Meetings and Conferences

INTERNATIONAL COSMIC RAY CONFERENCE

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THE International Cosmic Ray Conference was held in Moscow during July 6 -- 11, 1959, at the Moscow State University in Leninskie Gory. The Conference was sponsored by the Commission on Cosmic Rays of the International Union of Pure and Applied Physics, and was one of a series of similar conferences on cosmic rays that are being organized by the Commission regularly once every two years. (The 1957 Conference was held in Varenna, Italy; the 1955 Conference in Guanajato, Mexico; etc.) Participating in the Moscow Conference were 85 foreign scientists, about 200 Soviet scientists, and about 200 guests, who attended the various sessions. From the point of view of the number of participants, the Moscow Conference was several times larger than the previous cosmic ray conferences.

The preparatory committee, which had the task of preparing the Conference, was notified of about 250 prospective papers (out of which 85 were by Soviet scientists). In order to make a more efficient use of the time, papers on related subjects were grouped together on the Conference program. Altogether, only 103 papers were included in the program (out of which 30 were by Soviet scientists), and these were divided into 14 sessions. (Two parallel evening sessions were held daily: Session A on nuclear interactions at high energies, and Session B on intensity variations and astrophysical aspects of cosmic rays.) Nevertheless, the daily program of the Conference was overloaded, and the greater part of the discussions and deliberations took place outside the framework of the official sessions in the course of numerous unofficial "behind the scenes" meetings. These unofficial meetings were an essential part of the Conference, and their organization made it possible to discuss all the basic problems considered at the Conference much more thoroughly than would have been possible during the official sessions.

The deliberations of the Conference were devoted to the following main problems:

1. Nuclear interactions at energies which are, at present, not attainable with accelerators (experimental and theoretical investigations).
2. Electromagnetic interactions at high energies, and properties of μ mesons.
3. Extensive air showers.
4. Primary cosmic radiation (including experiments carried out using balloons, satellites, and rockets).
5. Origin of cosmic rays.
6. Intensity variation of cosmic rays.

The subjects discussed at the Moscow Conference differed from those of former conferences not only in that the experiments and results obtained by means of satellites and rockets were discussed for the first time, but also in that a substantially greater share of papers were devoted to nuclear interactions produced by particles of high and extremely high energies.

This was clearly due to the fact that new methods of investigating processes at high energies have been developed in various countries in recent years. (These consist of the "calorimetric" method of energy determination; the use of large multi-cell arrays of ionization chambers; the use of emulsion stacks of very large dimensions in conjunction with special processing methods, and marked improvements in the technique of exposing them at high altitudes; large-sized scintillation counters; the use of ionization chambers and of a photographic emulsion in a single array; the study of the Cerenkov radiation of extensive air showers; the use of electronic computers for reducing experimental data and for carrying out theoretical calculations; and others.) Of course, a great part of the credit must be given to the successes of the theory of processes at high energies.

In the study of nuclear interactions of cosmic rays which are of primary importance for this whole branch of physics, a series of facts have been firmly established in recent years. Among these are, first of all, the following: a very small variation (or even an approximate constancy) of the effective interaction cross section with energy, over a very wide range; a comparatively small multiplicity in the production of secondary particles; the fact that a great majority of the secondary particles produced are π mesons; the existence, in the center-of-mass system, of a marked "forward-backward" anisotropy in the angular distribution of secondary particles; independence of the transverse momentum of secondary particles on the energy of the primary particle over a wide energy range; a comparatively small value and small variation with energy of the mean fraction of primary energy carried away by secondary particles in nuclear-nucleon interactions up to 10^{13} -- 10^{14} ev, and large fluctuations of this quantity from collision to collision, which can be considered to be the result of a manifestation of some new collision parameter.

The results of the Conference permit us to assume that, in the near future, further fundamental results in the study of high-energy processes will be obtained which not only will considerably help to promote the understanding of these processes, but which will also shed light on the related problem of the structure of nucleons and other "elementary" particles.

On the other hand, the study of such properties and parameters of the "elementary" particles as mass, lifetime, spin, parity, conditions of their production, etc., has, in recent times, been transferred, for the greater part, from the field of cosmic rays to accelerators, where they are studied more conveniently by means of artificially accelerated particles. In connection with this, the work in this field was not discussed at the Cosmic Ray Conference, but at the Conference on High-Energy Physics held in Kiev during July 15--25, 1959. The affinity of the subjects of these two conferences made it practical to have them take place one after the other, so that scientists who came for one conference could also take part in the other.

During the discussion of experiments on nuclear interactions in the range of high energies, great interest and very lively debates were provoked by results obtained by the emulsions method on the energy spectrum of γ rays produced by high-energy particles.

The group of Prof. Powell in Bristol (**J. Duthie, C. Fisher, P. H. Fowler, A. Kaddoura, D. H. Perkins,** and **K. Pinkau**) took advantage of experimental flights of British jet planes and exposed, for 600 and 1200 hours at an altitude of $\sim$11 km, two stacks with a volume of $\sim$30 liters each, consisting of layers of emulsion alternated with layers of lead.

The very large time of exposure (emulsion stacks had usually been exposed at an altitude of 25--30 km for 8--10 hours) made it possible to detect a large number of high-energy interactions. About 600 electron-photon showers with energy larger than 2×10^{12} ev were found in the emulsions. The alternating of emulsion and lead layers led to a fast multiplication of particles in the electron-photon showers, and made it possible to observe such intensive showers in the emulsion with the naked eye.

The total background of tracks in the emulsion was so large (due to long exposure time) that the usual microscopic observation of the emulsion was impossible. It was therefore replaced by microphotometering a part of the emulsion containing the electron-photon shower found. The measurements of the microphotograms make it possible to determine the total energy spent in the shower, and consequently the energy of the γ ray which originated it.

The new method is much less laborious than the normal method of emulsion measurements by means of a microscope. The evaluation of the obtained data showed that, in the γ-ray energy range of 2×10^{12} -- 2×10^{13} ev, the integral energy spectrum is of the form $N_\gamma(>E) \sim E^{-3.5 \pm 0.3}$.

The exponent 3.5 ± 0.3 characterizes both the spectrum of γ rays produced in the layer and of γ rays produced in air and incident upon the stack from the outside.

