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A. T. Filippov

ANNUAL REPORT

BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

Report to the 87th Session
of the JINR Scientific Council
January 13–14, 2000

Dubna 1999

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1 SCIENTIFIC RESEARCH

1.1 Fields and Particles

The theme "Fields and Particles" included a wide range of researches on problems of "pure theory" and of particle physics. The main activity was concentrated on the following domains:

- Quantum symmetries, supersymmetries, and integrable models, with applications to strings, gravity and cosmology;

- Perturbative computations in gauge theories and various approaches to non-perturbative treatment;

- Standard model and its extension;

- Heavy flavors and B-physics;

- Spectroscopy of light flavors.

Note the growth of activity in the theory of superstrings, integrable models, and lattice gauge theories.

The theory of quantum matrix algebras became in recent years one of the most intensively developing topics in the mathematical theory of quantum groups. These algebras found their application in the description and investigation of quantum-mechanical and statistical integrable models, being, in fact, an adequate mathematical tool for formulation of the notion of integrability. The investigations carried out in this direction at BLTP resulted in the construction of a new family of quantum matrix algebras that includes all previously known quantum matrix algebras as particular cases [A.P. Isaev, O.V. Ogievetsky, P.N. Pyatov, J. Phys.A: Math.Gen. **32** (1999) L115-L121]. For these algebras the problem of finding a special commutative subalgebra — the so-called spectrum of a quantum matrix — was solved in general. For the corresponding integrable models, the spectrum of the quantum matrix gives an involutive set of the integrals of motion. The techniques developed for calculations with quantum matrices was applied for investigation of the 'zero modes' algebra of the chiral Wess-Zumino-Novikov-Witten model [M. Dubois-Violette, P. Furlan, L.K. Hadjiivanov, A.P. Isaev, P.N. Pyatov, I.T. Todorov, hep-th/9910206].

The superfield models with $1/2$ partial spontaneous breaking of the global D=3, N=2 supersymmetry were discussed, both within nonlinear and linear realizations of supersymmetry [B.M. Zupnik, Phys. Lett. **B461** (1999) 203; E. Ivanov, S. Krivonos, Phys. Lett. **B453** (1999) 237]. In the first approach, the manifestly $N = 1, D = 3$ supersymmetric superfield action of a $D = 4$ supermembrane was derived for the first time, and its dual equivalence to the worldvolume action of an $N = 2$ "space-time filling" D2 superbrane was demonstrated. In the second approach, the same partial breaking arises in the abelian gauge model describing low-energy interactions of the real scalar field with $3D$ vector and fermion fields. The partial breaking of $N = 1, D = 10$ supersymmetry was treated from a similar standpoint within

nonlinear realization [S. Bellucci, E. Ivanov, S. Krivonos, Phys. Lett. **B600** (1999) 348] and that of $N = 2, D = 4$ within linear realization [E.A. Ivanov, B.M. Zupnik, Yad. Fiz. **62** (1999) 1110].

The multidimensional $N = 4$ **supersymmetric quantum mechanics (SUSY QM)** was constructed by using the superfield approach. As a result, the component form of the classical and quantum Lagrangian and Hamiltonian was obtained. In the considered SUSY QM, both classical and quantum $N = 4$ algebras include central charges, and it opens various possibilities for the partial supersymmetry breaking, including the fractional options [E.E. Donets, A. Pashnev, J. Juan Rosales, and M.M. Tsulaia, Preprint JINR E2–99–218, hep-th/9907224, Phys. Rev. **D** (in press)].

A bound system composed of the Yang monopole coupled to an isospin particle by the $SU(2)$ and Coulomb interaction was considered. A system like that is an example of **the Seiberg-Witten duality in quantum mechanics**. The generalized Runge-Lenz vector and the $SO(6)$ group of hidden symmetry were found. It was also shown that the group of hidden symmetry allows one to algebraically compute the spectrum of systems of that sort [L.G. Mardoyan, A.N. Sissakian, and V.M. Ter-Antonyan, Mod. Phys. Lett., **14** (1999) 1303].

By carefully analysing the picture-dependence of the BRST cohomology, an infinite set of symmetry charges of **the closed N=2 string** was identified [K. Jünemann, O. Lechtenfeld and A.D. Popov, Nucl. Phys. **B548** (1999) 449-474]. The transformation laws of physical vertex operators were shown to coincide with the linearized nonlocal symmetries of the Plebanski equation (which is the effective field theory of a closed N=2 string). Moreover, it was shown that the corresponding Ward identities are powerful enough to allow for a rederivation of the well-known vanishing theorem for tree-level correlation functions with more than three external legs. Holomorphic Chern-Simons-Witten theories defined on 6D manifolds with a complex structure were considered, and 4D conformal field theories connected with them were described [A.D. Popov, Nucl. Phys. **B550** (1999) 585-621]. All these models are solvable. Analogs of the Virasoro and affine Lie algebras, the local action of which on fields of holomorphic Chern-Simons-Witten theories becomes nonlocal after pushing down to an action on fields of solvable 4D conformal field theories, were described.

