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BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

Report to the 91st Session
of the JINR Scientific Council
January 17–18, 2002

Dubna 2001

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1 SCIENTIFIC RESEARCH

1.1 Fields and Particles

Theoretical research in the *Fields and Particles* division of BLTP covers a wide field of activity in quantum field theory (QFT) and theoretical particle physics. Following the current situation in high energy physics, the QFT research goes far ahead of experimental grounds and is concentrated mainly in the field of mathematical physics. On the other hand, the high-energy phenomenology is developed in close contact with modern accelerator experimental data. Although these two directions seem to diverge, new interfaces between theory and experiment emerge, e.g. in astroparticle physics and cosmology.

The topics of main focus in quantum field theory are:

- Supersymmetry and superstrings;
- Integrable models, noncommutative field theories;
- Nonperturbative approaches to QCD and lattice gauge theories;
- Quantum gravity and cosmology.

Phenomenology of particle physics includes the Standard Model of fundamental interactions and its extension as well as high and low energy hadron physics. The main topics are:

- SUSY and Higgs boson search;
- New trends in neutrino physics;
- QCD structure functions;
- Spin and polarization phenomena;
- Chiral model and meson spectroscopy;
- Very high multiplicity physics.

In the last year, a considerable progress was achieved in several directions. Below one can find a short description of selected results obtained at BLTP in both the domains.

The integrable model called the "Quantum relativistic Toda chain at root of unity" was formulated and investigated in detail. This model is the simplest "hybrid" one: the space of the dynamic variables is a bundle, whose layer is the local Weyl algebra – the quantum algebra of the observables, and the base is a space of centers. The "hybrid" formulation allowed us to obtain the Baxter equation on a quantum curve covering the classical high genus hyperelliptic one and also to obtain the quantum separation of variables explicitly as a consequence of the classical separation. A series

of papers on this subject were published, and the survey is the paper: [S. Pakuliak, S. Sergeev, Journal of Applied Mathematics, (2001)].

Noncommutative Yang-Mills theory is known to possess a class of localized solutions that do not exist in the commutative case. The configuration consisting of a set of such objects (called lumps) is not a static solution anymore, because these objects interact. Dynamics of such interacting lump configurations corresponding to nontrivial vacua in noncommutative Yang-Mills theory was considered. It was found that this dynamics is effectively described by a matrix model, which exhibits stochastic behaviour [C. Sochichiu, e-Print Arxive hep-th 0104076]. Two-dimensional noncommutative mechanical systems in a constant magnetic field were considered. It appeared that, depending on the value of magnetic field and noncommutative parameter, the system may exist in one of two phases having different symmetries [S. Bellucci, A. Nersessian, C. Sochichiu, Phys. Lett. **B522** (2001) 345–349].

The study of nontrivial backgrounds for fermionic $N = 2$ strings in the presence of D-branes and NS-NS B-fields was initiated. Coupling a B-field with the supersymmetric $2d$ matter of the sigma model on world sheets with boundaries, we derived the corresponding action which produced $N = 2$ supersymmetric boundary conditions. It was demonstrated that the open $N = 2$ string with a constant B-field background in the presence of D3- or D2-branes yields noncommutative self-dual Yang-Mills or a noncommutative $2 + 1$ dimensional modified $U(n)$ sigma model. Various classes of explicit multi-soliton configurations corresponding to D0-branes moving inside the D2-branes were constructed and studied in detail. [O. Lechtenfeld, A.D. Popov and B. Spendig, J. High Energy Phys. **06** (2001) 011; O. Lechtenfeld, A.D. Popov, J. High Energy Phys. **11** (2001) 040; Phys. Lett. **B523** (2001) 178].

For the first time, an off-shell $N = 3$ supersymmetric extension of the abelian D=4 Born-Infeld action was constructed, starting from the action of supersymmetric Maxwell theory in $N = 3$ harmonic superspace [E.A. Ivanov, B.M. Zupnik, Nucl. Phys. **B618** (2001) 3–20].

Using the $N = 2$ superfield approach, full supersymmetric low-energy effective actions were constructed for $N = 4$ SYM models, with both $\mathcal{N} = 2$ gauge superfield strengths and hypermultiplet superfields included. It was proved that the effective potentials of the form $\ln W \ln \overline{W}$ can be $N = 4$ completed and present the precise structure of the corresponding completions. [I.L. Buchbinder, E.A. Ivanov, e-Print Archive: hep-th/0111062; Phys. Lett. B, in press].