On the other hand, it is well known that, in a very large energy range up to energies of at least 10^{17} ev, the integral energy spectrum of primary cosmic-ray particles is $N_p(>E) \sim E^{-17 \pm 0.2}$ The comparison of these two spectra shows that the fraction of the primary energy on the average transferred to π_0 mesons, and through these to γ radiation, falls strongly with increasing primary energy. The absolute value of the energy carried away by γ rays remains approximately constant, and is independent of the energy of the primary particle.

As there is, at present, no basis for doubting the existence of charge symmetry in the π-meson production, the above result means that the total fraction of the energy carried away in nuclear interactions by π mesons, or by particles which quickly disintegrate into π mesons, falls off with increasing energy. In the discussion of this conclusion at the Conference, it was stressed that, from the experimental point of view, it is easier to miss a low-energy electron-photon shower than a high-energy one in the scanning of an emulsion stack. This fact clearly indicates that there is no basis for considering the spectrum exponent 3.5 as being too high.

A large amount of material on nuclear interactions at high energies, obtained by means of emulsion stacks exposed at high altitudes, was reported at the Conference by **M. Schein** (U. S. A.), His data, however, refer mainly to energies lower than those studied by the Bristol group. Therefore, a quantitative comparison of the data of Schein with those of the Bristol group cannot be carried out.

In an experiment of Japanese physicists (**I. Fujimoto, S. Hasegawa, M. Kazuno, J. Nishimura, K. Niu,** and **N. Ogita**) the spectra of γ rays produced in nuclear interactions were studied by means of huge "emulsion chambers" (with a volume of the order of magnitude of one cubic meter). Such an "emulsion chamber" consists of alternate layers of emulsion, absorbers, and gaps, and makes it possible to determine the intensity of electron-photon showers which are initiated and developed in the absorbers of the chamber similarly as with an emulsion stack. The Japanese physicists exposed two such chambers at mountain altitudes for a duration of several thousand hours and, in scanning the plates, found in them about one hundred electron-photon showers with energies higher than 10^{11} ev.

The reduction of these data showed that, up to energies of $\sim 10^{12}$ ev, the exponent of the integral γ-ray spectrum is 1.8 ± 0.2. For higher energies, however, in agreement with the results of the Bristol group, the spectrum becomes steeper and its exponent is 2.8 ± 0.2.

On the basis of these data, the Japanese physicists also came to the conclusion that the energy fraction carried away by π mesons decreases with the energy of the primary particle, but that the total inelasticity factor changes little (due to the increase of the energy transfer to particles of another nature).

The American physicist W. **Fretter** also reached an analogous conclusion concerning the decreased energy fraction carried away by π mesons, in the energy range up to 10^{12} ev, from his precision experiments carried out with a cloud chamber placed in a magnetic field. (The measurements were carried out at sea level.) By counting the number of drops along a particle track in the cloud chamber and in this way determining the ionization produced by the particle, and by determining its momentum from the curvature of the track in the magnetic field, Fretter found the nature of secondary particles produced in a given interaction. The energy of primary particles was determined from the kinematics of the secondaries. From these data, Fretter also found that the energy carried away in a nucleon-nucleon collision by secondary π mesons falls markedly with energy.

On the other hand, in an experiment reported at the Conference by **N. L. Grigorov**, and carried out by him and his collaborators of the Moscow University at mountain altitudes by means of another method, substantially different results were obtained. In these experiments, the spectrum of ionization bursts, produced by γ rays of roughly the same energy range as the γ rays in the experiments of the Bristol group, was determined by means of an array consisting of two rows of large ionization chambers with layers of graphite and lead above and between them. However, the results of these experiments led to an integral spectrum of the γ rays of the form $N_\gamma(>E) \sim E^{-1.7 \pm 0.5}$. Thus, according to this result, the spectrum of high-energy γ rays is similar to the energy of primary nuclear-active particles and, consequently, the energy fraction carried away in nuclear interactions by π mesons remains, on the average, approximately constant.

The data obtained by Yu. A. Smorodin and his collaborators, also by means of ionization chambers at an altitude of $\sim$10 km, are in agreement with the results of N. L. Grigorov. In these experiments, a value close to 1.7 was obtained for the power exponent γ of ionization bursts produced by the electron-photon component in the energy range 10^{10}--10^{12} ev, i.e., in the same range to which the data of W. Fretter refer, and the curves obtained do not exhibit an increased slope of the spectrum for higher energies.

A discussion of the methods of the two groups held at the Conference revealed that both had used techniques having a high degree of accuracy, and consequently, the data obtained should be accepted without question. In order to explain the interesting situation that has arisen, further investigations are necessary, which will certainly be of great importance for the understanding of the processes at high energies.

Considerable interest was also attracted at the Conference by preliminary results on nucleon-nucleon interactions at 200-300 Bev energy obtained in the Cosmic Ray Laboratory of the Physical Institute of the Academy of Sciences U.S.S.R. with the collaboration of workers of the Moscow State University. In these experiments, carried out at an altitude of 3860 m above sea level, interactions produced in a thin layer of LiH placed between two cloud chambers were investigated. The energy of the primary particle producing a given interaction was determined from the total energy spent in a multi-layer "ionization calorimeter" placed under the cloud chambers, and the energy of the secondaries was found from the curvature of the tracks in the lower chamber.

Since the energy of the primary particle was, in these experiments, determined independently of the angular distribution of the secondaries and, consequently, without assuming their symmetrical emission in c. m. s., it was possible to check to what extent this assumption holds for individual interactions. The few events detected so far clearly indicate that, quite often, the majority of secondary particles are emitted in c. m. s. either "forwards" or "backwards" (with respect to the motion of the primary particle in the laboratory system). The average value of the inelasticity factor (i. e., the ratio of the energy of secondary particles to the energy of the primary particles) is close to 0. 3. However, for individual interactions, the values of this quantity fluctuate strongly, and the detailed study of the distribution showed that it is very tempting to consider the symmetrical showers as the result of the interaction of two virtual π mesons, and the asymmetrical ones as the result of the collision of a virtual π meson, belonging to one nucleon, with a central region ("kernel") of the other. If further analysis of the data already obtained and of new data should confirm the preliminary conclusions about the existence of asymmetric showers, then this will open up great possibilities for the investigation of the features of the internal nucleon field.

