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Meetings and Conferences

SIXTH ALL-UNION CONFERENCE ON THE THEORY OF ELEMENTARY PARTICLES

(Uzhgorod, October 14–23, 1965)

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THE Sixth All-union inter higher educational institutions conference on elementary particle theory including a separate session on photonuclear reactions was convened by the Ministry of Higher and Middle Special Education of the U. S. S. R. on the initiative of the Chair of Theoretical Physics of Uzhgorod University. It attracted over 200 participants - mostly young scientists - from practically all the scientific centres of the Soviet Union where research on the physics of elementary particles is conducted: Moscow, Dubna, Leningrad, Kiev, Novosibirsk, Minsk, Baku, Khar'kov, Dnepropetrovsk, Uzhgorod and other cities. Scientists from a number of countries of peoples' democracies - Hungary, Poland and German Democratic Republic-also participated in the work of the Conference. The Conference took place in the resort "Nevitskiĭ" - a picturesque place at a distance of 12 km from Uzhgorod.

Following the example of two preceding conferences the work of the conference itself was preceded by an "Autumn School" (14–17 October) - a set of review papers on the principal topics in the theory of elementary particles accompanied by discussions. The conference itself took place from the 19 to the 23rd of October. On Sunday the participants in the conference could familiarize themselves with various noteworthy sights of Transcarpathia.

It is well known how "critical" is the present state of the theory of elementary particles a very brief evaluation of which we shall attempt to give below, naturally without aspiring to achieve general approbation and necessarily exhibiting an imprint of the personal predilections of the author. After an experimental, and later also a theoretical confirmation of the fact that the extreme right-hand singularity of the partial amplitude in the complex angular momentum plane is not a pole but a branch point the nature of which is, moreover, unknown, physicists were deprived of their single apparent hope of the possibility of a theoretical interpretation of strong interactions of elementary particles at high energies. And at the present time only attempts are made to give some sort of a scheme to replace the Regge model which has not justified itself.

As concerns strong interactions at low energies, the Mandelstam dispersion approach yields here a number of results which are in satisfactory agreement with experiment, although further prospects of this approach are, apparently, tied in the closest possible manner to obtaining external information on the nature of the interaction between particles at high energies.

In spite of the ever increasing number of papers interest in unitary symmetries has diminished in connection with the fact that until now quarks have not been discovered, and also following the lack of success of a relativistically consistent introduction of spin. But the recently introduced line of investigation which unifies the idea of higher symmetries with a dispersion approach appears to be definitely encouraging.

Very encouraging also is the dynamic approach to the problem of weak interactions based on a special method of "peratization" which somewhat modifies the method of l-summation proposed earlier. The problem of CP-invariance in weak (or, possibly, in "superweak") interactions the confirmed violation of which has been sensationally demonstrated in the anomalous $K \to 2\pi$ decay and which is, possibly, pregnant with the most fundamental consequences, continues to worry greatly and to disturb the minds of physicists. In the axiomatic approach which with each year attracts an every increasing number of adherents a very important development has become delineated in recent times not only in breadth but also in depth which is devoted to the physical justification of the use in this approach of one or another generalized function space. Of fundamental significance are the various asymptotic relations between the amplitudes of cross reactions obtained recently within the framework of this approach to a large extent on the basis only of physically justified postulates of quantum field theory.

Finally, certain new aspects of the theory of electromagnetism and gravitation also deserve attention.

All these aspects were to some degree represented at the conference and were subjected to extensive businesslike discussion. It is worth while to note specially the ever rising level of the All-union Conferences systematically convened in Uzhgorod

University. The next Seventh All-union Conference on the theory of elementary particles will be convened in Uzhgorod in April 1967.

1. THE AUTUMN SCHOOL

The lecture of **N. N. Meĭman** (Institute for Theoretical and Experimental Physics, Moscow) was devoted to the problem of the proof of the analyticity of the retarded asymptotic amplitude $A_{\infty}^{ret}(s, t)$ which coincides with the amplitude for the elastic scattering of two particles in the physical region of the direct reaction at high energies, and to the elucidation of the structure of allowable generalized functions on the basis of only the physical postulates of the theory of elementary particles. It was shown that the retarded amplitude A_{∞}^{ret} is analytic with respect to s in the upper half-plane and increases not faster than a linear exponential. On the basis of the principles of microcausality and of the absence of action at a distance a more general form has been found of allowed generalized functions which may contain products of δ-functions of arbitrary order.