Tau-functions of **the N-soliton solutions** of the Kadomtsev-Petviashvili hierarchy of equations and of its B-type reduction were shown to describe fixed-temperature partition functions of the specific Coulomb plasmas on the plane with some boundaries. In this picture, coordinates of the charges coincide with the complex spectral variables of solitons, phase shifts (describing scattering of solitons) coincide with the Coulomb interaction potentials, and the hierarchy evolution "times" contributions correspond to external electric fields. This identification generates some new solvable lattice plasma models. A $(1+1)$-dimensional discrete-time chain associated with the three-term recurrence relation of the R_{II}-type and some of its similarity reductions were described. [I. Loutsenko and V. Spiridonov, Nucl. Phys. **B538** (1999) 731-758; A. Zhedanov and V. Spiridonov, Uspekhi Mat. Nauk (Russ. Math.

Surv.) **54**, No. 2, (1999) 173-174 (in Russian)].

Photon and fermion correlators were studied analytically and numerically in the quenched **lattice QED** within the Lorentz (or Landau) gauge. It was shown that zero-momentum modes (ZMM) as well as Dirac sheets (DS) play an important role in fixing the Lorentz gauge nonperturbatively. They spoil fermion and photon propagators, and the standard fermion mass estimate fails for the commonly employed Lorentz gauge fixing procedure. To resolve the problem, a new gauge fixing procedure – zero-momentum Lorentz gauge (ZML) – was proposed. Therefore, the Gribov ambiguity problem was finally resolved in quenched QED on the lattice in the (physical) Coulomb phase [I.L. Bogolubsky, V.K. Mitrjushkin, M. Müller-Preussker, P. Peter, Phys. Lett. **B458** (1999) 102; I.L. Bogolubsky, V.K. Mitrjushkin, M. Müller-Preussker, P. Peter, and N.V. Zverev, Preprints JINR E2-99–288 (1999), HUB-EP–99/51].

A.D. Sakharov's idea that gravitation can be induced by vacuum polarization effects was generalized. It was suggested that the same mechanism is responsible also for the origin of other long-range forces in Nature. As an example, an ultraviolet-finite model, where the Einstein and Maxwell actions are entirely induced by quantum effects of very massive constituent fields, was constructed. The gravitational and gauge fields appear here on equal footing and, thus, the model is a unified theory of gravitation and electromagnetism. In the low-energy limit, the induced **Einstein-Maxwell gravitation** admits standard solutions and rotating charged black holes, in particular. It was shown that the Bekenstein-Hawking entropy of these black holes is described by the same statistical-mechanical formula as the entropy of a Schwarzschild black hole. This demonstrates that the mechanism of generation of the Bekenstein-Hawking entropy in induced gravitation is universal, and it does not depend on the angular momentum and the charge of a black hole [V.P. Frolov and D.V. Fursaev, gr-qc/9907046, hep-th/9910006, to appear in Phys. Rev.].

In **supersymmetric gauge theories** with soft supersymmetry breaking, a powerful method to obtain the renormalization-group equations for soft terms was proposed. The method is based on the Taylor expansion in the Grassmannian parameter and also allows one to derive the solutions of RG equations. New solutions for the soft terms in the Minimal Supersymmetric Standard Model, in SUSY GUTS, and in N=2 Seiberg-Witten Models were obtained [D.I. Kazakov, Phys. Lett. **B449** (1999) 201].

The structure functions of inelastic lepton–nucleon scattering processes were analyzed starting from the general principles of the theory expressed by the Jost-Lehmann–Dyson integral representation. A nonstandard scaling variable that leads to analytic moments of the structure functions was used, and the relation between these analytic moments and the operator product expansion was established [D.V. Shirkov, I.L. Solovtsov, Teor. Mat. Fiz. **120** (1999) 482 (in Russian)].

