that the parton model predicts certain specific qualitative effects that are manifested especially clearly in the energy range from 10 to 100 GeV, for example the so-called antiscreening effect, i.e., an increase in the number of particles around the highest rapidities with increasing A.

Also discussed were the experimental possibilities for study of violations of rapidity-distribution scaling in multiple particle production at the highest cosmic-ray energies accessible for this purpose ($10^{14}-10^{16}$ eV) in the context of studies made by a group of laboratories using large (up to 1000 m²) x-ray-emulsion cameras at altitudes above 4 km (Pamir) and with a complex system for registration of extensive atmospheric showers (Tien-Shan).

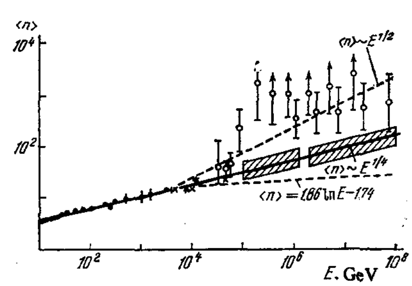

FIG. 2. Average multiplicity plotted against energy. The open circles represent data on the EAS electron component at high altitudes. The results of measurements of the muon component made in the mountains are represented by the shaded strip. The corresponding errors and the spread of the strip take account of both statistical errors and, most importantly, the uncertainty of conversion from one interaction event to the nuclear cascade in the atmosphere.

The new opportunities for accelerator experiments that are offered by large bubble and streamer chambers were discussed. Cosmic-ray specialists are also taking part in some of these experiments.

Several interesting theoretical reviewed papers were also submitted at the workshop, discussing various aspects of the quark problem and the special role of nonabelian gauge fields in the contemporary theory of elementary particles. It was stressed that many of the relationships observed in experiments (the meson-baryon cross section ratio at high energies, e^+e^- annihilation to hadrons, the energy dependence of large-angle-scattering amplitudes, etc) find natural explanations within the framework of simple quark models of the elemantary particles. Much attention was given to a discussion of the problem of confining quarks.

A theoretical seminar functioned regularly at the workshop. It was used for discussion of problems with a bearing on derivation of models of weak lepton-hadron interactions, on the mass ratio m_e/m_μ in spontaneous violation of symmetry, on the use of field-theory methods in the theory of phase transitions in statistical physics, etc. A paper on the properties of the Gell-Mann-Low function $\psi_n(\lambda)$ in $\lambda\varphi^n$ theory with the space dimension $d=2n/(n-2)$ aroused great interest. It indicated that at $n \gg 1$, the perturbation-theory asymptotic series in λ for $\psi_n(\lambda)$ can be summed, and that the function $\psi_n(\lambda)$ has a point of ultrastability. Extrapolation (though not fully justified) of the result to the case $n=d=4$ results in a fundamental conclusion: the presence of solutions in the $\lambda\varphi^4$ model in four-dimensional space-time that correspond to a finite renormalization of the "charge λ."

Popular papers on biophysical (the so-called cellular clock) and astrophysical subjects (aspects of the synthesis of ultraheavy elements in supernovas) also met with great interest.

Practical recommendations for further improvement of the large complex installation of the Georgian Academy of Sciences Institute of Physics at Tskhra-Tskaro Pass were discussed in detail at a session of the Scientific Council.

A separate session of the Council was devoted to general appraisal of the workshop and acknowledged the great assistance rendered in its planning and conduct by D. M. Kotlyarevskiĭ's Organization Committee; pertinent recommendations were sent to the Division of Physics and Mathematics of the Georgian Academy of Sciences.

Representatives from the Academy of Sciences Physics Institute, Institute of Theoretical and Experimental Physics, Moscow State University Scientific Research Institute of Nuclear Physics, Join Institutes of Nuclear Research, Leningrad Institute of Nuclear Physics, the Institute of Physics of the USSR Academy of Sciences at Tiflis, and various other scientific agencies took an active part in the workshop.

Translated by R. W. Bowers