V. Ya. Faĭnberg (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) gave a review of the principal assumptions and results of the axiomatic approach. He stated the principal postulates of the theory and discussed some problems of the theory of generalized functions and of invariance. He dealt in detail with the Wightman approach in the axiomatic method and, in particular, with the definition of the Wightman functions and with the conditions imposed on them, with the proof of Wightman's theorem, with the theorems of Hall and Wightman and of Jost and Haag and with the problems associated with them. He considered the formulation of the principle of microcausality due to Bogolyubov-Medvedev-Polivanov and derived a system of a chain of nonlinear equations for the matrix elements of the S-matrix from the basic axioms of quantum theory. The application of the principle of minimal singularity enabled him to obtain a system of equations equivalent, at least from the point of view of perturbation theory, to the usual series of the perturbation method for the renormalizable variants of the theory.

In the lecture by **Yu. M. Lomsadze** and **S. S. Tokar'** (Uzhgorod University) a discussion was given of the problem of finding the possibilities existing in principle of the experimental discovery of the existence or the absence of a stationary singularity of the field-theoretic amplitude $Tg^2(s, t)$ for the renormalizable meson theories in the case of a vanishing physical coupling constant g for the fields. Although with respect to electrodynamics and to the nonrenormalizable theories there are convincing arguments in favor of the existence of such a singularity, nevertheless in the renormalizable meson theories this problem is in fact completely open. Two possible methods of solving this problem have been discussed, the method based on utilizing the Mittag-Loeffler procedure, and the method utilizing a suitable analytic continuation of the coefficient function $U_n(s, t)$ into the complex n-plane. If it will be shown that in strong interactions the point $g^2 = 0$ is not occupied by a stationary singularity, then the former method can be utilized as the method for the effective evaluation of the amplitude $Tg^2(s, t)$, while the latter method can be utilized as the method for the effective evaluation of its asymptotic character for $s \to \infty$.

É. M. Lipmanov (Volgograd Pedagogical Institute) reported on a model of weak interactions with intermediate vector bosons, the hadron part of which possesses broken isotopic symmetry SU(2) in analogy with SU(3) for the strong interactions. The known empirical facts - the rules $\Delta T = 1/2$, $\Delta S = +\Delta Q$, $|S| < 2$ and the suppression of processes with a change of strangeness - acquire the meaning of "simple rules" for the violation of the primary SU(2)-symmetry of weak interactions of hadrons.

M. G. Meshcheryakov (JINR, Dubna) carried out a detailed theoretical analysis of the reaction $pp \to \pi^+ d$ and pointed out new problems arising from this.

V. I. Man'ko (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) reported on the possibility of the use of noncompact groups for the classification of elementary particles. He discussed the group aspects of the Schrödinger equation for the hydrogen atom on the basis of results obtained by a I. A. Malkin and V. I. Man'ko.

II. ORIGINAL COMMUNICATIONS AT THE CONFERENCE

1. Higher Symmetries of Elementary Particles

N. P. Konopleva and **G. A. Sokolik** (Scientific Research Institute of Introscopy, Moscow) have shown that the condition for covariance of equations of the type: $\Gamma^a X_a \Psi + m\Psi = 0$ with respect to a real n-dimensional unimodular group isomorphic with SU(n) is the requirement that X_a should belong to the regular representation of the group, and Γ^a should coincide with the generator of SU(n). As a final result the invariant equation takes on the form of a second order equation.

L. M. Tomil'chik (Physics Institute, Academy of Sciences Belorussian S.S.R., Minsk) has shown that the existence of a monopole as a second "electromagnetic" charge in the case of strongly interacting particles is inconsistent with the SU(2) group as an isotopic symmetry group.

R. M. Asherova, Yu. F. Smirnov and **V. E. Troitskiĭ** (Scientific Research Institute for Nuclear Physics, Moscow State University, Moscow) have calculated the Clebsch-Gordan coefficients of the SU(6) group for decomposition into irreducible

representations of the direct products of the representations 35 × 35; 56 × 56; 56* × 56*, which can be utilized for the analysis of processes in which mesons and baryons take part within the framework of the SU(6) scheme.

M. B. Menskiĭ (Scientific Research Institute for Introscopy, Moscow) obtained to arbitrary order with respect to the semistrong interaction the mass relationships for a mixture of any number of irreducible representations of SU(3).

Nguyen Van Hien and Pham Quy Tu (JINR, Dubna; Kiev University) have investigated the relationship between the symmetry groups SL(6) and $\tilde{U}(12)$, and also the structure of the vertex parts in these groups. They have studied the decay of π mesons and of vector mesons into two leptons and have shown that in this case the results of the theory of the SU(6) and $\tilde{U}(12)$ groups coincide.

A. I. Akhiezer and M. P. Rekalo (Physico-technical Institute, Khar'kov) have analyzed the different consequences of SU(6)-symmetry for processes of meson photoproduction.