It was proved that any spherically symmetric solution of the Einstein equations can be generalized to a new solution that describes a space-time pierced by an arbitrary number of infinitely thin cosmic strings directed radially. Each string produces an angle deficit proportional to its tension, while the metric outside the strings is a locally spherically symmetric solution. There can be arbitrary configurations of strings provided that the directions of the strings obey a certain equilibrium condition. In general, this equilibrium condition can be written as a force-balance equation for string forces or as a constraint on the product of holonomies around strings. [V.P. Frolov, D.V. Fursaev, D.N. Page, e-Print Arxive hep-th/01121129].

A new class of integrable models of (0+1)- and (1+1)-dimensional dilaton gravity coupled to any number of scalar fields was proposed. Their solutions expressed in terms of elementary functions describe, among other things, spherical black holes and cosmologies, emerging in high-dimensional supergravity theories, and reveal nontrivial relations between these two objects [A.T. Filippov, to be published in Yad. Fiz.].

Quantum field theory with nontrivial boundary conditions requires development of a new calculation technique and, first of all, of new regularization methods. The high temperature asymptotics of the thermodynamic characteristics of the electromagnetic field subjected to boundary conditions with spherical and cylindrical symmetries were constructed by making use of the relevant heat kernel coefficients. The obtained results reproduce all the asymptotics derived by other methods in the problems under consideration and involve some new high temperature expansions. [M. Bordag, V.V. Nesterenko, I.G. Pirozhenko, Nucl. Phys. Proc. Suppl. **104** (2002) 228–231].

On the basis of recently devised global Analytic Perturbation Theory (APT), some QCD observables were analyzed in spacelike and timelike domains with $f = 3, 4$ and 5. All the examples demonstrate the effect of improved convergence of nonpower APT expansions as compared with ordinary power expansions (in power of $\bar{\alpha}_s(Q^2)$ or $\bar{\alpha}_s(s)$). The three-loop contribution (of order $\bar{\alpha}_s^3$) to an APT expansion is, as a rule, numerically inessential [D.V. Shirkov, JINR preprint E2–2001–153; e-Print Arxive hep-ph/0107282, to be published in Europ. Phys.J. C].

The method of nonperturbative a-expansion developed at the Laboratory that gives a self-consistent description of both spacelike and timelike regions was applied to analyze the D-functions and smearing quantities corresponding to the e^+e^- annihilation into hadrons and inclusive τ-decay data. Threshold effects were taken into account via a new relativistic Coulomb-like factor that summarizes singularities of a perturbative expansion of the type $(\alpha_s/v)^n$ and generalizes the well-known Sommerfeld-Sakharov factor. It was shown that the method proposed provides good agreement with experimental data down to the lowest energy scale. [A.N. Sissakian, I.L. Solovtsov and O.P. Solovtsova, JETP Letters, **73** (2001) 166-199; K.A. Milton and I.L. Solovtsov, Mod. Phys. Lett. **A16** (2001) 2213–2219].

In the framework of the Minimal Supersymmetric Standard Model a global statistical χ^2 analysis of the data was performed including the influence of higher order corrections to $b \to s\gamma$ decay rate and new recent data on the anomalous magnetic moment of the muon. It was shown that there exist an allowed region of parameter space bounded from below by the Higgs limit and from above by the anomalous magnetic moment [W. de Boer, M. Huber, A.V. Gladyshev, D.I. Kazakov, Eur. Phys.J. **C20** (2001) 689–694; W. de Boer, M. Huber, C. Sander, D.I. Kazakov, Phys. Lett. **B515** (2001) 283–290]. It was shown that renormalization of the Fayet-Iliopoulos term in a softly broken SUSY gauge theory, in full analogy with all the other soft term renormalizations, is completely defined in a rigid or an unbroken theory. The four-loop renormalization proportional to the soft scalar masses and

soft triple couplings was calculated [D.I. Kazakov, V.N. Velizhanin, e-Print Arxive hep-ph/0110144].

Calculations of the perturbative parts of the structure functions F_2^c and F_L^c for a gluon target with a nonzero momentum squared were performed for the process of photon-gluon fusion. The results are quite compact in form for both the types of gluon polarization: the Feynman gauge one and BFKL-like one. The results were applied in the framework of k_T factorization approach to analyze the present data on the charm contribution to the structure function F_2 (F_2^c). The analysis was performed with several parametrizations of unintegrated gluon distributions for comparison. A good agreement of the results obtained with different parametrizations of unintegrated gluon distributions was found with experimental F_2^c HERA data, except at low Q^2 ($Q^2 \leq 7$ GeV^2). Quite a large value of the charm contribution to the structure function F_L^c was also obtained at low x and high Q^2 ($Q^2 \geq 30$ GeV^2). [A.V. Kotikov, A.V. Lipatov, G. Parente and N.P. Zotov, Preprint US-FT/7-01, Santiago de Compostela, Spain, 2001; e-Print Arxive hep-ph/0107135].

