The present status of quantum field theory (from materials of the Fifth International Meeting on Nonlocal Quantum Field Theory, Alushta, the Crimea, April 19–25, 1979)

M. K. Volkov and G. V. Efimov
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The Fifth International Meeting on Nonlocal Quantum Field Theory was held in Alushta during the period April 19–25, 1979.

This meeting, like the four previous ones (Dubna, 1967; Azau, 1970; Alushta, 1973; Alushta, 1976), was organized on the initiative of the director of the Laboratory of Theoretical Physics of the Joint Institute for Nuclear Research and Associate Member of the USSR Academy of Sciences, Dmitriĭ Ivanovich Blokhintsev, who died suddenly in January, 1979.

The name of D. I. Blokhintsev is inseparably linked with the history of the peaceful atom, with the development of diverse fields of modern physics, with a major contribution to the organization of Soviet science, and with the analysis of its philosophical and methodological problems.

Dmitriĭ Ivanovich Blokhintsev was always attracted to the most pressing problems of theoretical physics. A number of his papers were devoted to fundamental problems of quantum field theory—causality, and nonlocal and nonlinear interactions. In order to discuss the latest achievements in this field and to consider a large class of problems pertaining to the structure of classical and quantum field theory describing the interactions of elementary particles, the International Meeting on Nonlocal Quantum Field Theory was held in Dubna in 1967 on the initiative of D. I. Blokhintsev. Since then, these meetings became traditional and have been repeated regularly every three years at various places in our country.

The present meeting was dedicated to the memory of D. I. Blokhintsev. At this meeting, the most topical problems of contemporary field theory were discussed:

—Nonlocal field theory and the problem of strong coupling.
—Dynamics of small distances.
—Non-Abelian gauge theories.
—Unified field theories and local symmetries.
—Classical solutions of nonlinear theory and the problem of quantization.
—Confinement of quarks in quantum field theory.

Approximately 130 scientists from 10 countries took part in the work of the meeting. Over 50 talks were heard and discussed, 18 of which had the character of a review.

The meeting showed that the chosen topics completely reflected the principal directions of research in quantum field theory. Significant progress has been achieved in the past three years in each of the directions listed above.

1. THE PROBLEM OF STRONG COUPLING AND NONLOCAL QUANTUM FIELD THEORY

This problem, which is one of the most important ones of quantum field theory, was the subject of several talks.

D. I. Kazakov and D. V. Shirkov (JINR) presented a review of the problem of summing asymptotic series of perturbation theory. They outlined the achievements of recent years in the techniques for calculating the coefficients of those series, as well as the methods of obtaining estimates of these coefficients in higher orders of perturbation theory. They considered in detail a large class of methods for summing asymptotic series, using information from both low and high orders of perturbation theory and based on Padé-Borel and conformal transformations. They considered applications of these methods of summing series to problems of quantum field theory and statistical physics.

This same problem was the subject of a report by A. A. Vladimirov, D. V. Kazakov, and O. V. Gorchakov (JINR), who gave an account of a calculation of the renormalization-group functions in the φ_4^4 model in the four-loop approximation. These functions were used to find the coefficients of the ε expansions for critical indices, up to order ε^4 inclusive. A method of summation which includes Borel and conformal transformations was used to analyze the series of the ε expansion. The results are in good agreement with those of other theoretical approaches and with experiment.

A new solution of the problem of strong coupling in nonlocal theory was presented in a review talk by G. V. Efimov (JINR). The S matrix in this case was represented in terms of a functional integral, for which an existence theorem was proved. The analytic properties of the energy density of the vacuum with respect to the coupling constant and its asymptotic behavior as $g \to \infty$ were determined. This paper also contained a description of a possible way of introducing quarks in nonlocal field theory as special fields—virtons, whose propagators have no poles. The results of this model are in totally satisfactory agreement with experiment.