2. Analytic Approach to the Problem of Strong Interactions (High and Low Energies)

V. M. Kolomiets and Yu. V. Tsekhmistrenko (Physics Institute, Ukrainian Academy of Sciences, Kiev), have investigated with the aid of the Fredholm method the analytic properties of a many-channel nonrelativistic amplitude without restricting the number of channels and have demonstrated the meromorphic nature of the amplitude on the physical sheet of the energy for any value of the coupling constant and for maximally general restrictions on the potential. For a finite number of channels they have constructed a Lehmann ellipse and have investigated the possibility of an analytic continuation of the amplitude with respect to the transferred momentum q_n to the whole plane of q_n with a cut.

A. V. Rokhlenko and Yu. V. Tsekhmistrenko (Institute for problems in materials science, Ukrainian Academy of Sciences, and Physics Institute, Ukrainian Academy of Sciences, Kiev) have developed a method for constructing in explicit form the S-matrix for elastic scattering of a nonrelativistic particle by a central field of fairly general form. The S-matrix is represented in the form of improper constructions which converge uniformly in the complex k-plane and can be utilized for approximate calculations. To any order of approximation practically the whole information regarding the analytical structure of the S-matrix and the nature of its dependence on the parameters is contained in it. The method enables one to obtain various estimates for bound states and to construct a regular procedure which, in principle, does not depend on the form of the potential operator.

Yu. M. Lomsadze and S. S. Tokar' (Uzhgorod University) have investigated the correlation between the structure of the λ-plane of the partial amplitude $f_\lambda(j, s)$ (in nonrelativistic scattering λ is the "intensity of interaction", in field-theoretic scattering $\lambda = g^2$, where g is the physical coupling constant for the fields) and its asymptotic behavior for $s \to \infty$. For nonrelativistic scattering by arbitrary twice continuously differentiable "physical" potentials the asymptotic behavior has been obtained of $f_\lambda(l, s)$ for $|\lambda| \to \infty$ along an arbitrary direction in the complex λ-plane and an explicit expression has been obtained for $f_\lambda(l, s)$ only in terms of the trajectories of $\lambda(l, s)$, its poles and the residues at these poles. The asymptotic behavior of $f_\lambda(l, s)$ for $s \to \infty$ is completely determined by its Born term. For the field-theoretic amplitude in the case of renormalizable theories an analytic continuation can be made into the n-plane of the coefficient function $U_n(j, s)$ which enables one to relate the asymptotic behavior of $f_{g^2}(j, s)$ for $s \to \infty$ with the extreme right-hand singularity of $\sin^{-1}\pi n U_n(j, s)$ in the n-plane.

V. I. Lend'el, A. I. Lend'el, V. A. Meshcheryakov, and B. M. Érnst (Uzhgorod University) have obtained a good description of the form-factors of nucleons by combining the dispersion relations for forward-backward scattering and have established the connection between the parameters of $\pi\pi$ and πN scattering and the parameters of the form-factors written in the form of Clemental and Willey formulas.

I. V. Khimich (Uzhgorod University) has shown that the field-theoretic partial amplitude in the complex plane of the coupling constant can have branch points as a result of taking into account the many-particle terms in the conditions of unitarity.

Yu. L. Mentkovskiĭ (Physics Institute, Ukrainian Academy of Sciences,) has studied the analytic properties of the partial amplitude for the scattering of nonrelativistic charged particles by the potential $(a/r) + v(r)$ and has shown that at the point $k = 0$ the partial amplitude has a very strong singularity which is of a purely Coulomb character, and has a discontinuity along the imaginary axis (without a gap). This excludes the possibility of its direct utilization in dispersion relations. The unpleasant singularities of the partial amplitude have been separated out in the form of explicit factors.

L. V. Fil'kov (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) has obtained one-dimensional dispersion relations for fixed transferred momentum in Compton scattering by a proton, from the Mandelstam representation taking into account the fact that as a result of the spin dependence of the amplitude of the process additional one-dimensional integrals appear in double dispersion relations without subtraction. In order to take the $\pi\pi$ interaction into account fourth-order perturbation theory has been utilized and also the relationship of the annihilation channel to the scattering channel obtained by the author. It is

shown that the most interesting region for investigation in which one can seek parameters of the $\pi\pi$ interaction giving a contribution to the Compton scattering is the energy interval for the incident γ quantum from 100 to 150 MeV.