A process of nonlinear backward Compton scattering of circularly polarized laser photons, being one of the basic processes at future high energy photon colliders, was considered. Very high intensity of laser wave leads to a broadening of the energy (luminosity) spectra and a shift to lower energies (invariant masses). All this is necessary for the optimization of the conversion region at photon colliders and the study of physical processes where a sharp edge of the luminosity spectrum and monochromaticity of collisions are important. [M. Galynskii, E. Kuraev, M. Levchuk, V. Telnov, Nucl. Instrum. Meth. **A472** (2001) 267].

A single spin asymmetry of a photon emission in deeply virtual Compton scattering was calculated. This problem is of high priority for it allows one to study generalized parton distributions within the framework of QCD (a particular case of which are parton distributions first introduced by Feynman) and, as a consequence, the nucleon spin structure. [I. Akushevich, E. Kuraev, B. Shaikhatdenov, Phys. Rev. **D64** (2001) 094010].

Recently, HERMES measured an azimuthal asymmetry $A_{UL}^{\sin\phi}$ in electro-production of π^0 in semi-inclusive deep inelastic scattering of unpolarized positrons off longitudinally polarized protons. It was shown that this asymmetry is well reproduced theoretically, with no free adjustable parameters, by using the calculation of the proton transversity distribution h_1^q in the effective chiral quark-soliton model of the Bochum University group, combined with experimental data (DELPHI) on the average analyzing power $\langle H_1^\perp / D_1 \rangle$ of the Collins effect, responsible for a left-right asymmetry in the fragmentation of transversely polarized quarks into nonpolarized hadrons (see Fig.1a).

Using the z-dependence of the HERMES azimuthal asymmetries for π^+ and π^0 and the calculated transversity distributions, the z-dependence of the analyzing power was obtained for the first time (see Fig.1b), showing the linear rise $H_1^\perp(z_h)/D_1^\perp(z_h) = 0.15 z_h$. [A.V. Efremov, K. Goeke and P. Schweitzer, Phys. Lett. B **522**, (2001) 37 ; e-Print Arxive hep-ph/0108213].

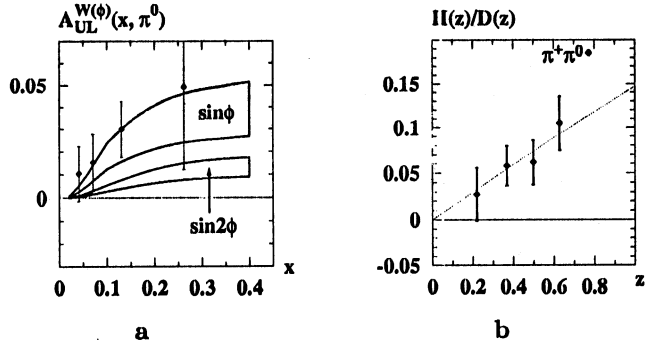

Figure 1: **(a).** *Azimuthal asymmetry A_{UL}^{W} for π^0 as a function of x. The enclosed areas correspond to the statistical error in $\langle H_1^{\perp}/D_1 \rangle$.* **(b).** *$H_1^{\perp}/D_1$ vs. z extracted from HERMES data for π^+ and π^0 combined.*

Double spin asymmetries for longitudinally polarized leptons and transversely polarized protons in diffractive vector meson and $Q\bar{Q}$ production in the HERMES energy range were considered. The asymmetry predicted for meson production is quite small. Large asymmetry is expected for $Q\bar{Q}$ production. [S.V. Goloskokov, e-Print Arxive hep-ph/0110212].

An interpretation of 19 scalar meson states with masses from 0.4 to 1.7 GeV was given for the first time [M.K. Volkov, V.L. Yudichev, Eur. Phys. J. **A10** (2001) 223]. It was shown that these states can be considered as two nonets: the nonet of ground states (lighter than 1 GeV) and the nonet of their first radial excitations (heavier than 1 GeV) and a scalar glueball with mass 1.5 GeV. The mixing of scalar isoscalar quarkonia and the glueball was taken into account.