It should be noted that N. L. Grigorov and his collaborators, also using the "ionization calorimeter", found that, in the energy range $\gtrsim 10^{11}$ ev, the inelasticity factor characterizing the collision of a nuclear-active particle with a Fe nucleus is roughly equal to 1. Thus, in this energy range, from a light (Li, C) nucleus to a medium (Fe) nucleus, the mean inelasticity factor varies substantially. On the other hand, N. L. Grigorov emphasized that such a variation of the inelasticity factor does not occur for particles with an energy of 10^{10} ev. Therefore, N. L. Grigorov and his collaborators believe that, in the energy range 10^{10} ev, a qualitative change takes place of the character of the interaction of nuclear-active particles with heavy nuclei.

During the Conference, a fruitful discussion of the problem of so-called "two-center" stars, noted first in experiments of Polish and Czechoslovak physicists, took place. In showers of this type, the angular distribution of secondary particles corresponds to their isotropic emission in the intrinsic systems of two excited centers ("fireballs") produced in the interaction emitted in opposite directions. The "two-center model" of nuclear collisions has been also discussed in detail in a number of theoretical investigations by Japanese physicists, and reported at the Conference by **S. Hayakawa**. It became clear from the discussion that the majority of physicists working in this field consider such "two-center" stars produced in the decay of two "fireballs" to represent a small fraction of showers, although a universally accepted point of view concerning this question does not yet exist.

In a series of experiments, the Kazakh physicist Zh. S. Takibaev and his group have studied, in addition to "two-center" stars, the role of consecutive collisions which may occur when a primary particle hits a complex nucleus (in particular, an emulsion nucleus). The authors have come to the conclusion that the showers, that are by many investigators interpreted as nucleon-nucleon collisions, should rather be regarded as being produced in collisions of the primary particle with several nucleons of the target nucleus. An important process involved is the reabsorption of antinucleons inside the nucleons.

In a number of experiments reported both by Soviet and foreign scientists, data have been obtained which confirm the assumption made several years ago about the approximate constancy of the transverse momentum of secondary particles. Experiments with emulsions and cloud chambers have shown that, to a first approximation, the transverse momentum of secondary particles is independent of the primary-particle energy and of the angle of emission of the secondary particle. For secondary mesons, $P_{\perp}$ can be taken as $\sim 2.5\,\mu_{\pi}$, where μ_{π} is the π-meson mass. For secondary heavy mesons, $p_{\perp}$ will be several times greater.

These results have again been confirmed in an experiment of the Japanese physicists **S. Kaneko, O. Kusumoto, S. Matsumoto,** and **M. Tanaka,** reported at the Conference. The authors have studied nuclear interactions at 10 -- 30 Bev in an emulsion stack exposed in Japan at an altitude of 29 km. The sound establishment of these results is, of course, of great importance for the interpretation of the interaction processes at high energies.

Both during official and unofficial meetings devoted to the theory of interactions at high and extremely high energies, the present state of the hydrodynamical theory of the interactions and its outlook for the future were discussed in detail. The basic ideas concerning the problem had already been developed several years ago. However, considerable progress in the development of the theory has been made recently.

Most of the work in this field has been done by Soviet and Japanese physicists. The following were presented at the Conference: a detailed review paper by E. L. Feĭnberg, a paper by S. Hayakawa describing theoretical work on multiple meson production recently carried out in Japan, a paper presented by D. S. Chernavskiĭ describing a whole series of investigations, the papers of G. V. Wataghin (Italy), K. Sitte (Israel), and others.

E. L. Feĭnberg, in his paper, emphasized that the problem concerning the correctness of the theory of high-energy processes is essentially related to the applicability of present-day ideas concerning space and time to very small distances.

One of the most interesting points discussed in these papers is the relation between the various theories of high-energy and extremely-high-energy processes (the Fermi-Landau theory, Heisenberg theory, and others) that has been studied, in particular, by the young Soviet theoretician G. H. Milekhin. Milekhin explains the effect of the equation of state of nuclear matter in the hydrodynamical Landau theory on one hand, and of the form of the interaction Lagrangian in the Heisenberg theory on the other, on the different characteristics of nuclear interactions, and on the resulting relation between both theories and the conditions under which one theory merges into the other. In the paper by the Japanese physicist Z. Koba, it is also mentioned that the existing different variants of the hydrodynamical theory of nuclear collisions should be considered not as excluding, but rather as supplementing, each other.

It is also very interesting to divide nucleon-nucleon collisions into central and peripheric ones. Essentially, the theories of Landau and Heisenberg in their original forms concern central collisions, in which the whole energy of colliding particles is transferred to the secondaries. However, as has been shown in numerous experimental investigations mentioned above, and as can also be concluded from general considerations, a large fraction of all nucleon-nucleon collisions should be accompanied by a transfer of a comparatively small fraction of the primary-particle energy to secondary particles (so-called collisions with small inelasticity). Such a process should be characteristic for peripheric collisions of nucleons. Therefore, the explanation of the features of such collisions and the attempts of their theoretical interpretation are doubtlessly of great importance. As has been shown in the papers of E. L. Feĭnberg and D. S. Chernavskiĭ, the study of peripheral collisions, characterized by the exchange of a small number of mesons, is still in a preliminary phase. Definite results, however, have already been obtained, and the very existence of the problem of peripherical collisions in itself points to a definite success in the task of studying the structure of the nucleons.

A large number of papers presented at the Conference were devoted to extensive air showers. The following two aspects of the problem were discussed: extensive air showers as a means of studying nuclear processes at the highest energies encountered in nature and as a means of answering certain problems concerning the theories of the origin of cosmic rays, in particular of the production of particles with extremely high energies.

In recent years, a number of large complex arrays working both at sea level and at mountain altitudes have been set up at the Moscow University, the Physical Institute of the Academy of Sciences (U. S. S. R.) in the Pamirs, Tbilisi, Tokyo, Mt. Norikura (Japan), Harwell (England), Cambridge (U. S. A.), Bolivia, South India, Australia, and other places. These arrays are continuously being improved and complemented by new apparatus, and thus yield more and more data on extensive air showers.

Referring to the papers on extensive air showers presented at the Conference, one should first mention the similarity between the work carried out in the U. S. S. R. and in Japan. In both countries, attempts are being made to obtain data on processes at high energies through the study of extensive air showers. Special attention is being given to a detailed study of the core of extensive air showers.