As is well known, one of the methods of strong-coupling theory is the method of dispersion relations. A development of this method and a proof of the generalized optical theorem were given in a paper by M. K. Po-

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livanov, A. A. Logunov, B. V. Medvedev, V. P. Pavlov, and A. D. Sukhanov (USSR), who considered the analytic properties of the matrix element for the scattering of three particles into three particles and established that the various amplitudes corresponding to all possible channels of this process are the boundary values of a single analytic function of many variables. This implies the properties of crossing symmetry and the generalized optical theorem, which in general contains contributions from 12 different processes. The technique which has been developed also makes it possible to treat arbitrary matrix elements of the processes $m \to n$.

A paper by V. I. Zhuravlev (JINR) was devoted to an analysis of dispersion relations for πN scattering in a nonlocal model proposed by D. I. Blokhintsev and G. I. Kolerov. The fundamental length in this model is estimated to be 10^{-17} cm. It was found that the size of the fundamental length depends strongly on the model for the violation of causality.

V. G. Kadyshevskiĭ (JINR) presented a review in which he proposed a new gauge-invariant formulation of the theory of electromagnetic interactions containing, besides $\hbar$ and c, one further universal scale—a fundamental length l. The equations of motion for the fermion and electromagnetic fields contain l as a parameter and generalize the Dirac-Maxwell equations in a nontrivial way. The new equations predict that charged Dirac particles have electric dipole moments, and this leads to a violation of the P and CP symmetries. The modified Lagrangian of the electromagnetic interactions provides a natural interpretation of μe universality. This Lagrangian contains a four-fermion interaction which renders the decay $\mu \to 3e$ possible and which in principle may also lead to the appearance of a mass difference between the electron and the muon. By comparing the resulting theoretical predictions with experimental data, an upper limit was determined for the fundamental length l, which was found to have the value 10^{-16} cm.

A paper by J. Lopuszanski (Poland) was devoted to a new concept in quantum field theory—nonlocal charges. Nonlocal charges are defined as natural generalizations of the ordinary charges of relativistic quantum field theory. The general form of these charges was established in terms of the asymptotic fields. Preliminary results were reported on the constraints imposed on the nonlocal charges when an interaction is present.

A paper by D. A. Slavnov (USSR) dealt with the principle of causality for a system with nonlocal classical sources. It was established that the usual representation of the S matrix in the form of a T exponent follows from the principle of causality only when the nonlocality of the sources is concentrated on spacelike hypersurfaces. An adequate regularization procedure was constructed.

A paper by A. B. Govorkov (JINR) considered a generalization of the usual scheme of field quantization in the case when second quantization is applied not to the wave function, but to the density matrix of identical particles. The algebra of the creation and annihilation operators in this case turns out to be related to one of the classical groups—the orthogonal, symplectic, or unitary group.

In a paper by M. A. Solov'ev (USSR), the intersection of the spaces satisfying the condition of Jaffe localizability was found and the spacelike asymptotic behavior of the vacuum expectation values in nonlocal field theory was determined.

An original Hamiltonian formulation of quantum field theory was considered in a paper by S. N. Sokolov (USSR). He expounded the hypotheses and facts which lead to a relativistic Hamiltonian theory of a direct interaction. The inverse scattering problem was formulated for the most general Hamiltonian quantum field theory, and a particular class of solutions of this problem was found.

A nonlinear generalization of the Schrödinger equation with a logarithmic nonlinearity was considered in a paper by I. Bialynicki-Birula (Poland). It was shown that the Schrödinger equation in this case has analytic localized solutions for any dimensionality of space, which move like classical particles for a strong nonlinearity and like quantum particles for a weak nonlinearity.

2. DYNAMICS OF SMALL DISTANCES

A number of papers were devoted to the theoretical and experimental investigation of the dynamics of small distances, the most likely candidate for which is now believed to be quantum chromodynamics (QCD).

A. V. Efremov and A. V. Radyushkin (JINR) presented a review of the justification for the parton model in terms of quantum chromodynamics on the basis of a study of the asymptotic behavior of Feynman diagrams. In this approach, it was possible to generalize the operator expansions to a number of inclusive processes (the production of massive lepton pairs in hadron collisions) and exclusive processes (the electromagnetic form factor of the pion). This paper also considered the experimental status of QCD, and it was concluded that QCD provides a quantitative description of many characteristic features of hard processes and is rightly considered to be a serious candidate for a theory of the strong interactions. At the same time, a number of difficulties connected with the Fermi motion of quarks and discrepancies between the coupling constants obtained from various sources were noted.