The first estimation of **the proton transversity distribution** was done by using the azimuthal asymmetry in semi-inclusive DIS recently measured on longitudinally (HERMES) and transversely (SMC) polarized targets and experimental data of DELPHI on the T-odd fragmentation function, responsible for the left–right asym-

metry in the fragmentation of transversely polarized quarks. It was shown that the u-quark transversity distribution in a proton is close to the effective chiral quark soliton model and the u contribution to the proton tensor charge is of order 1. On this basis, one can state that the proton transversity distribution could successfully be measured in future DIS experiments (e.g. in COMPASS) with *longitudinally* polarized target together with measurement of ΔG. [A.V. Efremov, Proc. of Intern. Workshop "Praha–Spin99", Prague, September 5–12 1999 (to be published by Chech.J.Phys. Suppl.); A.V. Efremov, K. Goeke, M.V. Polyakov, D. Urbano, Preprint Ruhr-Univ.].

The spin dynamics described by the properties of nonperturbative matrix elements in QCD was analyzed. In particular, the consistent description of the tensor polarization of vector mesons originating in the fragmentation of quark and gluons was developed. New sum rules for T-odd fragmentation functions were derived. The notion of the T-odd fracture function describing single spin asymmetries in the polarized-particle fragmentation region was introduced. An interesting link between the spin structure of a nucleon and the Einstein equivalence principle was suggested [A. Schafer, O.V. Teryaev, hep-ph/9908412 (to appear in Phys.Rev. **D**.); A. Schafer, L. Szymanowski, O.V. Teryaev, Phys. Lett. **B464** (1999) 94-100].

A complete analysis of the helicity amplitudes in the small-angle process of double bremsstrahlung along one direction in electron–positron scattering at high energies was carried out. The analytic expression for a correction up to the next-to-leading order for the quasielastic radiative tail of the deep-inelastic and Bhabha scattering process with an account of nonleading corrections was obtained [E.A. Kuraev, A. Schiller, V.G. Serbo, B.G. Shaikhatdenov, hep-ph/9909220 (Nucl. Phys. **B** in press); V. Antonelli, E.A. Kuraev, B.G. Shaikhatdenov, JETP Lett. **69** (1999) 900; hep-ph/9905331, Preprint BICOCCA-FT-99-13 (Nucl. Phys. **B** in press)].

It is shown that a homogeneous self-dual gluon field, in which "analytic confinement" is realized (i.e. the quark propagator is an entire analytic function in the momentum space), leads to confinement in the sense of the Wilson criterion – there arises a growing confining potential between heavy quarks. By using the recent development of the axial gauge representation for QCD, it was demonstrated that in the high-temperature limit, the effective potential of the background field under consideration has a minimum at the zero field strength, which means that at some critical temperature there should be a confinement-deconfinement phase transition. The geometrical gluon mass at finite temperature (finite extension) acting as an infrared regulator in the system plays an important role in the derivation of the above result [G.V. Efimov, A.C. Kalloniatis, S.N. Nedelko, Phys. Rev. **D59** (1999) 014026].

A realistic nonlocal chiral U(3)xU(3) model with 't Hooft interaction was constructed to describe the mass spectrum of excited scalar, pseudoscalar, and vector mesons and their first radial excitations. This allowed us to interpret experimentally observed scalar, pseudoscalar, and vector meson states as members of quark-antiquark nonets in the energy interval from 400 MeV up to 1.7 GeV. It was shown that all the 19 scalar meson states can be considered as two nonets: a meson nonet of ground states and that of their first radial excitations plus one glueball with mass 1.5 GeV. The mass spectra and strong decay modes of excited scalar, pseudoscalar, and vector meson nonets were described. A quark model without unphysical $q\bar{q}$ thresholds (quark confinement) was proposed. The thresholds were eliminated by means of an infrared cut-off [M.K. Volkov, M. Nagy, V.L. Yudichev, Nuovo Cim. **A112** (1999) 225; M.K. Volkov, D. Ebert, V.L. Yudichev, J. Phys. **G25** (1999) 2025].

The relativistic Schrödinger-like wave equation suggested for the use in hadron spectroscopy was shown to approximately satisfy important constraints (such as the slope of meson Regge trajectories following from the relativistic string theory, the ratio between the contributions of anomalous and traceless parts of the QCD hamiltonian to hadron masses) coming from more general field-theoretical approaches. This wave equation was then applied to evaluate characteristics of higher radial excitations of vector resonances (masses, scaling relations for leptonic and total widths) needed for comparison with new analyses of the nucleon form factors in the space-like and time-like region and the electron-positron annihilation cross-sections [S.B. Gerasimov, Czech. J. Phys. **49** (1999) 65–74].