A novel mechanism for the empirical $\Delta I = 1/2$ rule found in weak $\Delta S = 1$ decays was suggested [N.I. Kochelev and V. Vento, Phys. Rev. Lett. **87** (2001) 11601]. This mechanism arises from the instanton contribution to weak decay amplitudes, and it is very important for understanding the large observed CP violation in weak decays of K-mesons.

A description was presented of the extremely inelastic high-energy hadron collisions when the multiplicity of produced hadrons considerably exceeds its mean value. In a generalization of the inclusive and semi-inclusive approaches, a new method was developed that is based on the statistical picture of processes in the very high multiplicity (VHM) region. To obtain model-free predictions, a real-time finite-temperature S- matrix theory was built. It allows one to develop a new phenomenology approach to VHM processes and make predictions that can be useful for future experimental programs (LHC, Tevatron, etc.).[J. Mandjavidze, A. Sissakian, Phys. Reports **246** (2001)]

Also, mention is to be made of the studies of evolution of the rotation frequency

for accreting compact stars [G. Poghosyan, H. Grigorian, and D. Blaschke, Astrophys. J. **551** (2001) L73] and of the possibility of CP-violation in the lepton sector from the data on neutrinoless double β-decay experiments [S.M. Bilenky, S. Pascoli and S.T. Petcov, Phys. Rev. **D64** (2001) 053010].

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In the nearest future, the investigations will be continued along the following lines:

in Quantum field theory:

Nonperturbative methods in quantum field theories (duality, lattice simulations in gauge theories, instanton effects,....); the nature of symmetries of classical and quantum field theories (gauge symmetries, supersymmetries, quantum symmetries, ...); gauge theories on noncommutative spaces; integrable dynamical systems; superstring and brane models - unification of all interactions; classical and quantum gravity and cosmology.

in Particle theory:

The Standard Model application and higher order calculations of physical processes; spin and polarization phenomena, hadron dynamics in QCD, structure of QCD vacuum, low x physics in deep inelastic scattering; nonforward deep inelastic scattering, heavy quark dynamics and B-physics; physics beyond the Standard Model; unification models and low energy supersymmetry; CP violation, neutrino physics; physics at hadron colliders.

1.2 Theory of Nuclei and Other Finite Systems

In 2001, investigations within the area "Theory of Nuclei and Other Finite Systems" were carried out in accordance with the four projects:

- Nuclear structure under extreme conditions;
- Dynamics and manifestation of structure in nuclear and mesoscopic systems;
- Few-body physics;
- Relativistic nuclear dynamics.

The following main results were obtained in the field of nuclear structure theory :
A method was developed to derive sets of relations between the experimentally observed reduced matrix elements of the quadrupole operator. This approach is based on the quadrupole shape invariants, selection rules of the Q-phonon scheme, and the fact that the corrections for noncommutativity of the components of the

quadrupole moment operator are small. As an example of the general scheme, fourth order Q-invariants of the ground state were given. A satisfactory agreement between the data and theoretical relations was obtained [V. Werner, P. von Brentano, R.V. Jolos, Phys. Lett. **B521** (2001) 146]. The magnetic dipole strength distribution in the energy range 4-10 MeV in the well-deformed ^{154}Sm nucleus was investigated. To this end, the quasiparticle-phonon model with a large basis of one- and two-phonon states was used. The strength is almost entirely due to spin excitations. It was proved that the experimentally observed two-hump structure is mostly due to separation of the proton and neutron excitations. On the contrary, the isoscalar and isovector spin strengths are spread over a rather large energy range. The calculations exclude that the two humps originate from separate $K^\pi = 0^+$ and $K^\pi = 1^+$ excitations [N. Lo Iudice, A.V. Sushkov, N.Yu. Shirikova, Phys. Rev. **C64** (2001) 054301]. Excitation energies, spectroscopic factors, and internal fermion structure of excited states up to 7 MeV in ^{208}Pb were calculated with a large basis of one-, two-, and three-phonon configurations. Calculations were performed in a consistent way with the ones in neighboring odd-mass nuclei. The theoretical results were compared with recent experimental data. The calculated spectrum of 0^+, 2^+, 4^+, and 6^+ states that includes mixing with the two octupole phonon multiplet was related to experimental states up to $E_x = 5230$ keV. The measured excitation strengths are consistent with the predicted fragmentation of the two octupole phonon states [B.D. Valnion, V.Yu. Ponomarev, Y. Eisermann, *et al.*, Phys. Rev. **C63** (2001) 024318]. High spin states of ^{32}S and ^{56}Ni were investigated by the cranking Hartree-Fock method with the Gogny interaction without imposing a restriction on the axial reflection symmetry. It was found that a non-axial octupole deformation of the Y_{31} type becomes important in the yrast states of ^{32}S. A similar effect was predicted for the nucleus ^{56}Ni [T. Tanaka, R.G. Nazmitdinov, K. Iwasawa, Phys. Rev. **C63** (2001) 034309]. In collaboration with experimenters, the implications of the fission modes in the γ -ray multiplicities from fission fragments in the reaction ^{208}Pb(^{18}O, f) were considered. The calculated shapes of the fission fragments helped to explain the observed multiplicities in the symmetric and asymmetric fission and confirmed the interpretation of each of the fission modes as going along its own fission valley. It was concluded that the concept of the valley structure of the potential energy surface is a universal tool for an explanation of properties of both a fissioning nucleus and fission fragments [G.G. Chubarian, M.G. Itkis, N.A. Kondratiev, E.M. Kozulin, V.V. Pashkevich, *et al.*, Phys. Rev. Lett. **87** (2001) 052701]. The problem of bosonization of physical degrees of freedom of a many-body system at finite temperature was considered in the context of the boson expansion method in the framework of the formalism of thermo-field dynamics. The importance of the bosonization of single-boson (fermion) operators in addition to the usual boson (fermion)-pair bosonization was stressed. The leading order results of the expansion for two models, the bosonic O(N) anharmonic oscillator and the fermionic Lipkin model, were derived, and the thermal excitations were shown to comply with both the symmetry and the particle statistics requirements. In the former case, it was