This same problem was the subject of a paper by D. Politzer (USA). In contrast with the approach developed in the previous paper, Politzer's approach is based on a study of the mass singularities. For self-consistency of the parton picture, it is required that the singular terms can be separated in the form of a universal factor which leads to a renormalization of the "naive" distribution functions and decay functions of the partons. It was shown that such factorization occurs in all the logarithmic terms of all orders of perturbation theory.

A paper presented by V. I. Zakharov (USSR) dealt with a study of the quark and gluon fields in a vacuum.

These fields are characterized by vacuum expectation values such as $\langle 0|q\bar{q}|0\rangle$ and $\langle 0|G_{\mu\nu}G_{\mu'\nu'}|0\rangle$, where q denotes the quark fields and $G_{\mu\nu}$ is the stress tensor of the gluon field. Expressions were found for the masses and lepton widths of the vector and axial-vector mesons in terms of these vacuum expectation values. The relation between $\langle q\bar{q}\rangle$ and $\langle G^2\rangle$, as well as their relation to the normalization point Λ of the quark-gluon coupling constant, were considered.

A number of original papers were devoted to this same topic.

A paper by N. I. Karchev (Mathematics Institute, USSR Academy of Sciences) dealt with the coefficient functions $G_{\varepsilon,\alpha}(p_1,\ldots,p_N)$ of the Feynman diagrams in massless models of quantum field theory, where the parameter ε brings about infrared regularization of the propagator. A formulation was given of the conditions for the existence of the limit $\varepsilon\to 0$, which required for a correct formulation of the subtraction procedure and for the derivation of Wilson's expansion.

A paper by A. V. Radyushkin (JINR) contained an account of a new approach to the study of the asymptotic behavior of the pion electromagnetic form factor in QCD. It was shown that the behavior of $F_\pi(Q^2)$ as $Q^2\to\infty$ is determined by the dynamics of the interaction at small distances. A formula was obtained in which the asymptotic behavior of $F_\pi(Q^2)$ is expressed in terms of the fundamental constants of the theory.

In a paper by K. G. Chetyrkin (USSR), the author discussed the result of a calculation of the three-loop corrections to the total cross section for e^+e^- annihilation into hadrons in QCD by means of a new technique which he developed using Gegenbauer polynomials in X space. It was shown that the corrections of order α_s^2 are not small and that allowance for them leads to a decrease (by approximately a factor 4) in the value of the fundamental constant Λ which determines the scale of the strong interactions.

A paper by E. Wieczorek (GDR) contained a discussion of corrections to the gluon propagator in QCD due to nonleading logarithms. It was proved that inclusion of nonleading logarithms of finite order cannot lead to the appearance of a power behavior near the mass shell, as is required for asymptotic confinement of quarks.

3. NON-ABELIAN GAUGE THEORIES

Great attention was paid at the conference to non-Abelian gauge theories, and in particular to Yang-Mills fields, whose specific features are the basis of hopes for solving the problem of "color" confinement.

A review of the present status of the theory of such fields was given by A. A. Slavnov (USSR). In his talk, he discussed various geometrical interpretations of the Higgs effect and the role of instantons in quantum dynamics. The possibility that instantons may not exist at all in the exact quantum problem was noted. A brief review was given of gauge theories on a lattice, and consideration was given to a formulation of the Yang-Mills theory in terms of contour variables, which explicitly demonstrates the analogy between this theory and the nonlinear σ model and which makes it possible to obtain nonlocal conservation laws.

In a paper by V. N. Pervushin (JINR), a new procedure was proposed for the quantization of non-Abelian gauge fields, which permits a separation of the transverse degrees of freedom and the degree of freedom describing the topological properties of the Yang-Mills field. Quantization of the topological degree of freedom leads to quantization of charge and to physically nontrivial background fields with zero effective action, which are capable of "confining" the quantum excitations of the color fields.