A new next-to-leading order QCD analysis was given for the world data on inclusive polarized deep inelastic lepton-nucleon scattering that extended the old set of data on the final SMC results, the HERMES proton results, and very recent SLAC/E155 deuteron data. An excellent fit to the data was found, and the results for polarized parton densities were presented in different factorization schemes. These results are in good agreement with theoretical predictions. It was also found that the main effect of the newly incorporated data is a more accurate determination of the polarized gluon density [E. Leader, A.V. Sidorov, D.B. Stamenov, Phys. Lett. **B462** (1999) 189-194].

A constrained instanton solution was suggested in the physical QCD vacuum described by large-scale vacuum field fluctuations. This solution decays exponentially at large distances. It is stable only if the interaction of an instanton with the background vacuum field is small, and additional constraints are introduced. The constrained instanton solution was explicitly constructed in the ansatz form, and the two-point vacuum correlator of gluon field strengths was calculated in the framework of the effective instanton vacuum model [A.E. Dorokhov, S.V. Esaibegian, A.E. Maximov, S.V. Mikhailov, hep-ph/9903450, Eur. J. Phys. C (accepted)].

1.2   Theory of Nuclei and Other Finite Systems

Investigations within the area "Theory of Nuclei and Other Finite Systems" in 1999 were carried out in accordance with four projects. Namely,

- Nuclear Structure under Extreme Conditions

- Dynamics and Manifestation of Structure in Nuclear and Mesoscopic Systems

- Few-Body Physics
- Relativistic Nuclear Dynamics

Let us start with the results in the field of **nuclear structure theory** .

The equations of the quasiparticle-phonon model using a phonon basis of an extended random phase approximation were generalized to include multipole particle-particle interactions. An effect of the new interactions on the ground state correlations and vibrational excitations was considered for the one highly degenerate shell model [A.P. Severyukhin, V.V. Voronov, D. Karadjov, Preprint JINR, P4-99-121, Dubna, 1999; accepted to Izv. RAN. ser.fiz]. A renormalized random phase approximation (TRRPA) for finite Fermi systems at finite temperatures was evaluated with the use of the thermo field dynamics formalism. The TRRPA takes into account the Pauli principle in a more proper way than the usual thermal RPA, thus incorporating a new type of correlations in a thermal ground state. It was applied to the exactly solvable Lipkin model. Advantages of TRRPA are especially evident in the vicinity of the phase transition point. Moreover within TRRPA the phase transition occurs at lower temperature than in thermal Hartree - Fock and thermal random phase approximations. [A.I. Vdovin, A.N. Storozhenko, Eur. Phys. J. A **5** (1999) 263]. The impact of the ratios of nuclear matrix elements on the weak induced pseudoscalar coupling constant extracted from the relative observables in nuclear ordinary muon capture was investigated. It appeared that the value $g_P/g_A \leq 0$ obtained from the experimental data on $\gamma\nu$-correlations in polarized muon capture by ^{28}Si can be explained by unexpectedly strong influence of velocity-dependent matrix elements [K. Junker, V.A. Kuz'min, A.A. Ovchinnikova and T.V. Tetereva, preprint PSI-PR-99-14, Paul Scherrer Institut, CH - 5232 Villigen PSI, 1999; accepted to Phys. Rev. C]. A new mechanism of high angular momentum states population in fission fragments, based on the quantum mechanical uncertainty relations between the orientation angles of the fragments and the angular-momentum content of their intrinsic states, was suggested. The angular momentum is "pumped" into the fragments by the forces responsible for their mutual orientation. Recent experimental measurements seem to be in favour of a new spin generation scheme. [I.N. Mikhailov and P. Quentin, Phys. Lett. **B462** (1999) 7]. Conditional asymmetric fission barriers were calculated on the basis of the rotating-liquid-drop model that takes into account short-range nuclear forces and the diffuseness of the nuclear surface. These calculations were performed for 15 nuclei in the range Z^2/A=20-40 for angular-momentum values from 0 to $70\hbar$. For any angular-momentum value, a direct comparison of theoretical mass distributions obtained within the statistical approach with available experimental data reveals reasonably good agreement in the interval Z^2/A=20-30 [A.Ya. Rusanov, V.V. Pashkevich, M.G. Itkis, Yad. Fiz. **62** (1999) 595].

New approaches to describe **nucleus - nucleus collisions** were developed.