3. Axiomatic Approach to the Theory of Elementary Particles

Yu. M. Lomsadze and **I. Yu. Krivskiĭ** (Uzhgorod University) have investigated with the maximum possible degree of generality the problem of making manifest the properties of the amplitude $T(s, t)$ on the basis of physically justified postulates of the axiomatic approach. In view of the difficulty of giving a general survey of this problem it is investigated further only with a restricted degree of generality. Three possible strict formulations of Bogolyubov's principle of microcausality are given. It is shown that the exponential bound on the asymptotic amplitude $T_\infty(k, t)$ in the upper k-plane which is sufficient both for writing the dispersion relations and for proving the Pomeranchuk theorem and its various generalizations is guaranteed by only one of the three formulations of this principle.

B. L. Voronov (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) has investigated the πN interaction within the framework of the axiomatic approach, the arbitrariness of which is significantly reduced by the introduction of the additional postulate of minimal singularity of the quasilocal operators.

F. A. Berezin and **V. N. Sushko** (Moscow State University) have obtained an exact expression for the elastic scattering matrix in the relativistic two-dimensional model of the self-interacting fermion field of nonzero rest mass.

4. Weak and Electromagnetic Interactions

T. S. Romanova and **F. I. Fedorov** (Physics Institute, Belorussian Academy of Sciences, Minsk) have investigated the possibility of a physical interpretation of quantum theory which utilizes an indefinite metric on the model of electrodynamics based on equations with higher order derivatives.

A. A. Borgardt and **D. Ya. Karpenko** (Dnepropetrovsk University) have solved the Kemmer equation in the field of an arbitrarily polarized plane electromagnetic wave. Reducible representations of the algebra and the method of projection operators have been utilized.

V. I. Vorontsov and **A. E. Levashev** (Belorussian University) have constructed in dual space a quasi-spin tensor on the basis of mutually dual six-dimensional bivectors of the electromagnetic field the matrix quadratic form of which forms a spin vector the components of which are the Lagrangians of the electromagnetic field with an electric and a magnetic "phase" (according to Wheeler) or of a mixed state. With the aid of a Lagrangian which is both Lorentz-invariant and covariant with respect to dual transformations the equations of motion and the conservation laws have been obtained from the variational principle in terms of Lie differentials. From a Schwarzschild Lagrangian equivalent to the former one the Lorentz- and dual-covariant equations of the electromagnetic field are obtained.

V. N. Baĭer and **V. M. Katkov** (Nuclear Physics Institute, Academy of Sciences, U.S.S.R., Novosibirsk) have investigated the phenomenon of electron polarization as a result of emission in the course of motion in a magnetic field.

V. N. Baĭer, V. S. Fadin and V. A. Khoze (Nuclear Physics Institute, U.S.S.R., Academy of Sciences, Novosibirsk) have investigated with the aid of the method of invariant integration of tensors the cross section for the electromagnetic production of pairs of particles, and have calculated the cross section for the electromagnetic production of pairs of particles in the interaction of a photon with a charged particle. The exact cross section for the annihilation of a pair of particles into two pairs of charged particles has been obtained. The integration of the Compton tensor of the fourth rank over the final states of the fermions has been carried out.

V. N. Baĭer, V. S. Fadin and **V. A. Khose** (Nuclear Physics Institute, Academy of Sciences, Novosibirsk) have derived general formulas for the cross sections for elastic scattering and for two- and three-particle annihilation of a pair of arbitrary particles in the one-photon approximation. They have also investigated processes for the production of a pair of particles in the interaction of a photon with a charged particle and in the inelastic electromagnetic annihilation of a pair.

I. B. Khriplovich (Nuclear Physics Institute, U.S.S.R., Academy of Sciences, Novosibirsk) has obtained the mass operator of the electron by means of taking into account the interaction of the gravitational and the fermion fields. In doing so he carried out the summation of compact self-energy diagrams with nonintersecting gravitational lines.

V. V. Sokolov (Nuclear Physics Institute, U.S.S.R. Academy of Sciences, Novosibirsk) has obtained spectral mass formulas in the theory of neutral vector mesons interacting with a conserved current.

É. M. Lipmanov (Volgograd Pedagogical Institute) has investigated the possibility of obtaining the minimal electromagnetic interaction of hadrons and their weak interactions as consequences of a concrete form of the breaking of symmetry of a single primary isotopically and CP-invariant interaction of hadron currents with intermediate vector bosons. Such a possibility is related to the introduction of additional currents of the $(V + A)$ type.

É. M. Lipmanov (Volgograd Pedagogical Institute) has studied the possibility of detecting hypothetical

heavy charged (e'^{+} and μ'^{+}) and neutral (e^0 and μ^0) leptons in experiments with very high energy neutrinos and in experiments on the electromagnetic production by γ quanta or in colliding electron beams.