A paper by I. Ya. Aref'eva (USSR) discussed a nonlocal reformulation of the Yang-Mills theory in terms of integrals of the gauge field over closed contours. It was shown that the D-dimensional Yang-Mills theory is equivalent to the $(D-1)$-dimensional theory of the basic chiral field on an appropriate global group specified in the space of contours. This effective reduction in the dimensionality of the space makes it possible to assert, for example, that the three-dimensional Yang-Mills theory, like the two-dimensional nonlinear σ model for the basic chiral field, is a completely integrable system, to which the methods of the inverse scattering problem can be applied. This paper demonstrated a profound relationship of the Yang-Mills theory in the contour representation with the theory of relativistic strings, i.e., with duality: with certain restrictions on the gauge fields ($F_{\mu\nu}F_{\mu\nu}\sim$ const+. . .), the equation for the basic chiral field on a contour is identical in form with the equation for the functional of a closed string.

An interesting formulation of the Yang-Mills theory was proposed in a paper by A. M. Polyakov (USSR), who introduced Green's functions whose arguments are not space-time points, but contours. A detailed study was made of the simplest Green's function depending on a single contour. This approach offers hope that the Yang-Mills field, at least without quark fields, will be, like two-dimensional chiral fields, a completely integrable system, i.e., that it will be possible here to construct infinite series of conservation laws.

J. Zinn-Justin (France) presented a discussion of the properties of a new class of nonlinear sigma models—the so-called CP_n sigma models, based on the group SU(n). By including certain nonminimal interactions, these models can be made gauge-invariant without introducing independent gauge fields. The CP_n models exhibit a particularly close analogy with non-Abelian gauge theories, and for this reason their study may greatly clarify the problem of quark confinement.

This same topic was the subject of a number of original papers.

It was shown in a paper by E. A. Ivanov (JINR) that the previously proposed interpretation of gauge fields as Goldstone fields naturally leads to a reformulation of the Yang-Mills theory in terms of bilocal variables. The Yang-Mills theory is then a definite sector of the nonlinear σ model for the bilocal basic chiral field on

an appropriate global group. In this approach, the string functional of the gauge fields arises in a natural way as a result of covariant elimination of the inessential parameters of the factor space of the local group with respect to the global subgroup. It was argued that the symmetric phase of the Yang-Mills theory should be described by a bilocal linear σ model, and the simplest linear infinite-dimensional representatives of the gauge group were constructed.

A paper by B. M. Zupnik (USSR) described a study of nonlocal symmetry groups whose transformations are determined by unitary operators. The corresponding gauge fields are bilocal field functions. The hypothesis of a nonlocal strong interaction of quarks was discussed in the framework of a nonlocal generalization of the Yang-Mills theory. Spontaneous symmetry breaking and the Higgs effect in nonlocal groups are described by means of bilocal Goldstone fields.

M. A. Savel'ev and A. N. Leznov (USSR) obtained equations of motion and duality equations for an arbitrary gauge group in the spherically symmetric case. They constructed the general solution of the duality equations, which generalizes the Liouville equations for the group SU(2).

A paper by A. K. Pogrebkov and M. K. Polivanov (USSR) dealt with the global solutions of the two-dimensional Liouville equation corresponding to initial data for the Cauchy problem with singularities. They showed that the singularities of the solutions form smooth nonintersecting timelike curves which extend to infinity.

In a paper entitled "Multicolored chromodynamics," A. A. Migdal (USSR) developed an approach to non-Abelian gauge theories based on functionals specified on space-time contours. It was suggested that this approach will be most suitable for constructing the mathematical formalism in the Yang-Mills theory. This author also considered the introduction into non-Abelian gauge theories of three gauge-invariant antisymmetric tensor fields. These fields are certain nonlinear combinations of the conjugate field tensor and obey the $O(3)$ algebra. An effective chiral Lagrangian for those fields is introduced. This describes three vector and three axial-vector fields with the quantum numbers of the vacuum. Masses arise as a result of spontaneous breaking of the Lorentz symmetry.