The role of the entrance channel in the fusion-fission reactions leading to nearly the same superheavy compound nucleus was studied in the framework of a dynamic model. It was shown that for the considered reactions, there is an energy window for the bombarding energy at which the capture cross section is large enough to have physical interest. This result puts strong limitations on the choice of the bombarding energy for a given reaction. The results of calculations showed that the ^{48}Ca + ^{244}Pu reaction is more favorable than ^{74,76}Ge + ^{208}Pb to produce the superheavy element Z=114. [R.V. Jolos, A.I. Muminov, and A.K. Nasirov, Eur. Phys. J. A **4** (1999) 245]. The energy thresholds for complete fusion in relative distance and mass asymmetry degrees of freedom were estimated. The time-dependent transition between a diabatic interaction potential in the entrance channel and an adiabatic potential during the fusion process was microscopically investigated. A large hindrance was obtained for a motion to smaller elongations of near symmetric dinuclear systems. The comparison of the calculated energy thresholds for the complete fusion in different relevant collective variables showed that the dinuclear system prefers to evolve in the mass asymmetry coordinate by nucleon transfer to the compound nucleus. [A. Diaz-Torres, N.V. Antonenko, W. Scheid, Nucl. Phys. **A652** (1999) 61].

The nuclear theory methods were applied in studying metallic clusters.

The orbital M1 collective mode was investigated for deformed single-charged metallic clusters in a microscopic self-consistent random phase approximation approach. The M1 strength appears to be fragmented over a large energy interval. It was concluded that in light clusters, the M1 mode has the character of a single-particle excitation. In heavy clusters the collective nature of the mode appears evident. The crucial role of the quadrupole field in promoting the M1 mode is confirmed [V.O. Nesterenko, W. Kleinig et al., Phys. Rev. Lett. **83** (1999) 57].

Interesting results were obtained within the project **Few-Body Theory**.

The scattering length for the η-meson collision with deuteron was calculated on the basis of rigorous few-body equations for various $\eta - N$ input. The results strongly support the existence of a resonance or a quasibound state close to the $\eta - d$ threshold [N.V. Shevchenko, V.B. Belyaev, et al. LANL e-print nucl-th/9908035, 1999]. Recent measurements for electromagnetic production of pions were analyzed. It was demonstrated that they can be explained in a dynamical and unitary isobar models, together with a simple scaling assumption for the bare $\gamma^* N\Delta$ form factors. It appeared that the bare Δ is almost spherical and the electric E2 and Coulomb C2 quadrupole excitations of the physical Δ are nearly saturated by pion cloud contribution in $Q^2 \leq 4.0$ GeV^2. The results well agree with experimental data, but deviate strongly from the predictions of perturbative QCD [D. Drechsel, O. Hanstein, S.S. Kamalov and L. Tiator, Nucl. Phys. **A645** (1999) 145]. It was shown that the life times of actual physical systems "two atoms + electron" ($\geq 10^6$ s) allow one to consider these systems as bound ones for any processes in gases. On the basis of the results of the previous study, a new class of diatomic negative molecular ions, having the states with anomalously large characteristic sizes, was predicted [F.M. Pen'kov, JETP **88**, 1079 (1999)].

The following **relativistic effects in nuclear physics** were studied.

The structure of the ϕ photoproduction amplitude in the $\sqrt{s} \sim 2 - 5$ GeV region was analyzed based on the Pomeron-exchange and meson-exchange mechanisms.

The differences between competing mechanisms were shown to have profound effects on various spin density matrices which can be used to calculate both the cross sections and various single and double polarization observables. A definite isotopic effect was predicted – polarization observables of ϕ photoproduction on the proton and neutron targets can differ by a factor of 2 and more [A.I. Titov, T.-S.H. Lee, H. Toki, and O. Streltsova, Phys. Rev. **C60** (1999) 035205]. The influence of the nuclear shape on various characteristics of multifragmentation was first studied within an extension of the statistical microcanonical model of multifragmentation. Combined effects of the shape of decaying nuclei, the high angular momentum and the collective expansion velocity were demonstrated by comparing the results for a hot source formed in central Xe+Sn (50 A/MeV) collisions with experimental data [A. Le Fevre, M. Ploszajczak and V.D. Toneev, Phys. Rev. **C60** (1999) R051602]. The method for the model-free derivations of the evolution of the nucleon structure in the lightest nuclei was developed. It allows one to express a structure function $F_2^A(x)$ in terms of structure functions of nuclear fragments and three-dimensional momentum distributions. It was found that the effects from nucleon relative time, which naturally follow from a relativistic treatment of the two-nucleon binding, play a decisive role in differences between structure functions of bound and free nucleons. The modification of the nucleon structure found for A=2 serves as a priming for the modifications in the three- and four-nucleon systems and plays a important role in evolution of the bound nucleon structure. [V.V. Burov, A.V. Molochkov, G.I. Smirnov, Phys. Lett. **B466** (1999) 1].

New results were also obtained in the Vavilov-Cherenkov radiation theory.