V. S. Vanyashin (Dnepropetrovsk University) has proposed to perform an experiment on the detection of the decay $K^+ \to \pi^+ + \nu + \bar{\nu}$. The necessity for the interaction of the neutrino current with the neutral hadron current which changes strangeness follows from the hypothesis of the existence of an intermediate boson of the Wentzel-Tanikawa type.

N. Sh. Pevzner (Dnepropetrovsk Mining Institute) has investigated the electron Green's function satisfying the Källen-Lehmann conditions neglecting corrections to Γ and D. From the existence of such a function it follows that the bare mass of the electron in the approximation under consideration is infinite, while the renormalization constant of the electron propagator is $Z = 1$. It turns out that for large momenta the propagator so obtained tends to the free electron propagator slower than in the case when the bare mass is equal to zero.

V. N. Tret'yakov (Physics Institute, Belorussian Academy of Sciences, Minsk) has shown that in the impulse approximation one can obtain satisfactory agreement with experiment by starting with the amplitudes of Compton scattering by nucleons calculated on the assumption of one-meson unitarity.

Doan Nykhong, G. S. Zinov'ev and F. S. Sadykhov (Physics Institute, Azerbaidzan Academy of Sciences,) have investigated possible and experimentally verifiable violations of CP-parity in electromagnetic interactions of hadrons within the framework of the electrodynamics of the intermediate meson, in particular, in the decay $\Sigma^0 \to \Lambda^0 + e^- + e^+$. The violation of CP-parity in this decay arises in taking into account the interference of the weak interaction with the Coulomb interaction, and also on the assumption of the complex nature of the form-factors due to weak interactions.

M. A. **Braun** (Leningrad University) has shown that there exists a gauge in which the singularity of the electron Green's function is of a pole nature as $p \to m$.

D. Ya. Karpenko and **A. P. Yaroshenko** (Dnepropetrovsk University), by utilizing the integrals of motion obtained by them in the Kemmer problem for a particle with integral spin and a system of projection operators have carried out a separation of the radial and angular parts of the wave equation. An investigation of the equations so obtained has been carried out.

V. I. Kushtan (Moscow State University) has proposed within the framework of the scheme developed by him earlier of semiweak interactions with two intermediate charged bosons to introduce a violation of CP-parity by means of a phase shift of certain interaction constants of these bosons by $\pi/2$. Two variants of such a possibility have been investigated and also the consequences obtained from them.

K. Kyĭv and L. Palgi (Institute for Physics and Astronomy, Estonian Academy of Sciences) have investigated the asymmetry of the recoil nucleus in the capture of a μ-meson by a nucleus with spin.

M. S. Zhuravleva (JINR, Dubna) has investigated the decay $K^0 \to 3\pi$.

A. A. **Sokolov** and I. M. **Ternov** (Moscow State University) have shown that if a relativistic electron situated in a constant and homogeneous magnetic field is irradiated by an electromagnetic wave, then the total power of the stimulated absorption and emission may become negative. This corresponds to the predominance of stimulated emission over absorption.

5. Experimental Data at High Energies

G. Gozoki, E. Fenyves, E. Gombosi and E. Nagy (Central Institute for Physical Research, Budapest; JINR, Dubna) have investigated the coherent inelastic scattering of π^- mesons by emulsion nuclei in the reaction $\pi^- + N \to \pi^- + \pi^+ + \pi^- + N + k\pi^0$ ($k = 0, 1, \ldots$). The peak obtained in the distribution of effective masses of the three charged pions in the final state at a value of $\overline{M} = (1.09 \pm 0.02)$ GeV with a half-width (0.17 ± 0.01) can be explained by means of the mechanism of diffraction dissociation without assuming a strong influence of the A_1 resonance.

E. Nagy (JINR, Dubna) has calculated the distribution of effective masses expected in diffraction dissociation processes. A curve is obtained for the reaction $\pi^- + N \to \pi^- + \pi^+ + \pi^- + N$, where N are the light and the heavy nuclei of the emulsion.

Z. S. Strugal'skiĭ (JINR, Dubna) has determined the ratio N_n/N_p at the periphery of a xenon nucleus from an analysis of the π^- – Xe interaction at 9 Gev/c in a xenon bubble chamber. The value of N_n/N_p at the periphery within the limits of error (11%) is the same as over the whole nucleus.

V. A. Tsarev (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) with the aid of dispersion relations has carried out an analysis of experimental data on the photoproduction of K^+ mesons on protons in the reactions $\gamma + p \underset{\to K^+ + \Sigma^0}{\to K^+ + \Lambda}$. Values have been obtained for the coupling constants: $g^2_{NK\Lambda}/4\pi = 5.0$, $g^2_{NK\Sigma}/4\pi = 1.5$, and for the magnetic moments: $\mu_{\Lambda\Sigma^0} \sim \pm 1.35\,(e/2M_N)$; $\mu_{\Sigma^0} \sim 3\,(e/2M_N)$.