In a paper by M. V. Terent'ev (USSR) entitled "Dynamics on a group and the path integral," the spectral expansion of the Green's function describing the free motion of a point on an arbitrary compact group was used to derive a representation in the form of a functional representation related to the compactness and to the curvature of the group representation.

Problems related to the complex topological structure of the vacuum in gauge theories, in particular the problem of CP invariance in QCD, were considered in a paper by V. A. Matveev, N. V. Krasnikov, and A. N. Tavkhelidze (USSR). Here possible methods of solving this problem were discussed: a) the assumption that the u gaurk is massless; b) the existence of a light axion; c) dynamical suppression of the structure of the Θ vacuum.

A paper by V. V. Bazhanov, V. I. Borodulin, G. P. Pron'ko, and L. D. Solov'ev (USSR) was concerned with the quantum theory of the Dirac-Schwinger monopole. An amplitude for small-angle electron-scattering satisfying the requirement of relativistic invariance was obtained.

4. UNIFIED FIELD THEORIES AND LOCAL SYMMETRIES

In connection with the major successes of the Weinberg-Salam unified theory of the weak and electromagnetic interactions, it seems particularly interesting to attempt to unify all interactions, including gravitational interactions, on the basis of supergauge symmetries. These problems also received great attention at the meeting.

S. M. Bilen'kiĭ (JINR) presented a review of the latest experimental data on neutral currents. He demonstrated the agreement of the data with the Weinberg—Salam gauge theory. The problem of lepton mixing and neutrino oscillations was considered in detail. A detailed discussion was given of P-odd asymmetries in deep inelastic scattering of polarized leptons by nucleons.

It was demonstrated in a paper by M. K. Volkov and D. Ebert (JINR) that all the decays of the pseudoscalar mesons of the basic octet can be well described in the framework of a quantum chiral SU(3)×SU(3)-symmetric theory. A discrepancy between theory and experiment is found only in the description of the decay $\eta \to \pi^0\gamma\gamma$. A unified Weinberg-Salam model was constructed in an SU(4)×SU(4) theory. A scheme of SU(4)×SU(4) symmetry breaking was proposed, making it possible to obtain mass formulas for the 15-plet of mesons and the 20-plet of baryons.

In a paper by V. I. Ogievetskiĭ and E. Sokachev (JINR), a minimal group for supergravity was proposed. The group is specified as the complex supergroup of general coordinate transformations in the conjugate left-handed and right-handed chiral superspaces. The gravitational axial superfield is identified with the imaginary part of the vector coordinate of the complex superspace. The formalism of differential geometry was developed for this supergroup. In this formalism, all quantities are expressed in terms of only the gravitational superfield, and the local Lorentz group is induced by the world supergroup.

A paper by D. V. Volkov and V. V. Akulov (USSR) considered superspaces with dimensionality $n = n_b + n_f$, where n_b is the dimensionality of the Bose coordinates and n_f is the dimensionality of the Grassman coordinates. It was shown that the Einstein superspaces with dimensionalities (0,2), (0,4), and (1,2) are spaces of constant curvature. The vacuum solution was found, and solutions of the Killing equations which preserve the vacuum metric in the superspace (1,2) were obtained. The group of motions of this metric contains the supersymmetry group as a subgroup.

The motion of a point particle in a superspace with

the most general metric was considered in a paper by A. I. Pashnev and D. V. Volkov (USSR). The corresponding action is invariant under arbitrary transformations of the proper time, the result of which is the presence of couplings in the model. It was shown that under certain conditions the couplings of the second kind disappear and only a single coupling of the first kind remains in the model. The equations of motion that are obtained admit an exact solution, which can then be readily quantized. The requirement of the existing coupling on the physical states leads to definite relations between the masses of the particles. The spectrum of physical states of the model contains three irreducible supermultiplets, within each of which the particles are degenerate in mass. Of these, are two scalar supermultiplets and one vector supermultiplet.