also shown that without single-particle mapping, the thermal Goldstone excitations were missing from the theoretical spectrum [Z. Aouissat, A. Storozhenko, A. Vdovin, J. Wambach, Phys. Rev. **C64** (2001) 015201]. Hyperdeformed (HD) states were described by dinuclear quasimolecular cluster configurations. They can be formed by heavy ion reactions. Optimum reaction partners, bombarding energies and angular momenta were selected to find these HD states. A new method to identify the populated HD states was suggested where $\gamma-$transitions between the HD states are measured in coincidence with the decay of the compound nucleus into the cluster fragments. These experiments would prove whether the HD states can be considered as cluster states [G.G. Adamian, N.V. Antonenko, N. Nenoff, W. Scheid, Phys. Rev. **C64** (2001) 014306].

Various problems were investigated within the project Few-body physics.

A solvable model designed to demonstrate the interplay of the molecular and nuclear resonance widths in a molecule was considered. The model exhibits explicitly the mechanism leading to the enhancement of fusion probability of nuclear constituents of a molecule in case the of a narrow near-threshold nuclear resonance. The case was considered where molecular Hamiltonians are arranged in the form of an infinite n-dimensional ($n \geq 1$) lattice. It was shown that if the real part of the narrow nuclear resonance lies within a molecular band generated by the intercellular interaction, there exist molecular states which decay exponentially, with a rate inversely proportional to the nuclear width [A.K. Motovilov, W. Sandhas, and V.B. Belyaev, J.Math. Phys. **42** (2001) 2490]. It was shown that a two-body system with a sufficiently weak inverse square interaction has a bound state with an infinitely large binding energy. To analyze a possible existence of such a collapse in a three-body system, the hyperharmonics method was applied, and three-body Schrödinger and Faddeev equations with two-body inverse square interactions were studied. Exact solutions of those equations were constructed as products of a hyperradial Bessel function and a finite linear combination of hyperharmonics. For these solutions, the existence criterion was proved and studied. It was found that the solutions describe the states when the collapse of all three particles is not possible although the sufficient condition for the two-body collapse is fulfilled for any two-body subsystem [V.V. Pupyshev, Theor. Math. Phys. **128** (2001) 1061]. A new dynamic model was developed describing most of the existing pion electromagnetic production data in threshold and resonance regions (Dubna-Mainz-Taipei model, http://www.kph.uni-mainz.de/MAID/dmt/dmt2001.html). In the case of threshold π^0 production, the effects of a final state interaction in the threshold region are nearly saturated by single charge exchange rescattering. This indicates that in ChPT it might be sufficient to carry out the calculation just up to one-loop diagrams for a threshold neutral pion production [S.S. Kamalov, G.Y. Chen, S.N. Yang, D. Drechsel, and L. Tiator, Phys. Lett. **B522** (2001) 27]. A microscopic few-body description of near-threshold coherent photoproduction of the η meson on ^{3}H and ^{3}He nuclei was given. The photoproduction cross-section was calculated with equations of the Finite Rank Approximation (FRA) by taking account of all orders of the

elementary ηN interaction. Results of FRA indicate the strong final state interaction of η-meson with the residual nucleus, producing fast grow of the cross section. Sensitivity of the cross section to the $\eta N \to \eta N$ and $\gamma N \to \eta N$ amplitudes was investigated [V.B. Belyaev, N.V. Shevchenko, S.A. Rakityansky, S.A. Sofianos, and W. Sandhas, Few Body Syst. Suppl. **13** (2001) 262].