In a paper presented by G. T. Zatsepin, describing an investigation of the cores of extensive air showers carried out at sea level by means of the array at Moscow State University, detailed data on the energy and the lateral distribution of various components of individual showers were reported. The main part of the array consists of two layers of ionization chambers, and the method used made it possible to establish that the energy flux of the electron-photon component in shower cores has no single-valued relation to the number of particles in the shower, although, on the average, proportionality is observed. The spread of the energy of shower cores around a mean value depends on the number of particles in the showers, and decreases with an increasing number of particles. For showers with a total number of particles at sea level equal to $\sim 10^5$, the measurements of the shower core energy fluctuate by a factor of ten and more. The energy of the component of the shower near the axis also varies sharply from shower to shower. Thus, experimental data on shower cores establish the existence of large fluctuations in their properties. Theoretical calculations that have been carried out show that, if we assume that the shower is produced by a small number of high-energy photons, the calculated value of the energy flux of the electron-phonton component in the shower core is greater than the observed one roughly by a factor of five.

A theoretical study of shower development was presented in a second paper by **G. T. Zatsepin**, according to which the initiation of a shower occurs as the result of many interactions of the primary nucleon of extremely high energy with the nuclei of atmospheric atoms. Fluctuations in the number of collisions, in their distribution in the atmosphere, and in the energy losses in each collision, determine the fluctuations of the shower properties. An analogous picture of shower development was also given by **T. E. Cranshaw** (England).

Another point of view concerning this problem was presented by **N. L. Grigorov**. In his paper, Grigorov stresses the role of large fluctuations in the characteristics of interactions at extremely high energies and of the fluctuations in the shower-initiation level in the atmosphere. From these considerations, Grigorov finds it possible to explain the characteristics of extensive air showers without assuming a predominant role of nuclear-active particles.

Fluctuations in the production level of extensive air showers were discussed in the paper of the Japanese physicist **S. Miyake**. The author comes to the conclusion that the presence of fluctuations can affect the shape of the energy spectrum of primary particles in the range of very high energies, and that the real number of these particles may be much smaller than presently assumed.

The role of the fluctuations in the development of extensive air showers has also been stressed in the experiment of the Tokyo group of physicists (**S. Fukui** et al.) carried out at sea level by means of a complex array consisting of scintillation counters, Cerenkov counters, a neon counterless hodoscope, μ-meson detectors, and a multi-layer detector for the study of the transition effect. At mountain altitudes, the fluctuations in the showers were studied by **S. Miyake** et al. also by means of a complex array, consisting of scintillation counters, a neutron monitor, and a huge cloud chamber with a volume of 2300 liters containing 21 lead plates.

An important approach to the experimental study of fluctuations in extensive air showers is the measurement of the intensity of the Cerenkov radiation pulses produced by the showers in the atmosphere. In fact, the intensity of such a pulse is determined by the total number of shower particles produced in the whole thickness of the atmosphere. Therefore, by comparing, for a given shower, the intensity of the light pulse with the number of shower particles at the observation level (determined, e.g., by means of a hodoscope) one can obtain a definite idea about the fluctuations in the shower development. The paper of **A. E. Chudakov** and his collaborators, based on experiments carried out on the Pamirs, was devoted to the Cerenkov radiation of extensive air showers.

The authors have come to the conclusion that, to a first approximation, the size of the light pulse is proportional to the number of particles in the shower at the observation level. With increasing shower size, only a small decrease in light intensity per charged particle is observed. The fluctuations of light intensity are small and, for showers with a number of particles $N > 10^5$, are not greater than 50%.

In a paper by the Japanese physicists **H. Fukuda, N. Ogita,** and **A. Ueda**, an analysis of the structure of extensive air showers has been carried out from the point of view of the mechanism of multiple-meson production at extremely high energies. The authors have come to the conclusion that the variation of the number of electrons with the altitude is determined essentially by the inelasticity of the collision and by the energy spectrum of secondary π mesons. In contrast, the lateral distribution of the electron-photon component is practically independent of the character of the interaction and the energy of the primary particle.

A very comprehensive quantitative study of extensive air showers at sea level has been carried out by **S. N. Vernov, G. B. Khristiansen,** and their collaborators, by means of the large array at Moscow University. In this experiment, detailed data have been obtained on the energy flux of the nuclear-active and electron-photon components of showers of various sizes. The lateral distribution of the flux of shower particles near the shower axis was determined by means of a diffusion chamber incorporated into this array. For distances of 5--30 cm from the axis, this distribution is rather flat and is of the form $\sim 1/r^n$, where $n = 0.6 \pm 0.1$.

The μ-meson component of the extensive air showers has also been studied by means of the Moscow University array. The most interesting result of this part of the work consists of the observation of such irregularities in the lateral distribution of the shower μ mesons which cannot be explained by statistical fluctuations. This has led the authors to suggest the existence of groups of correlated μ mesons in showers.

Results leading to analogous conclusions concerning the peculiarities of μ-meson production at very high energies were also obtained by Japanese physicists by means of a cloud chamber placed underground at great depths (paper by S. Higasi, M. Mitaki, et al.). In the paper of I. L. Rozental' and his collaborators, a possible explanation of μ-meson showers was considered from the theoretical point of view.

The μ-meson component of extensive air showers was also studied by T. E. Cranshaw et al. (England) and by K. Greisen (U.S.A.) at sea level, by E. L. Andronikashvili and his collaborators underground, and by S. I. Nikol'skiĭ et al. at mountain altitudes.

In the experiment of the Georgian physicists carried out at various depths underground, the energy spectrum of μ mesons in showers was investigated in detail, and the mean energy per μ meson was determined. It was found that the exponent of the μ-meson spectrum is independent of shower size and, for the integral spectrum, is roughly equal to unity. The mean energy of μ mesons at sea level was found to be 7 -- 8 Bev.

A series of experiments on the study of showers at mountain altitudes were reported by S. I. Nikol'skiĭ and his collaborators.

In these experiments, the lateral distribution of energy fluxes carried by the electron-photon and nuclear-active components of showers of various sizes, and the energy spectrum of nuclear-active particles, were studied. In addition, the characteristics of showers of various sizes were compared.

It has been demonstrated by these experiments that, in the central region of the shower (within one meter from the axis) the energy carried by nuclear-active particles is substantially greater than the total energy of electrons and photons. The energy spectra of the nuclear-active particles not accompanied by extensive air showers and of such particles in sufficiently large showers have been found to be different.