In a paper by G. Parisi (Italy), restictions on the masses of particles and the values of the fundamental constants were considered. It was shown that the fact that the masses of the nucleon and the W boson are close to one another on a logarithmic scale in comparison with the Planck mass has a natural explanation in the framework of a unified model of all types of interactions if the number of quarks is of order 16–20. For 16 quarks, the restriction $\alpha < 1/130$ and the value $\sin^2\Theta_W \approx 0.17$ were obtained. The bound $m \lesssim 200$ GeV on the masses of the heaviest quark and the Higgs boson was obtained. If the quark mass is $\gtrsim 100$ GeV, the mass of the Higgs boson is also bounded from below.

V. P. Frolov (USSR) presented a review of a large class of problems connected with the phenomenon of "quantum evaporation" of black holes. Particular attention was given to the explanation of the origin of the interaction of the thermal density matrix describing the particles produced by a black hole, in particular the relation to the principle of equivalence. It was argued that allowance for quantum effects weakens, and perhaps even eliminates, the singularity at $r = 0$ which arises inside a black hole during the collapse of a massive body. Consideration was also given to the possible existence of elementary black holes (maximons), their stability, and the possible production of gravitationally bound objects from maximons and their observation.

A paper by V. N. Mel'nikov (USSR) was concerned with the theory of gravitation with a conformal scalar field and its application to problems of cosmology: the singular state and the production of particles in the early stages of evolution of the Universe. It was shown that spontaneous breaking of the gauge symmetry leads to prevention of the singular state and to evolution of the masses of the physical particles. In the case of a massive scalar field, the symmetry is restored and the masses no longer evolve.

A paper by E. Lukierski (Poland) treated n-dimensional σ fields on quaternion projective planes whose topology is determined by the Pontryagin index. Three ways of introducing supersymmetric σ models were proposed.

P. Hasenfratz (Hungary) considered the appearance of an anomalous dependence of spin and statistics as a result of the action of the operator "disorder × order." He showed that the angular momentum can take the value $\frac{1}{2}$ ($\frac{1}{3}$) in a (2+ 1)-dimensional SU(2) (SU(3)) gauge theory, independently of the presence of soliton solutions or Higgs fields.

5. CLASSICAL SOLUTIONS OF NONLINEAR FIELD THEORY AND THE PROBLEM OF QUANTIZATION

These problems also received great attention at the meeting.

In a paper by L. D. Fadeev (USSR), the method of the inverse scattering problem which had been successfully applied to the solution of nonlinear evolution equations in the classical theory was generalized to the quantum case. Auxiliary linear equations, the consistency condition for which is the original nonlinear equation, were treated in this paper as operator equalities. The scattering matrix in the corresponding linear spectral problem was also regarded as a quantum operator. Commutation relations were postulated between the elements of the scattering matrix, which play the role of canonically conjugate dynamical variables, and the Hamiltonian operator was constructed. The proposed scheme for quantizing a nonlinear problem was illustrated for the example of the "sine-Gordon" equation, for which an exact quantum theory was constructed.

In a paper by V. E. Zakharov (USSR), the method of the inverse scattering problem was applied to the study of two-dimensional relativistically invariant models of field theory—the principal chiral fields on Lie groups, and chiral fields on homogeneous spaces of Lie groups, in particular n-fields, and on spheres and projective spaces. The method also makes it possible to integrate classical two-dimensional spinor systems: the model of Nambu and Jona-Lasinio, the model of Gross and Neveu, and similar models. In addition, the method enables one to construct a solution of Einstein's gravitational equations in a vacuum in the case when the meric tensor depends on two variables. In all cases, N-soliton solutions were constructed the Schwarzschild field in a vacuum is a particular case of a soliton solution.

A. T. Filippov (JINR), in his paper entitled "Nontrivial solutions of some nonlinear problems in classical and quantum field theory," called attention to the irregular solutions which arise in many physical problems (gauge theories and quark models). Owing to their singular character, these solutions are usually not considered. It was shown in this paper that a perspicuous physical interpretation can be given to the irregular solutions of nonlinear equations in many situations and, in addition, that it is these solutions that prove to be most appropriate for the physics in a number of cases (for example, a quark-quark potential which is singular at a finite distance, and so forth).