Numerical analysis of the Tamm problem (the charge motion on a finite space interval with the velocity exceeding light velocity in medium) on the basis of the exact solution to a nondispersive medium showed that the Fourier components of electromagnetic field strengths had no well pronounced maximum at the Cherenkov angle in the case of a finite motion interval. When the interval increases from an infinitesimal value many maxima appear. For the charge motion on an infinite interval, there appears an infinite number of maxima of the same amplitude [G.N. Afanasiev, V.G. Kartavenko and Yu.P. Stepanovsky, J. Phys. D: Appl. Phys. **32** (1999) 2029].

1.3   Theory of Condensed Matter

Theoretical investigations in the Theory of Condensed Matter were performed in the framework of the following projects:

- Strongly correlated systems
- Dynamic systems: chaos, integrability and self-organization
- Disordered structures: glasses, topological defects, nanostructures and Josephson junction
- Mesoscopic and coherent phenomena in quantum systems

In the field of **strongly correlated systems** main attention was paid to studies of electronic spectra, charge, magnetic and superconducting phase transitions for models of novel materials belonging to a class of marginal electronic liquids (manganites, cuprates, vanadates, heavy fermions).

A new solution to the Periodic Anderson Model with two strongly correlated subsystems of d and f electrons was proposed by using a special form of canonical transformation. The corresponding 16 rank S-matrix is constructed by using, as its elements, the orthonormalized system of eigenfunctions of the localized Hamiltonian for different eigenvalues. [V.A. Moskalenko, N.B. Perkins, Theor. Math. Phys. **121** (1999) 250].

A phase diagram of half-doped perovskite manganites within the extended two-orbital double-exchange model was studied. The orbital degeneracy results in appearance of charge-ordered states for different antiferromagnetic states only for a large enough Coulomb interaction. The relevance of the results to the experimental data obtained in neutron scattering experiments at FLNP is also discussed. [G. Jackeli, N.B. Perkins, and N.M. Plakida, cond-mat/9910133, Phys. Rev. B, submitted].

In order to account for competition and interplay of localized and itinerant magnetic behavior in correlated many-body systems, the $d-f$ and Kondo-Heisenberg models were considered [A.L. Kuzemsky, Physica **A267** (1999) 131].

LDA and LDA+U electronic band structure calculations were performed for multi-band effective models with strong Coulomb repulsion to interpret polarization dependent angle-resolved valence band photoemission measurements for different copper oxides [R. Hayn, H. Rosner, V. Yushankhai et al., Phys.Rev. **B60** (1999) 645-658].

In the field of the theory of **dynamic systems** the following results should be mentioned.

The theorem is proved that the upper critical dimension of the Abelian sandpile model is four [V.B. Priezzhev, math-ph/9904054, J. Stat. Phys. 1999 (in press)]

The eigenvectors of the Hamiltonian of 1D quantum spin chains with anelliptic form of exchange were described via the solutions to the highly transcendental systems of Bethe-ansatz type which were explicitly presented for the first time in all subspaces of the corresponding Hilbert space [V.I. Inozemtsev, math-ph/9911022].

The moduli space of self-dual Yang-Mills fields was described in terms of Čech and Dolbeault cohomology sets by using the correspondence between complex vector bundles over self-dual four-dimensional manifolds and holomorphic bundles over their twistor spaces [T.A. Ivanova, math-ph/9902015].

In the investigations of **disordered structures**, the following main results were obtained.

A variant of a gauge theory is formulated to describe disclinations on Riemannian surfaces that may change both the Gaussian (intrinsic) and mean (extrinsic) curvatures under deformations. As an application, two special cases are considered: elastic membrane and elastic sphere. For a single disclination on an arbitrary elastic

surface, a covariant generalization of the von Karman equations is derived. The model is suitable for description of the topological defects in membranes and layered structures [E.A. Kochetov and V.A. Osipov, J. Phys. A: Math. Gen. **32** (1999) 1961].

By appropriate generalization of the Ginzburg-Landau theory based on admixture of s-wave (S) and d-wave (D) superconductors, a differential thermoelectric power (TEP) of the SND configuration in $Bi_xPb_{1-x}Sr_2CaCu_2O_y$ is considered. In addition to its strong dependence on the relative phase $\theta = \phi_s - \phi_d$ between the two superconductors, two major effects are shown to influence the behavior of the predicted TEP based on the chemical imbalance at the SD interface. The experimental conditions under which the predicted behavior of the induced differential TEP can be measured are discussed in detail [S. Sergeenkov and M. Ausloos, Phys. Rev. **B59** (1999) 11974].