In the energy range 6×10^{11} -- 10^{13} ev, the integral energy spectrum for "single" nuclear-active particles has an exponent of ~ 1.5, while, for shower particles, it is roughly equal to unity. The value of the exponent depends strongly on the effective distance from the shower axis. This leads to a substantial difference in the absorption of the two kinds of particles. The number of ionization bursts produced by particles accompanied by showers decreases with increasing thickness of the lead absorber placed above the ionization chambers according to a mean free path of 570 ± 120 g/cm^2. For all ionization bursts (among which a large fraction are produced by "single" particles), the absorption mean free path is equal to 340 ± 60 g/cm^2.

In their paper, S. I. Nikol'skiĭ and his collaborators also discussed all available data on the dependence of the various shower characteristics on the shower size, i.e., on the total number of particles in them.

As is well known, the laterial distribution, both of all charged shower particles and of the electrons, is practically independent of the total number of shower particles, i. e., of the energy of the primary particle initiating the given shower. However, several years ago, S. I. Nikol'skiĭ and his collaborators obtained indications that the curve representing the variation of the number of nuclear-active particles in a shower with the total number of shower particles substantially changes its slope in the range of shower sizes of $\sim 10^5$ (which corresponds to a primary-particle energy of 10^{14} -- 10^{15} ev). To explain this feature, an assumption was, at that time, made about the variation of the character of the nuclear interaction at these energies. At present, S. I. Nikol'skiĭ and his collaborators have obtained data which show that the flux of particles in the central region of showers with a total number of particles from 10^5 to 5×10^5 is absorbed in dense absorbers stronger than the flux of particles in the central region of showers with a smaller number of particles. A comparison of different experiments shows that the variation of the number of μ mesons in showers with the shower size also changes somewhat for the larger showers.

These new data are in agreement with the point of view expressed by S. I. Nikol'skiĭ claiming a substantial difference in the characteristics of showers produced by primary particles with energies lower and higher than $\sim 10^{15}$ ev.

Another explanation for these variations in showers has been indicated by B. I. Peters (India). Peters assumes that the main part of showers with a number of particles $> 10^5$ is produced by protons. At higher energies, however, at which protons cannot be confined anymore by the magnetic fields inside our galaxy, their number decreases strongly, and the main bulk of showers in this range is produced by nuclei. This leads to certain differences in the shower characteristics, which can explain the peculiarities observed by S. I. Nikol'skiĭ

For a solution of this interesting problem, further investigations are necessary.

W. **Hazen** (U. S. A.) reported his observation of multiple cores of showers by means of an array consisting of 27 ionization chambers at sea level. It has been found that, out of 18 cases of the passage of a shower axis through the array, one core was observed in 16 cases, 2 cores in one case, and 3 cores in one case. Hungarian physicists (G. **Gemesy**, T. **Szandor**, and A. **Somogyi**) have, by means of a cloud chamber, studied the relation between the number of photons and electrons in showers.

The main paper dealing with the astrophysical aspect of extensive air showers was presented by B. **Rossi** and his collaborators (U. S. A.). Rossi reported a whole series of experiments carried out in various places at sea level and at mountain altitudes in the United States, India, and Bolivia, by means of powerful arrays which detected showers with different numbers of particles, up to huge showers of 10^9 particles.

The main detectors used in these arrays were large scintillation counters in the shape of a disc made of a plastic scintillator with a suitably placed photomultiplier. These detectors were placed at relatively large distances one from the other. The large resolving power of such arrays made it possible to determine the delay between the pulses produced by the shower in various counters, and thus to find not only the position of the shower axis, but also the plane perpendicular to it and, consequently, the direction of the shower axis in space. In certain cases it was even possible to measure the curvature of the shower front. The radius of curvature of this surface was found to equal several kilometers.

The determination of the direction of the shower axis in space is especially of great interest for showers produced by primary particles of highest energies, whose directions are least influenced by magnetic fields in cosmic space. The data obtained show that primary particles of highest energies are also distributed isotropically in space, which leads to the question of how particles can attain such high energies.

No anomalies have been detected in the spectrum of the greatest showers. The exponent for the integral spectrum in this region is 1.9 ± 0.1.

Since the array made it possible to determine the zenith angle of the shower axis, the absorption mean free path was found to be 113 ± 9 g/cm^2, which is in good agreement with the value determined by other methods by the majority of other investigators.

A number of attempts to establish the variation of the rate of recorded extensive air showers with the solar and stellar time and with the latitude of the place of observation were reported at the Conference by K. **Greisen** (U. S. A.), C. B. A. **McCusker** and collaborators (Ireland), S. **Ozaki** (Japan), D. S. **Krasil'nikov** (Yakutsk), E. F. **Bradley**, and N. **Porter** (England). However, in spite of the importance of the problem, and in spite of the fact that the attempt to detect a variation in the rate of extensive air showers has a long history, no data have been obtained so far which would show a definite variation in the rate of extensive air showers that is not due to any processes in the earth's atmosphere.

A series of papers devoted to the electromagnetic interactions and the properties of μ mesons at high energies were also presented.

Among the papers of this group, we should mention those by I. P. **Ivanenko** and his collaborators, by A. A. **Varfolomeev**, I. I. **Gurevich**, et al., by the workers of the Bristol group, and by the united group of Hungarian and Czechoslovak physicists, all of which were devoted to the calculation of the development of electron-photon showers at high energies and the comparison of these calculations with experimental data, especially for the initial stage of shower development. Special attention has been given in these papers to the influence of multiple scattering and of polarization of the medium on the bremsstrahlung (the Landau-Pomeranchuk and the Ter-Mikaélian effects). Measurements have been carried out with emulsion stacks irradiated by cosmic rays at high altitudes pertaining to electron-photon showers initiated by photons with an initial energy of 10^{10} -- 10^{13} ev. In spite of the fact that the measurements here are quite difficult and that the statistical fluctuations are large, the general results of these experiments indicate that the effects due to the medium are rather large in the high-energy range, and that the Bethe-Heitler formulae, which had been derived neglecting these effects, do not describe the experimental facts. In contrast, the theory of electromagnetic processes at high energies, which takes the influence of the medium into account, is, evidently, in sufficiently good agreement with experiment.

An extensive calculation program on the cascade theory, and in particular on the comparison of the development of electron-photon showers in air and in aluminum, has been carried out by means of an electronic computer by H. **Messel** and his collaborators (Australia).