A review of the utilization of methods of differential geometry in the theory of nonlinear two-dimensional models was presented by V. V. Nesterenko and B. M. Barbashov (JINR). The field functions in two-dimen-

sional theories specify some surface, which in the general case is embedded in a Riemannian space. According to the embedding theorem of differential geometry, such a surface can be described by means of its basic quadratic forms. The coefficients of these forms obey the Gauss-Peterson-Codazzi-Ricci equations, which are treated in this approach as equations of motion. If use is made of the fact that these equations constitute the consistency condition for the derivative formulas describing the motion on the surface of the moving basis, it is possible to construct the corresponding linear equations required for the application of the method of the inverse scattering problem. The nonlinear two-dimensional sigma model and the theory of the relativistic string were considered in this approach. A discussion was given of the soliton solutions which arise in this case in the string model, as well as their quasiclassical quantization and mass spectrum.

6. CONFINEMENT OF QUARKS IN QUANTUM FIELD THEORY

The session was opened with a review talk by P. N. Bogolyubov (USSR) entitled "The present status of quark models." This paper was concerned with different variants of quark models based on appropriate equations for bound states. The results obtained for the intrinsic properties of elementary particles are in good agreement with experiment. The latest achievements and difficulties of the bag model were discussed in detail.

A paper bu M. A. Ivanov and G. V. Efimov (JINR) was devoted to the nonlocal field approach to quark confinement. In this theory, it is possible to construct a quantized field, called the virton field, which is absent in the free state but which can exist in a virtual state. This field was used to construct a model of hadronic interactions in which the virton is identified with a quark. It is assumed that the physical particles are described by ordinary quantized fields but interact with one another only through quark-virton fields. This model was used to calculate the widths of a number of strong, weak, and electromagnetic decays of mesons and baryons. Satisfactory agreement with experiment was obtained.

One of the possible variants of the nonlocal quark model was proposed by L. Micu (Rumania) in a paper entitled "A covariant nonlocal quark model." In constructing this model, use was made of the axiomatic approach to nonlocal field theories.

The problem of quark confinement led to the study of the relativistic equations for the mechanics of two material points with a linear interaction potential, which was considered in a paper by N. S. Shavokhina and N. A. Chernikov (JINR). A solution was given in the form of a boundary-value problem for a minimal surface in the space-time of the spectral theory of relativity. The laws of conservation of energy, momentum, and angular momentum were demonstrated. The concept of a proper time axis for the system was given. The case in which the mass of one of the particles is infinite was considered. In this case, a differential equation with a displaced argument is formed, which in the nonrelativistic limit reduces to the corresponding Newton's equation of classical mechanics. The problem of two particles with equal masses leads to this same case. The concept of minimons as carriers of the studied interaction was introduced.

In a concluding talk, the chairman of the organizing committee, Academician M. A. Markov, summarized the meeting and indicated the principal lines of development of the contemporary science of the microworld. The speaker considered fundamental problems of physics, such as black holes an gravitation, the existence of hypothetical particles—maximons, the hypothesis of an elementary length, the dynamics of strong interactions and quark confinement, and unified field theory. In conclusion, he commented on the high scientific level of the contributions and on the good organization of the meeting, and he expressed hope that the tradition of holding such meetings will continue in the future. The participants of the meeting who spoke after this, L. D. Faddeev (Leningrad Division, Mathematics Institute, USSR Academy of Sciences), V. Ya. Fainberg (P. N. Lebedev Physics Institute, USSR Academy of Sciences), J. Lopuszanski (Poland), and J. Zinn-Justin (France), expressed agreement about the high appraisal of the meeting.

The Publishing Department of the Joint Institute for Nuclear Research has published the collected works of the Fifth International Meeting on Nonlocal Quantum Field Theory (Proc. of the 5th Intern. Meeting on Nonlocal Field Theory, Dubna, R-12462, JINR, 1979), which contains mainly the reviews mentioned in this report.

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