To clarify the underlying microscopic transport mechanisms in exhibiting colossal magnetoresistance (CMR) in manganites, the substitution effects in $La_{0.7}Ca_{0.3}MnO_3$ were studied. An anomalous behavior of resistivity in $La_{0.7}Ca_{0.3}Mn_{0.96}Cu_{0.04}O_3$ due to Cu doping was found and attributed to the Cu induced weakening of the kinetic carrier's energy and concomitant strengthening of potential barriers. In turn, CMR and magneto-TEP observed in $La_{0.6}Y_{0.1}Ca_{0.3}MnO_3$ suggest spin hopping transport mechanism (with magnetization dependent charge carrier localization length) dominated by strong magnetic fluctuations. [S. Sergeenkov et al., Phys. Rev. **B60** (1999) 12322 ; S. Sergeenkov et al., JETP Lett. **69** (1999) 858; ibid **70** (1999) 141; ibid **70** (1999) 473].

Mesoscopic and coherent phenomena in quantum systems were studied in the following papers.

A fermionic path integral approach is applied to analyze the phase transition in the two-dimensional Ising model with quenched site disorder. The log-log singularity in the specific heat near T_c for weak site dilution was obtained [V.N. Plechko, In: "Path Integrals from peV to TeV: 50 Years after Feynman's Paper", Ed. by R. Casalbuoni et al (World Scientific, Singapore, 1999) p. 137; hep-th/9906107].

The shift of the ^4He excitation spectra, caused by the ^3He admixture, is evaluated by using the partition function in the form of a path integral. The excitation (neutron scattering) spectrum $E_p(\lambda, \rho_f, T)$ is found as a function of ^3He-^4He interaction λ, ^3He density ρ_f and temperature T. The largest influence of the ^3He admixture is noticed in the region of roton minimum of the ^4He spectrum due to influence of the pure ^3He dispersion curve [D. Baranov, V. Yarunin, Physica **A269** (1999) 222].

A new way of treating the dilute Bose gas with the strongly singular potential is developed. Using the reduced density matrix of the second order and a variation procedure, this way allows one to operate with singular potentials of the Lennard-Jones type [A.Yu. Cherny and A.A. Shanenko, Phys. Rev. **E60** (1999) R5].

A variational study of the ground-state energy of an exciton-phonon system spatially confined to a quantum well with a confinement potential in the form of a parabolic function was performed. An interpolation formula for the ground-state energy bound was obtained which corresponds to similar formulae for the free polaron or the free exciton-phonon system [B. Gerlach, J. Wüsthoff, and M.A. Smondyrev, Phys. Rev. **B60** (1999) 16569].

A mechanism for creating well-collimated beams of neutral particles by magnetic fields is suggested [V.I. Yukalov and E.P. Yukalova, Phys. Lett. **A253** (1999) 173]. Theory of nonlinear spin dynamics in ferromagnets with electron-nuclear coupling is developed [V.I. Yukalov, Phys. Rev. **A60** (1999) 721]. Transient effect of negative electric current in nonuniform semiconductors is predicted [V.I. Yukalov, E.P. Yukalova, and M.R. Singh, Phys. Rev. **B59** (1999) 10111].

2 COMPUTER FACILITIES

The concept of development of the Laboratory's computer facilities is based on the idea of balanced development of the stocks of both servers and personal computers, all connected via the computer network with adequate performance.

In 1999, 24 new personal computers with CPU Pentium II and III 300-450 MHz were installed on workplaces. The most powerful workstation Ultra 2 was equipped with the second processor Ultra SPARC 300 MHz. The system memory on this workstation was extended to 768 MB. Several disks were added to the cluster of Sun's computers, the total disk space available now is about 80 GB. New operating system Solaris 7 was introduced on two workstations. Among the new software available on workstations there is StarOffice 5.1 which is capable to deal with the files in the format of Microsoft Office (Word, Exel etc.). The renewed software includes Reduce 3.7, Netscape Communicator 4.7, Java Workshop 2, Java Studio 1.0, Acrobat 4, GNU CC 2.8.1. The publicly accessible archive of free software was created on thsun1.jinr.ru. Currently, the archive contains full mirrors of CTAN (tex-archive), CPAN (Perl archive), GNU software, Solaris public patches, Solaris freeware (binaries and sources), and other widely used software and documentation. The archive is equipped with the file search engine and available at http://thsun1.jinr.ru/file-archive.html . Among other new computer services available now at BLTP, there is the cache server (accelerator) at http://thsun1.jinr.ru:1081 which stores files requested from the E-print archive xxx.itep.ru. The cache server provides instant access to new publications on xxx.itep.ru which are automatically downloaded every morning. There is also a common proxy cache server http://thsun4.jinr.ru:3128 which stores all files requested from Internet and also automatically redirects requests sent to xxx.itep.ru to the accelerator http://thsun1.jinr.ru:1081. Protocols supported by the server are HTTP, FTP and Gopher. The Proxy Auto Configuration (PAC) script intended for automatic configuration of Internet Explorer and Netscape Communicator to use this proxy server is located at http://thsun1.jinr.ru/proxy.pac. BLTP continues to support local mirror of the Journal of High Energy Physics (JHEP) http://jhep.jinr.ru which got a larger disk space, system memory and new base software. Laboratory's WWW server base software was renewed also, improved access statistics becomes available.