A unique case of an electron-photon shower has been found by M. Schein and his collaborators (U. S. A.) in an emulsion stack exposed at an altitude of about 35 km. The authors believe that a primary photon with an energy close to 10^{15} ev underwent a collision in the emulsion in which a π° meson or a Σ° hyperon was produced which initiated an electron-photon shower. From a comparison of the shower parameters with theory, one can conclude that the energy transferred to the electron-photon component amounted to about 2×10^{13} ev. The shower can be followed in the emulsion for about 8 cascade units, and, near the place where the shower leaves the emulsion, about 7000 charged particles were counted.

A series of papers at the Conference were devoted to high-energy μ mesons. Several years ago, experiments were reported devoted to the so-called anomalous scattering of μ mesons. It was then pointed out that the occurence of large-angle scattering of μ mesons in their passage through a dense medium is higher than would be expected on the basis of pure Coulomb scattering, However, experimental data were rather contradictory. In connection with this problem, a paper by A. I. Alikhanyan and his collaborators was presented at the Conference, The authors show that, in reality, no anomalous scattering exists, and that, consequently, it is not necessary to introduce any additional interactions for an explanation of the properties of μ mesons.

K. Greisen (U. S. A.) has made an attempt in his paper to conclude about the inelasticity factor of nucleon-nucleon collisions from the value of the "positive excess" (i.e., from the excess of the number of positively charged particles in the penetrating component of cosmic radiation over the number of negatively charged particles). He has come to the conclusion that, on the average, the energy fraction transferred in a single nuclear interaction of a 600 Bev proton to the π mesons produced amounts to $(9^{+6}_{-4})\%$.

In a theoretical paper by G. T. Zatsepin, an estimate of the intensity of the electron-photon component accompanying high-energy μ mesons ($\geq 10^{12}$ ev) has been made. At these energies, a large role is played by the direct production of electron-positron pairs by μ mesons. Estimates carried out by G. T. Zatsepin show that, in principle, the presence of such pairs makes it possible to measure the energy of single μ mesons of very high energies by means of an array consisting of a large number of layers of ionization chambers separated by lead.

Among papers devoted to the primary component of cosmic radiation, the greatest attention was naturally paid at the Conference to experiments carried out by means of satellites and rockets.

As is well known, as a result of the experiments carried out by Soviet and American physicists by means of satellites and cosmic rockets, a new phenomenon has been discovered, consisting of a halo of charged particles around the earth. A charged particle in the magnetic field of the earth moves along a helix around a magnetic line of force from one hemisphere to the other. Near the magnetic pole, in the region where the gradient of the magnetic field increases, the particle is reflected, turns back, and begins to execute oscillations along the lines of force with respect to the equatorial plane. Thus, the magnetic field forms a trap around the earth in which oscillating particles are stored. Therefore, a comparatively weak source injecting particles into the magnetic trap produces a high density of particles in the halo. However, the mechanism of particle injection into the trap is not so simple, because of the symmetry between the capture and the leakage process. If a charged particle cannot leave the trap, then it also cannot enter it from the outside. Therefore, the problem of the origin of the halo deserves special attention.

The experiments carried out by means of Soviet and American satellites and rockets have shown that two zones of intense radiation -- inner and outer -- exist around the earth, separated one from the other by a region of low intensity. The inner zone represents a belt in the equatorial region stretching into both hemispheres up to 30 -- 35° latitude, beginning at an altitude between 500 and 1000 km, and ending at several thousand kilometers. The outer zone evidently reaches to 65 -- 70° latitude and, in the equatorial region, occupies an altitude range of the order of 3 -- 5 earth radii.

The composition of both zones is also substantially different. The energy of particles in the inner zone is much higher than the energy of particles in the outer zone, where electrons with energies of tens of kilovolts are predominant. In addition, protons with comparatively high energies are also present in the inner zone.

A paper describing the American experiments on the halo of particles around the earth was presented at the Conference by the person who had carried them out, J. A. Van Allen. His paper contained data already known together with new data published for the first time. Measurements carried out by means of the American rocket Pioneer IV showed a marked increase of the intensity in the inner zone at distances greater than

20,000 km from the earth's center. The data show large fluctuations in the intensities in the outer zone, and a strong injection of particles from the sun into this zone during the period preceeding the flight of the rocket.

Intensity variations at comparatively small distances from the earth were found in the observation of the artificial belt produced by an atomic-bomb explosion by the Americans (the "Argus" experiment).

Great interest was aroused by the data presented by J. A. Van Allen on the study of particles in the inner zone by means of emulsions carried by a rocket to an altitude of $\sim$1000 km. The result obtained in this experiment, namely the discovery of protons with energies of 50 -- 700 Mev in the inner zone, is in agreement with data found by means of the third Soviet artificial satellite.

A paper about Soviet experiments in this field was presented by S. N. Vernov and A. E. Chudakov. In this paper, systematic data about the inner and outer high-intensity zones around the earth were given, together with the results of measurements of the intensity of the "true" primary cosmic radiation in the interplanetary space. Data were presented on the position of the zones, on the stability of the radiation intensity in them, on their composition, and on the energy spectrum of the particles in them. A variation of the energy spectrum of electrons near the borders of the outer zone has been discovered.

In the inner zone, protons with energies of the order of 100 Mev have been found. The particles prevalent on the edge of the inner zone already have low energies.

The great majority of particles in the outer zone are electrons with energies of 20 -- 100 kev. If we represent the integral energy spectrum of these electrons in the region of maximum intensity in the form $E^{-\gamma}$, then $\gamma \approx 5$.

As far as the "true" primary cosmic radiation is concerned, the experiments carried out show that its intensity in interplanetary space beyond the limits of the outer zone is constant, and corresponds to the intensity which is obtained in experiments at those altitudes near the earth's surface where the absorption in the atmosphere is not yet felt (i.e., ~ 0.18 particles/cm^2 sec-sterad).

Papers especially devoted to an attempt to interpret the data on the high-intensity radiation zones were also heard at the Conference. In a paper by S. N. Vernov, A. I. Lebedinskiĭ, I. P. Ivanenko, and A. E. Chudakov, the hypothesis, previously proposed by these authors, that the inner zone is produced as a result of neutron decay is analyzed in detail. High-energy primary cosmic-ray particles produce nuclear disintegrations in the upper layers of the atmosphere. A certain fraction of the neutrons that are knocked out from the nuclei of atmospheric atoms disintegrate at relatively small distances from the earth, and the protons and electrons originating in the neutron decay are captured by the trap formed by the magnetic field of the earth.