The main results of the project Relativistic nuclear dynamics are:

The high-energy approximation was adapted for the nucleus-nucleus scattering at energies of several dozens MeV/nucleon. It was shown that the closed form of the eikonal phase derived for the realistic Woods-Saxon type potential hopeful for further applications. The differential elastic and total reaction cross sections comply well with the results of corresponding numerical solutions of the wave equation. The nuclear surface plays an important role in the formation of elastic and reaction cross sections. The origin of a continuous ambiguity in optical potential parameters was revealed in interpreting total cross sections [V.K. Lukyanov, B. Słowinski, E.V. Zemlyanaya, Phys. At. Nucl. **64** (2001) 1273]. It was established that the isoscalar-isovector $(\rho - \omega)$ interferences in the exclusive reactions $\pi^- p \to n e^+ e^-$ and $\pi^+ n \to p e^+ e^-$ near the ω threshold leads to an obvious difference in dielectron invariant-mass distributions depending on the beam energy. The strength of the predicted effect is determined by the coupling of resonances to the nucleon vector-meson channels and other resonance properties. Therefore, the found effect can be used as a powerful tool to study the baryon resonance dynamics. The effect can be tested by measuring the angular distribution of decay particles in reactions of the type $\pi N \to NV \to N e^+ e^-$ which are accessible with the pion beam at the HADES spectrometer at GSI/Darmstadt [A.I. Titov, B. Kämpfer, Eur. Phys.J. **A12** (2001) 217]. Dynamics of partons created through vacuum tunneling in a time-dependent spatially homogeneous field was studied for typical conditions of ultrarelativistic heavy-ion collisions. A coupled self-consistent set of equations consisting of the Vlasov-like kinetic equation with a source term, derived on the dynamic basis, and the renormalized Maxwell equation, accounting for the back-reaction mechanism, were solved numerically. Clear signals of a stochastic nature were found in temporal oscillations of the parton distribution function for phase space cells and in essential irregularity of momentum spectra at a later time. If the back reaction is neglected, these features vanish completely, and oscillation dynamics takes an ordinary regular form [D. Vinnik, V. Mizerny, A. Prozorkevich, S. Smolyansky, V.D. Toneev, Yad. Fyz. **64** (2001) 836].

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In the nearest future, the studies within the area will be concentrated on the manifestations of sypersymmetry in nuclear spectra, anharmonic effects in nuclear spectra with realistic interactions, cluster phenomena in heavy nuclei, resonance effects in various few-body physics, and the baryon resonance dynamics.

1.3 Theory of Condensed Matter

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

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

Main results in the problem of strongly correlated systems were obtained in the investigation of the electronic spectrum and mechanisms of superconductivity in copper-oxide materials and in studies of magnetic properties of materials with complicated phase transitions like manganites.

A theory of superconducting pairing mediated by antiferromagnetic exchange was developed to explain a strong variation of the superconducting temperature with the lattice constant recently discovered in mercury superconductors. Calculations were performed within the two-band Hubbard model in the limit of strong correlations. Retardation effects are unimportant due to a large excitation energy at antiferromagnetic exchange of pairs of electrons from different Hubbard subbands which results in the pairing of all electrons in the conduction band and a high superconducting temperature. The oxygen isotope effect is caused by a variation of the exchange interaction with the zero-point oxygen ion vibrations. [N.P. Plakida, JETP Letters, **74** (2001) 36–40].

Spin dynamics was calculated in the ferromagnetic state of manganites within the generalized Kondo lattice model with taking account of strong on-site correlations between itinerant electrons and antiferromagnetic exchange between localized spins. It was shown that spin excitations have a conventional Dq^2 spectrum in the long-wavelength limit, whereas a strong deviation from the spin-wave spectrum of the isotropic Heisenberg model is observed close to the zone boundary in accordance with recent experiments. [F.Mancini, N.B.Perkins, N.M.Plakida, Phys. Lett. **A284** (2001) 286–293].