3 CONFERENCES AND MEETINGS

1. III-th Research Workshop "Nucleation Theory and Applications", (April, 4–27, Dubna).

2. International School "Symmetries and Integrable Systems", (June 8–11, Dubna).

3. Research Workshop "Collective Exitations in Nuclei and Other Finite Fermi Systems", (June 14–24, Dubna).

4. VIII-th International Colloquium "Quantum Groups and Integrable Systems", (June 17–19, Prague, Czech Republic), jointly organized by BLTP, Czech Technical University, Charles University and LPTMC, University Paris 7.

5. V-th International Symposium "Dubna Deutron-99", (July 6–10, Dubna), jointly organized by LHE and BLTP.

6. Workshop "Diffraction on Colliders", (July 3–6, Dubna).

7. Workshop "Supersymmetries and Quantum Symmetries", (July 27–31, Dubna).

8. Research Workshop "Quantum Gravity and Superstrings", (August 2–10, Dubna).

9. III-rd International Conference "Constrained Dynamics and Quantum Gravity", (September 13–17, Villasimius, Italy), jointly organized by BLTP, Univ. di Torino, Univ. di Cagliari, and MPI für Grav. Physik, Golm.

10. Workshop "Physical Variables in Gauge Theories", (September 21–25, Dubna).

11. International Bogolybov Conference "Problems of Theoretical and Mathematical Physics", (September 27 – October 6, Moscow-Dubna-Kyiv).

12. NATO Advanced Research Workshop "Lattice Fermions and Structure of the Vacuum", (October 5–9, Dubna).

Preliminary Plans for 2000

1. IVth Research Workshop "Nucleation Theory and Applications", (April 3–28, Dubna).

2. Vth Workshop "Heavy Quark Physics", (April 5–9, Dubna).

3. International Conference "Nuclear Structure and Related Topics", (June 6–10, Dubna).

4. IXth International Colloquium "Quantum Groups and Integrable Systems", (June 21–23, Prague, Czechia), to be jointly organized by BLTP, Czech Technical University, Charles University and LPTMC, University Paris 7.

5. Research Workshop "Quantum Gravity and Superstrings", (July 9–18, Dubna).

6. International Seminar "Supersymmetry and Quantum Field Theory", (July 25–29, Kharkov, Ukraine), to be jointly organized by BLTP and NSC KIPT.

7. XXIII International Colloquium "Group Theoretical Methods in Physics", (July 31 – August 5, Dubna).

4 SUMMARY

- In 1999, about 600 papers were published in the leading scientific journals, Proceedings of conferences and as preprints.

- A wide scientific collaboration is continued and expanded with scientific centres of Member States and other countries. Of particular importance are the collaboration of BLTP with scientific and educational centres of Russia and training of specialists for these centres (see, e.g., "Problems of Modern Physics": Collected papers dedicated to the 90th anniversary of the Saratov State University and to the 40th anniversary of the JINR-SSU collaboration, JINR preprint D2-99-263, Dubna, 1999). At present, about 30 scientists from many regions of Russia (Moscow, St.Petersburg, Petrozavodsk, Tomsk, Novosibirsk, Vladivostok, etc.) are working at BLTP on a contract basis. At our laboratory, there are post-graduate students not only from the JINR University Centre, but also from a number of Russian Universities.

  In 1999, the international collaboration was supported by grants of the plenipotentiaries of the Czech Republic, Poland, the Slovak Republic, and Hungary.

  Within the Heisenberg–Landau Programme more than 70 papers were published jointly with the colleagues from German scientific centres. 33 joint projects and 7 meetings obtained financial support from the HLP. Collaboration with the INFN sections (Italy), IN2P3 Institutes (France) and the CERN TH is continued.

- In 1999, 9 meetings organized by BLTP were supported by UNESCO.

- Grants of the scientific Funds: Programme of supporting the leading scientific school, National Programme of RF, RFBR-DFG (joint project), RFBR-INTAS (joint project), INTAS, RFBR, State Committee of the RF for Education.