The outer zone is evidently formed in the interaction of intense streams of charged particles from the sun with the earth's magnetic field. The resulting magnetic field of the earth and of the particle stream can, at a certain moment, become such that it will capture particles falling into it from the outside.

The most difficult and so far unresolved question is that concerning the causes that lead to the limitation of the space taken up by the inner zone, and its separation from the outer zone.

In the paper of the American physicist S. F. Singer, the possibility of the escape of high-energy protons due to the adiabaticity nonconservation, and of the escape of slow protons as a result of charge exchange, were discussed.

Great interest was attracted at the Conference by the paper of N. V. Pushkov and D. Sh. Dolginov on the measurement of the anomalies of the earth's magnetic field in the region of the maximum intensity of the outer zone, detected by the authors by means of a magnetometer set up in the Soviet cosmic rocket.

In this experiment, direct experimental data were first obtained on the intensity of the earth's magnetic field at distances of several earth radii from its surface, and a relation between the magnetic field and the particle halo around the earth was established.

The report of Australian scientists on the data obtained by them through the reception of signals from the third Soviet artificial satellite, and that of Japanese scientists on similar observation on American satellites, were also presented at the Conference.

V. I. Krasovskiĭ, I. S. Shklovskiĭ et al. reported measurements of the number of electrons with energies of the order of 10 kev carried out by them using the third Soviet satellite.

Among the experiments reported at the Conference which were devoted to the study of the primary cosmic radiation in the upper layers of the atmosphere, the majority were carried out by means of emulsion stacks raised to high altitudes by balloons Papers by C. J. Waddington (England), D. E. Evans; M. Schein and a group of Japanese authors; K. Kristiansson et al. (Sweden); S. Biswas et al. (India) .

In these experiments, the charge spectrum of heavy nuclei in primary cosmic radiation, the energy spectrum during various periods of sun activity, the spectrum at various altitudes, and some experimental problems, were investigated.

In the experiments of M. Shapiro et al., carried out at the maximum altitude attainable by means of balloons (at the pressure of 2.7 g/cm^2), extensive data on the number of Li, Be, and B nuclei in the primary radiation were obtained but have, as yet, not been evaluated. As is well known, the problem of the relative abundance of Li, Be, and B in the composition of primary radiation is of great importance for the estimate of the path traversed by primary cosmic-ray particles in space before reaching the earth's atmosphere. In recent years, various authors have therefore made a series of attempts to solve this problem. A clear-cut answer, however, has not been obtained as yet. The data reported at the Conference permits us to hope that, in the comparatively near future, the fraction of Li, Be, and B nuclei in the primary cosmic radiation will be accurately determined.

In the paper of A. N. and T. N. Charakhch'yan on the results of investigations carried out in the stratosphere at various latitudes by means of counters, data on the total flux of primary cosmic-ray particles were presented. For this quantity, the value of 0.48 ± 0.04 particles/cm^2 min-sterad has been obtained at the equator.

H. V. Neher (U.S.A.) reported on results obtained from a large number of balloon flights with ionization chambers at various latitudes ranging from the North Pole almost to the south geomagnetic pole. These experiments helped to locate more accurately the position of the kink on the curve representing the latitude variation of the cosmic-ray intensity at high altitudes for the southern and northern hemispheres.

N. M. Kocharyan and his collaborators have determined the spectrum of protons at the altitude of 3200 m above sea level by means of a magnetic spectrometer, and have compared it with the spectrum of the primary radiation.

No significant new ideas on the origin of cosmic radiation were disclosed. In the papers of V. L. Ginzburg, I. S. Shklovskiĭ, A. A. Korchak, and S. I. Syrovatskiĭ, the supernova theory of origin was developed in connection with new radio-astronomical data. It should be mentioned that the work of Soviet authors developing along this direction has achieved wide recognition.

Ya. P. Terletskiĭ reported on his calculation of the acceleration of charged particles by the electromagnetic field of the earth's magnetic dipole.

Japanese physicists (S. Hayakawa, M. Koshiba, M. Nishida et al.) have, in their papers on the origin of cosmic rays, focused their attention mainly on the chemical composition of the primary radiation and, in this connection, on the conditions of the acceleration of particles in supernovae. L. Davis (U.S.A.) reported on the results of his work on a number of problems related to the character of motion of cosmic-ray particles and to the possibility of their acceleration at various stages of the evolution of the galaxy.

A large number of papers on the cosmic-ray intensity variations were submitted to the Conference. However, because of the limited time, and since this problem had been discussed rather in detail a year ago in Moscow during the I.G.Y. Meeting, only short papers on variations containing material of astrophysical interest were included in the program of the Conference. Nevertheless, an exhaustive review paper by L. I. Dorman was presented at the Conference to give a total picture of the present state of the subject.

In this paper, L. I. Dorman noted that the study of intensity variations of cosmic rays had already begun in the early twenties. However, it attained great momentum only in very recent times, in connection with the comprehensive experiments included in the program of the International Geophysical Year. Before the beginning of the I.G.Y. in 1956, about 40 stations placed at various points on the earth continuously recorded the intensity of cosmic rays. At present, more than 100 such stations situated in the Soviet Union and in almost all other countries of the world (among them some in Greenland and in the Antartic) are in operation, both at sea level and at mountain altitudes.

These stations carry out measurements by means of standardized apparatus, both of the total cosmic-ray intensity and of that of its separate components. The hard and soft components in vertical direction and at certain angles with the vertical are measured at various azimuths, the neutron component is recorded by means of a specially developed neutron monitor, and the μ-meson component is recorded either by means of shielded chambers or underground. In a number of places, a continuous recording of the rate of extensive air showers is carried out. Recently, the study of the variations of the "true" primary component of cosmic rays has become widespread, and especially of the variations of the proton, the

α-particle, and the heavy-nuclei fluxes, by means of different apparatus (including emulsions) raised by balloons to high altitudes. Very valuable data on the intensity variations of the primary component of cosmic radiation and on their distribution over the earth can, and has already been, obtained by means of instruments carried by artificial earth satellites.

Investigations on such a wide front provide, at present, the possibility of thoroughly studying the separate specific intensity variations of cosmic rays and their relation to the various processes in the earth's atmosphere, in the geomagnetic field, and in the atmosphere of the sun. In addition, a detailed study of cosmic-ray variations yields valuable information on the corpuscular streams emitted by the sun which cause magnetic storms on the earth, on the state of the interplanetary space and the processes taking place in it, and on the weak but extensive cosmic magnetic fields. Thus, the data obtained from the study of cosmic-ray variations substantially complete our information obtained by astronomical and radioastronomical methods, and join the results on the study of the cosmos obtained from experiments with satellites and rockets.