In the field of the theory of dynamical systems: chaos, integrability, and self-organization, the following results should be mentioned:

A new kind of integrable stochastic processes was proposed to describe one-dimensional avalanche dynamics in dissipative systems. The Bethe-ansatz method and an iterative procedure based on a detailed balance were used to obtain exact results for an asymmetric avalanche process on a ring. The average velocity of particle flow, v, was derived as a function of the toppling and the density of particles ρ. As ρ increases, the system shows a transition from the intermittent to continuous flow, and v diverges at a critical point ρ_c with exponent α. The exact phase diagram of the transition was obtained, and α was found to depend on the toppling rules

[V.B. Priezzhev, E.V. Ivashkevich, A.M. Povolotsky, and C.-K. Hu, Phys. Rev. Lett., **87** (2001) 084301].

In the investigations of disordered structures the following main results were obtained:

The electronic structure of graphitic cones was investigated within the self-consistent field-theoretical model. The local and total densities of states (DOS) near the apex were calculated for cones of different opening angles. The total DOS was found to vanish at the Fermi level at any opening angles except for 60° where a local metallization of graphite occurs. [V.A. Osipov and E.A. Kochetov, JETP Lett. **73** (2001) 562].

The problem of both the phonon and electron scattering by long-range strain fields caused by wedge disclination dipoles (WDD) was studied. The WDD-induced contribution to the residual resistivity in nanocrystalline metals was estimated. Phonon scattering due to randomly distributed WDDs was shown to result in the clear crossover from T^3 to T^2 behavior in the thermal conductivity, κ, at low temperatures. The results are in a good agreement with the experimentally observed κ in a-SiO_2, a-GeO_2, a-Se, and polystyrene. [S.E. Krasavin and V.A. Osipov, J. Phys.: Cond. Mat. **13** (2001) 1023].

Contribution to the specific heat of crystals due to pinned twist disclinations was studied. To this end, the model of heterogeneous string was formulated for vibrating disclinations. The specific heat due to twist disclinations was found to be a linear function of the temperature and defect density. The frequency-dependent loss due to twist disclinations was studied by treating the disclination as a damped oscillating heterogeneous string. It was found that the decrement has a resonant type behavior. The internal friction was predicted to be proportional to the fourth power of disclination length, which could be tested in experiments with rotationally disordered crystals. [D.V. Churochkin and V.A. Osipov, Phys. Lett. **A282** (2001) 92 ; ibid **A289** (2001) 273].

The main topics of mesoscopic and coherent phenomena in quantum systems cover the expansion of basic quantum effects to the cases of finite (mesoscopic) systems.

Investigation of the Bose-Einstein condensation (BEC) in optical atomic traps became recently one of the main trends in the study of quantum fluids and solids. The estimates of the balance between the kinetic and potential energies of trapped atoms at almost zero temperatures were obtained [A. Cherny, A. Shanenko, Phys. Rev. **E64** (2001) 027105-1–027105-4]. The physical reasons for positive and negative values of the scattering lengths of atoms due to the interaction between them were discussed. The conditions were formulated for each of these regimes which can be observed experimentally.

As the potential barriers of traps are very small ($\sim 10^{-9} ev$), the atoms in traps are sensitive to the presence (or absence) of a gravity. The shift of a critical BEC temperature provided in the atomic trap by the gravitational field was estimated [D. Baranov, V. Yarunin, JETP Lett., **71** (2001) 266]. This result concerns the recent NASA project of new precise physical experiments in the outer space.

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In the nearest years, investigations in the field of Condensed Matter will continue according to the lines described above.

In particular, it is planned to study: quasiparticle spectra and phase transitions in the basic models of materials with strong electron correlations; dynamic systems and self-organized criticality, one-dimensional stochastic transport; structural, spin and superconductive glasses, topological defects in membranes and nanostructures; quasiparticle spectra in quantum wells, wires and dots, Bose-Einstein condensation in quantum liquids and in magnetic traps.

2 COMPUTER FACILITIES

For the first time at BLTP, the server with two processors Athlon with clock rate 1.2 GHz was installed (http://thsun1.jinr.ru/guide/athlon) Peak productivity of 4.8 GFlops and 1 GB of the RAM allow to solve, on the new computer, the most complicated problems with the use of Fortran, C, C ++, Reduce, Form, and Mathematica. The server is running license manager providing up to 30 licenses for Mathematica for Windows running on PC at JINR.

In 2001, acquired and installed were 24 modern personal computers based on Pentium-III. Installation of new hard disks on the main BLTP computer thsun1.jinr.ru allowed to increase the user disk space twice and to speed up the read/write operations. The system software and some applications were renewed on the Sun cluster. The user disk space on the file server TFS was doubled.