P. S. Baranov, V. A. Kuznetsova, L. I. Slovokhotov, G. A. Sokol and **L. N. Shtarkov** (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) have carried out a measurement of the angular dependence of the differential cross section for the Compton scattering of γ quanta by protons in the angular range for the scattered γ quantum from 70° to 150° in the c.m.s. at two energies of the incident γ quanta: 214 and 249 MeV. The resultant angular distributions have a considerable backward anisotropy. A comparison is made of the experimental angular dependences of the

differential cross section with theoretical ones obtained on the basis of using double dispersion relations.

6. Theory of Gravitation

S. M. Kolesnikov, G. A. Sokolik and **K. P. Stanyukovich** (Scientific Research Institute of Introscopy, Moscow) have proposed a model of unitary symmetry which reproduces a concept proposed by K. P. Stanyukovich of gravitation as a quadrupole exchange interaction between elementary particles. At the basis of the mathematical formulation lies the fact noted by Kursunoglu that the anticommutators of the generators of SU(2) together with the generators of the angular momentum themselves form an SU(3) algebra.

V. D. Zakharov (Scientific Research Institute of Introscopy, Moscow) gave a new generally covariant definition of the state of gravitational radiation and has shown that in the sense of this definition fields of purely gravitational radiation are the gravitational fields of the degenerate II type according to the classification of Petrov. He also defined and investigated a new class of solutions of the Einstein equations describing the coexistence of gravitational and electromagnetic waves without sources. He gave an interpretation of the front and of the trajectories of the gravitational and the electromagnetic waves from the point of view of groups of motion. He also investigated the relation of the solutions so obtained to the classification of Petrov.

S. V. Peletminskiĭ and **P. I. Fomin** (Physicotechnical Institute, Khar'kov) have defined physical space in the case of the metric created by a particle of charge e and of total mass m and have introduced a system of coordinates adequate for the "physical space." They have shown that in the "physical space" defined in this manner a pure field theory of a point particle of charge e can be constructed which leads to a finite value of the field mass $e/\sqrt{\gamma}$ (γ is the gravitational constant).

M. P. Korkina (Dnepropetrovsk University) has considered a nonlinear theory of gravitation in a plane space where nonlinearity is taken into account by the method of successive approximations. For a spherically symmetric static field an exact solution is obtained which coincides with the Schwarzschild solution in the general theory of relativity.

L. E. Lebedev (Dnepropetrovsk University) has introduced the second variational principle for a system of interacting fields which leads to the Lagrange problem with variable charges. He constructed a set of stationary points of the system and determined the charges for the limiting states.

7. Strong Interactions

V. I. Filimonov (Nuclear Physics Scientific Research Institute of Tomsk Polytechnical Institute) has investigated the possibility of Σ-hyperon decays of double hypernuclei as a result of the process $\Lambda + \Lambda \rightarrow \Sigma + N$. The probability of a process involving such decay must be of the same order as the probability of the decay of these hypernuclei into π mesons.

V. A. Lyul'ka and **V. I. Filimonov** (I. V. Kurchatov Institute of Atomic Energy, Nuclear Physics Scientific Research Institute of Tomsk Polytechnical Institute) have discussed the problems of the structure of hypernuclei, Λ-nucleon forces and the decay of hypernuclei.

A. G. Potashev (Nuclear Physics Scientific Research Institute of Tomsk Polytechnical Institute) has given an estimate of the magnitude of the $\Lambda\Lambda$ forces from the binding energy of ${}_{\Lambda\Lambda}Be^{10}$ taking into account the compressibility of the nuclear core.

Yu. P. Bulychev, G. M. Radutskiĭ and **V. A. Serdyutskiĭ** (Nuclear Physics Scientific Research Institute of Tomsk Polytechnical Institute) have calculated the cross section for the bremsstrahlung of pions when they are scattered by nucleons. They have shown that in order to explain the experimental value of the total cross section it is necessary to take into account the contribution of the γ-3π interaction.

I. B. Khriplovich (Institute for Nuclear Physics, U.S.S.R. Academy of Sciences, Novosibirsk) has found the planes of symmetry for a system consisting of two transversely polarized fermions and has pointed out the selection rules following from the existence of these planes for the production of pseudoscalar mesons in the annihilation of these particles.