If we add that the apparatus for the investigation of cosmic-ray variations is much simpler than the arrays necessary for the study of nuclear interactions at high and extremely high energies, then the great extent of work in this field is understandable.

In connection with the above, one should bear in mind a number of factors which complicate the analysis of the data on intensity variations of cosmic rays. First of all, it should be mentioned that, except for a few comparatively rare increases, the amplitude of these variations, especially at sea level and at low altitudes, is very small. In addition, the variations of the atmospheric conditions, especially of the pressure and of the temperature distribution, also lead to variations of cosmic-ray intensity, and the meteorological effects influence the different cosmic-ray components each in a different way. The corrections for meterological effects are not always sufficiently accurate since, for their determination, it is necessary to know the temperature distribution over the whole depth of the atmosphere at a given moment. Finally, charged particles of the primary cosmic radiation substantially change the direction of their motion in the magnetic field of the earth.

These difficulties, however, are not basic, and substantial success in overcoming them has been attained recently.

Among the numerous papers on specific problems of the cosmic-ray intensity variations that were presented at the Conference by Soviet, Japanese, American, English, Hungarian, Indian, German, Swedish, Argentinian, Bolivian, Italian, and Australian physicists, we can mention only a few in this limited survey.

The paper of **S. N. Vernov, A. N. Charakhch'yan** et al. on the investigation of cosmic-ray intensity variations in the stratosphere attracted great interest. By carrying out systematic and rather frequent balloon flights at three different latitudes, the authors investigated in detail the high-altitude variation with a 27-day period that had been observed by them earlier (clearly due to the rotation of the sun around its axis), and the change of its amplitude with the activity of the sun. It has been found that this variation is very pronounced for low-energy particles, and its amplitude varies therefore strongly with the elevation of the observation level.

Also important are the observations during magnetic storms. These observations stress once more that the picture of cosmic-ray variations is greatly complicated by magnetic storms. The measurements show that sometimes, (e.g., during the magnetic storm of July 8, 1958) an increase in the number of low-energy particles (< 1.5 Bev) by roughly a factor of two is accompanied by a decrease in the number of high-energy particles.

A number of papers on these problems were presented by the Moscow group of physicists studying the cosmic-ray intensity variations (**Ya. L. Blokh, E. G. Glokova, L. I. Dorman, N. S. Kaminer**, et al.). They have managed to carry out a detailed analysis of cosmic-ray intensity variations during more than 20 magnetic storms, and to deduce from the results several characteristics of each storm (distribution of the magnetic field on the front of the corpuscular stream producing each storm, the way in which the earth is engulfed in the stream, and others).

A detailed study of cosmic-ray intensity variations related to magnetic storms that were reported in the papers of **R. Chasson** and **K. Maeda** (U.S.A.), **A. M. Conforto, D. Cattani,** and **M. Galli** (Italy), and others, has made it possible to obtain definite information about the corpuscular streams and about their relation to magnetic activity. Since magnetic storms differ greatly from each other not only in their intensity but also in their character, the velocity of their growth, the degree of influence on cosmic-ray intensity, etc., comprehensive investigations at all altitudes of all components of cosmic radiation at many stations placed all over the earth are necessary in order to obtain such information. By making some assumptions concerning the velocities and sizes of the corpuscular streams carrying a frozen magnetic field in the interplanetary space, and concerning the way in which these magnetic fields engulf the earth (with their side, their front at various distances from the axis, etc.), we can compare the theoretically expected and the observed data on cosmic-ray intensity variations, and thus are able to choose with a greater or smaller degree of accuracy the most probable among the various assumptions about the corpuscular streams.

A large number of stations carrying out continuous variation measurements of the different components of cosmic radiation are essential for investigations along this direction. We can therefore hope that the attack on this problem made along such a wide front during the I. G. Y. will help to change substantially the whole situation in the study of corpuscular streams in the interplanetary space through variations of cosmic-ray intensity.

The Yakutsk group of physicists reported on a comprehensive program of investigations of cosmic-ray variations at one locality. The measurements of the hard component were carried out at sea level, at various depths underground, and by means of a double-coincidence telescope in balloon flights. In addition, extensive air showers of various sizes were recorded at sea level.

The pronounced continental climate of Yakutsk is especially favorable for the determination of the barometric and temperature coefficients for the various components of cosmic radiation, and the data of the Yakutsk physicists are, therefore, especially reliable in this respect.

Underground measurements of the intensity of the hard component for the purpose of determining the atmospheric coefficients were also carried out by the Hungarian group of physicists.

A series of papers by J. Simpson (U. S. A.), H. Elliot (England), and A. Ehmert (German Federal Republic) were devoted to the modulation of the energy spectrum of primary radiation by solar activity, and attracted great interest. In the paper of H. Elliot, data on the energy dependence of the variation with an 11-year period and of the 24-hour variation were compared with various models of the sun's magnetic field and that of the interplanetary space. It was found that these data do not contradict the hypothesis of H. Alfvén concerning the dipole character of this field.

The paper by V. A. Sarabai and other Indian physicists was devoted to the study, at low latitudes, of the energy spectrum of the anisotropic part of the primary radiation, and of the variations of cosmic rays with geomagnetic disturbances.

Argentinian physicists presented a large group of papers on observations of the variations of the nucleonic and of the hard components of cosmic radiation in the southern hemisphere, and on their correlation with sunspots.

In the papers of J. Escobar and other Bolivian physicists, the determination of temperature coefficients for the hard component and for extensive air showers at mountain altitudes in the equatorial region was reported. In these experiments, it was found that the east-west asymmetry has a value of about 14%, in agreement with the already available data. The experiment also showed that it is subject to a 24-hour variation with an amplitude of about 0.3%, and that the variations for particles coming from the east are much greater than for particles coming from the west.

On the whole, the Conference undoubtedly played an important role in the development of cosmic-ray research, and the discussions that were held will help gain a much deeper understanding of the processes at high energies and to find an explanation for the relation between cosmic rays and the various astrophysical phenomena.

From beginning to end, the Conference took place in a business-like and friendly atmosphere, and has undoubtedly contributed to the further strengthening of contact and cooperation between scientists of various countries.

Translated by H. Kasha