The central stack of network switches at BLTP was extended to 120 ports. Migration to Fast Ethernet on workplaces was continued. Now all servers at BLTP and about 80 most powerful PC are connected to the Fast Ethernet.

The proxy-caching server and software archive (http://thsun1.jinr.ru/guide/web/) were moved to the new dual-processor PC server operating under Linux. This work was supported by RFBR (The Russian Foundation for Basic Research).

Plans for the nearest 3 years (2002–2004) are:

- to renew 20% of personal computer stock each year;
- to complete development of the UTP-based cabling system;
- to extend the stack of Fast Ethernet switches;
- to continue migration to Fast Ethernet on workplaces;
- to install a server with two Ultra SPARC III processors;
- to replace the BLTP main computer thsun1.jinr.ru;
- to install a server with two P4 Intel processors;
- to renew the file server;
- to introduce Gigabit Ethernet on the server cluster;
- to renew the existing network printer;
- to provide a more convenient user access to storage devices like CD-R,CD-RW;

– to renew the existing and install more user-demanded software on shared PC;
– to continue development of the user guide to computer resources of the Laboratory.

3 CONFERENCES AND MEETINGS

1. V-th Research Workshop "Nucleation Theory and Applications", (April, 2–28, Dubna).
2. IX-th International Conference on Supersymmetry and Unification of Fundamental Interactions, (June, 11–17, Dubna).
3. Research Workshop and School on Quantum Gravity and Superstrings, (June 18–28, Dubna).
4. X-th International Colloquium "Quantum Groups and Integrable Systems", (June 21–23, Prague, Czech Republic).
5. IXth International Conference "Symmetry Methods in Physics", (July 3–8, Yerevan, Armenia).
6. International School-Workshop Advanced Study Institute: Symmetries and Spin, (July 15–28, Prague, Czech Republic).
7. IXth International Workshop on High Energy Spin Physics, (August 2–7, Dubna).
8. DAAD Summerschool on Dense Matter in Particle - and Astrophysics, (August 20–31, Dubna).
9. International Conference New Trends in High Energy Physics, (September 22–29, Yalta, Crimea, Ukraine).
10. International Workshop "Supersymmetries and Quantum Symmetries, (September 17–21, Karpacz, Poland).

Preliminary Plans for 2002

1. International Workshop "New Models and Nuclear Methods in Biophysics and Biochemistry", (January 24–26, Dubna).
2. V-th International Conference "Renormalization Group 2002", (March 10–16, High Tatras, Slovakia).
3. VI-th Research Workshop "Nucleation Theory and Applications", (April 4–28, Dubna).
4. International School "Heavy Quark Physics", (May 27 – June 5, Dubna).

5. XVI International Baldin Seminar on High Energy Physics Problems Relativistic Nuclear Physics and Quantum Chromodynamics, (June 10–15, Dubna).
6. XI-th International Colloquium "Quantum Groups and Integrable Systems", (June 21–23, Prague, Czechia).
7. Research Workshop "Quantum Gravity and Superstrings", (July, Dubna).
8. DAAD Summerschool on Quantum Statistics in Many-Particle, (July 21 – August 10, Dubna).
9. Simposium on Nuclear Clusters: From Light Exotic to Superheavy Nuclei, August 5–9, Rauischholzhausen, Germany).
10. XXXII International Simposium on Multiparticle Dynamics, (September 7–13, Alushta, Crimea, Ukraine).

4 SUMMARY

- In 2001, 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.

  BLTP has effectively collaborated with the National Centre of Particle and High Energy Physics, Minsk, Belarus and Gomel State University. In 2001, a good deal of efforts in organizing and conducting the Gomel School on High Energy Physics (Gomel, 7–16 August) was undertaken by BLTP. It is to be mentioned that our Laboratory was an initiator of these schools held starting from 1971.

  In 2001, the international collaboration was supported by grants of the plenipotentiaries of the Czech Republic, Poland, the Slovak Republic, and Hungary; the collaboration with Polish theorists was based on the Bogoliubov–Infeld Programme and with Czech theorists, the Blokhintsev–Votruba Programme.

  Within the Heisenberg–Landau Programme, about 90 papers were published jointly with the colleagues from German scientific centres, 31 joint projects and 6 meetings obtained financial support from the HLP. Collaboration with the INFN sections (Italy), IN2P3 Institutes (France) and the CERN TH is continued.
- In 2001, 4 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), BMBF, DAAD, INTAS, RFBR, State Committee of the RF for Education.

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