V. V. Babikov (JINR, Dubna) has given a review of the present state of the meson theory of nuclear forces. He has given a comparative analysis of different models of the nucleon-nucleon interaction taking into account exchange of known pion resonances. He has considered the following models: the potential model, the dispersion relations and models utilizing the unitarization of the amplitude of one-meson exchange in explicit form, in particular, the model of the K-matrix.

8. General Problems of Particle Theory

G. A. Sokolik and **N. P. Konopleva** (Scientific Research Institute of Introscopy, Moscow) have proposed a geometric interpretation of the field potentials as coefficients of affine connectivity and have given a relation connecting the intensity of an arbitrary field and the curvature tensor.

V. I. Mal'chenko (Dnepropetrovsk University) has shown on the example of the Dirac and the Klein-Gordon equations and in the quasioptical approach that the energy-dependent absorptive potential can be constructed in a unique manner from the scattering amplitude.

V. A. Pazdzerskiĭ (Tashkent University) has obtained integral equations for the model scattering of a single scalar particle by a bound state of two other

particles without taking into account explicitly the three-particle intermediate states. This enables him to obtain an equation which depends on only one variable.

A. A. **Borgardt** (Dnepropetrovsk University) has considered the strict formulation of the boundary conditions of the Kemmer equation within the framework of relativistic quantum mechanics as applied to the passage of vector bosons through potential barriers, to diffraction problems and to diffraction in time.

A. I. **Naumov** (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) has investigated the possibility of applying perturbation theory within the framework of the Heisenberg variant of a nonlinear theory, and has proposed a modification of the free propagator which includes contributions of ghost states. With the aid of perturbation theory modified in this manner he has calculated the "nucleon" mass and the fine structure constant.

B. A. **Veklenko** and A. N. **Starostin** (Moscow Energetic Institute, Moscow) have proposed on the basis of the third quantization of a relativistic scalar field a model in which the field operator is expanded in terms of creation and annihilation operators for conglomerations of coalesced particles. In discussing interactions with an arbitrary Lagrangian of the type $\sum_m c_m \varphi^m(x)$ none of the Feynman diagrams contains any singularities.

Yu. M. **Lomsadze**, A. E. **Koval'chuk** and I. Yu. **Krivskiĭ** (Uzhgorod University) have given a rigorous proof of the well-known theorem of von Neumann on the impossibility of a dynamic description of the "reduction of a wave packet" without some assumption regarding the reproducibility of the result of a measurement. This assumption was essential in the proof of this theorem by A. Komar who discovered a weak point in the original proof of this theorem by von Neumann himself.

9. Newest Investigations in the Domain of Photonuclear Reactions and of their Applications

L. A. **Kul'chitskiĭ** (Physico-technical Institute, Leningrad) has given a review of papers devoted to the study of the photodisintegration of light nuclei.

V. P. **Denisov** and L. A. **Kul'chitskiĭ** (Physico-technical Institute, Leningrad) have investigated the photodisintegration of oxygen nuclei accompanied by emission of protons.

E. B. **Bazhanov**, A. P. **Komar**, A. V. **Kulikov** and V. I. **Ogurtsov** (Physico-technical Institute, Leningrad) have obtained curves for the differential and the integral cross sections for the yield of photoneutrons from Li^7, C^{12} and Ca^{40} nuclei.

A. P. **Komar** and E. D. **Makhnovskiĭ** (Physico-technical Institute, Leningrad) have investigated the emission of deuterons, tritons and α particles in the photodisintegration of nuclei.

Yu. M. **Volkov**, A. P. **Komar** and V. P. **Chizhov** (Physico-technical Institute, Leningrad) have investigated the excitation functions for the reactions $Be^9(\gamma p)$, $Be^9(\gamma t)$, $Be^9(\gamma d)$, and $O^{16}(\gamma d)$.

N. P. Yudin (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) has given a review of the present state of the problem of giant resonances in photonuclear reactions.

B. S. **Ishkhanov**, I. M. **Kapitonov**, V. G. **Shevchenko** and B. A. **Yur'ev** (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have studied the spectra of photoprotons from sulfur.

B. I. **Goryachev**, L. V. **Maĭling**, V. G. **Neudachin**, and B. A. **Yur'ev** (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have carried out a calculation of the dipole absorption of γ quanta by the sulphur nucleus.

B. I. **Goryachev**, B. S. **Ishkhanov**, I. M. **Kapitonov**, Zh. M. **Seliverstova**, Y. G. **Shevchenko** and B. A. **Yur'ev** (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have measured the photoproton spectra in the reaction $Si^{28}(\gamma\text{-}p)$.

D. F. **Zaretskiĭ**, M. G. **Ugrin** and A. A. **Lushnikov** (Engineering Physics Institute, Moscow; Kurchatov Atomic Energy Institute) have considered problems relating to the theory of the direct nuclear photoeffect.

G. G. **Bunatyan** (Engineering Physics Institute, Moscow) has considered some problems in the theory of photonuclear reactions.

V. S. **Dolbilkin** (Physics Institute, Academy of Sciences U.S.S.R., Moscow) has given a review of papers devoted to the measurement of the cross section for absorption of γ quanta by light nuclei in the neighborhood of the dipole giant resonance and has discussed certain theoretical problems associated with this problem.

V. G. **Ivanchenko** and B. S. **Ratner** (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) have investigated the cross section for the reaction $Zn(\gamma p)$.

Yu. N. **Ranyuk** and P. V. **Sorokin** (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) have investigated the photofission of nuclei by γ quanta up to energies of 260 MeV.

V. A. **Kaminskiĭ** and Yu. V. **Orlov** (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have reported on the role of nonphysical singularities in the partial amplitudes for scattering in the problem of the photodisintegration of the deuteron.

G. N. **Sirenkin**, A. S. **Soldatov**, N. S. **Rabotnov**, L. N. **Usachev** and Yu. M. **Tsipenyuk** (Institute for Physical Problems, U.S.S.R. Academy of Sciences, Moscow) have investigated the angular anisotropy of

photofission of Pu-239 and the quadrupole fission of even-even nuclei.

I. A. Grishaev, A. S. Litvinenko, I. S. Gorbenko and A. V. Rubashkin (Physico-technical Institute, Khar'kov) have reported on the results of experiments on the acceleration of positrons in an electron linear accelerator.

A. K. Val'ter, I. A. Grishaev, B. I. Shramenko and M. P. Rud' (Physico-technical Institute, Khar'kov) have obtained quasimonochromatic γ quanta by means of scattering of light by relativistic electrons.

L. D. Blokhintsev, É. I. Dolinskiĭ and V. V. Turovtsev (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have reported on the diagram approach to the theory of direct nuclear reactions.

F. A. Zhivopistsev, V. M. Moskovkin and N. P. Yudin (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have studied the effect of states of the type particlehole on the width of the giant resonance.

G. G. Bunatyan (Engineering Physics Institute, Moscow) has investigated certain theoretical problems concerning μ-capture).

S. P. Kruglov, V. P. Koptev, I. V. Lopatin, and V. M. Suvorov (Physico-technical Institute, Leningrad) have carried out a measurement of the intensity of bremsstrahlung radiation from electron accelerators by means of a scintillation total-absorption γ spectrometer.

I. V. Lopatin (Physico-technical Institute, Leningrad) has carried out a measurement of the energy flux of bremsstrahlung in electron accelerators.

G. A. Cherevatenko (State Committee on the Utilization of Atomic Energy) has made a measurement of the intensity of the spectra and of the energy of photons in beams of bremsstrahlung from electron accelerators with the aid of a scintillation spectrometer and a thick wall chamber.

B. S. Ratner (Physics Institute, U.S.S.R. Academy of Sciences, Moscow) has investigated the possibility of utilizing the reaction $Cu^{63}(\gamma n)$ as a monitor.

S. I. Grishanova and N. M. Kabachnik (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have considered questions associated with the study of statistical and dynamic magnetic properties of light nuclei by means of fast electrons and have discussed the behavior of the cross section for inelastic scattering of electrons at a scattering angle of 180°.

K. V. Shitikova (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) has established the connection between dipole and spin-wave collective excitations in nuclei.

V. V. Balashov and R. A. Éramzhyan (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) have investigated the mechanism of "shaking off" of nucleons in photonuclear reactions.

V. V. Balashov (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) has presented the main results of the microscopic theory of collective excitation of nuclei in the case of muon capture which has been developed recently.

V. V. Balashov and R. A. Éramzhyan (Nuclear Physics Scientific Research Institute, Moscow State University, Moscow) has considered the problem of the interaction between high energy electrons and nuclei.

I. A. Grishaev, D. I. Sikora, L. A. Shabalina, V. A. Shkoda-Ul'yanov and B. I. Shramenko (Physico-technical Institute, Khar'kov and Uzhgorod University) have determined the cross section for the reactions $Cu^{63}(\gamma n)$, $O^{16}(\gamma n)$, and $Pb(\gamma n)$ with the aid of the Belen'kiĭ-Tamm equilibrium spectrum.

M. M. Dorosh, N. P. Mazyukevich, Ya. E. Kostyu and V. A. Shkoda-Ul'yanov (Uzhgorod University) have determined the cross section for the reaction $O^{18}(\gamma p)$ by recording delayed neutrons.

Translated by G. Volkoff