BOGOLIUBOV LABORATORY OF THEORETICAL PHYSICS

At the Bogoliubov Laboratory of Theoretical Physics (BLTP), studies are carried out on the following four themes: «Fields and Particles», «Modern Mathematical Physics», «Theory of Nuclei and Other Finite Systems», «Theory of Condensed Matter». Important components of BLTP's activities are theoretical support of experimental research to be carried out with JINR participation and recruiting of young researchers, students, and postgraduate students for the work.

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 *phenomenology of particle physics*.

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:

- Supersymmetry phenomenology;
- QCD structure functions;
- Spin and polarization phenomena;
- Chiral model and meson spectroscopy.

In 2003, considerable progress was achieved in several directions. Below one can find a brief description of selected results obtained on the theme at BLTP.

Two-loop corrections to the anomalous dimension matrix for twist-2 operators in the $N = 4$ supersymmetric Yang–Mills theory were calculated for polarized and unpolarized cases. In the first two orders of perturbation theory, the eigenvalues of this matrix are expressed in terms of a universal function with arguments shifted by integer numbers. The leading-order part of this function is Euler's Psi-function. The next-to-leading correction has a more complicated form and can be expressed via the second derivative of Psi-function together with some related functions. In the framework of the AdS/CFT correspondence, which allows one to investigate the proper strong-coupling limits through the calculations in classical supergravity in the anti-de-Sitter space, these results are interpreted as an indication of the corresponding relations between the weak- and strong-coupling regimes for the eigenvalues of the anomalous dimension matrix of Wilson operators [1].

The «returning-to-resonance» mechanism can be used to obtain a simple procedure of taking RC to DIS cross section into account in the framework of the Drell–Yan picture. The iteration procedure is proposed. The kinematic region $y \to 1$ can be described in the framework of the Drell–Yan picture using a structure function approach. The large RC in the lowest order reflect Sudakov form factor suppression, which can be taken into account in all the orders of perturbation theory. Based on explicit calculation in two lowest orders of perturbation theory, we construct the cross section in the $y \to 1$ region obeying renormalization group equations along with the Sudakov-like form factor suppression [2].

Starting with the very high energy elastic and inelastic electron–nucleon scattering with a production of a hadronic state X moving closely to the direction of the initial nucleon, then utilizing analytic properties of the forward Compton scattering amplitudes on the protons and neutrons, for the case of small transferred momenta one can finally derive a sum rule relating Dirac radii and anomalous magnetic moments of the proton and the neutron to the integral over a difference of the total proton and neutron photoproduction cross sections [3].

The polarized quark distributions obtained by SMC and HERMES were analyzed. It was shown that while the SMC results for the first moments $\Delta_1 q$ were in good agreement with the Bjorken sum rule, the respective HERMES result was inconsistent with this important sum rule. Both experiments have applied the LO QCD technique to extract $\Delta q(x)$ from measured asymmetries. But Q^2 region of HERMES is lower than that of SMC, and the NLO QCD approach in the HERMES case may be necessary. The possibility of broken polarized sea scenario was also analyzed. It was shown that if one uses the published HERMES results for the valence quark distributions, then application of the sum rule written in terms of the valence and sea quarks, which is equivalent to the Bjorken sum rule, leads to a rather amazing result

$$\Delta_1 \bar{u} - \Delta_1 \bar{d} = 0.235 \pm 0.097;$$

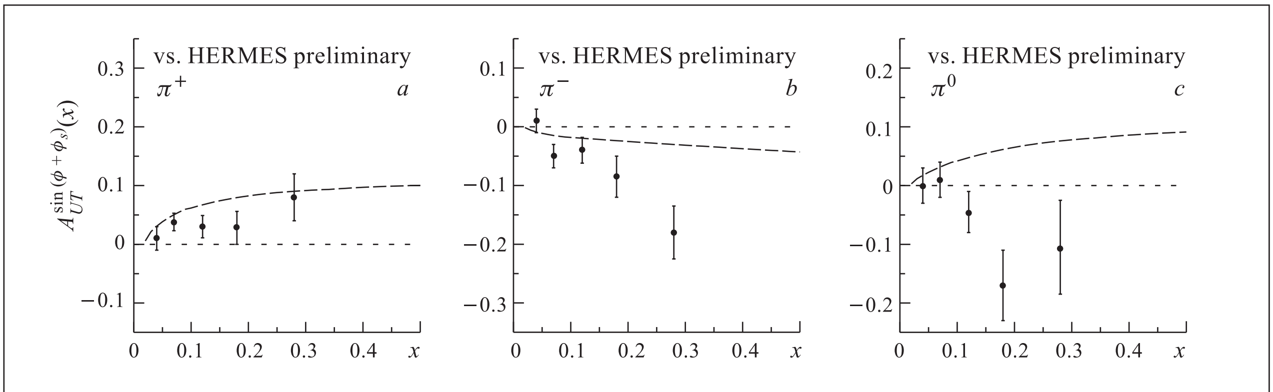
i.e., the polarized sea of light quarks is asymmetric with respect to $\bar{u}$ and $\bar{d}$ quark polarized distributions [4].

Predictions are made for single spin azimuthal asymmetries due to the Collins effect in pion production from semi-inclusive deeply inelastic scattering off transversely and longitudinally polarized targets for the HERMES and COMPASS experiments. The x-dependence of the asymmetries is evaluated using the parton distribution functions from the chiral quark–soliton model. The overall normalization of the predicted asymmetries is determined by the information on the Collins fragmentation function extracted from the previous HERMES data on azimuthal asymmetries $A_{UL}^{\sin\phi}$ from a *longitudinally* polarized target where the Sivers effect is shown to be strongly suppressed. The single spin asymmetries

$$A_{UT} = \frac{\int d\phi \, \sin(\phi + \phi_S)\,(d\sigma^+/P^+ d\phi - d\sigma^-/P^- d\phi)}{\int d\phi dy\,(d\sigma^+/d\phi + d\sigma^-/d\phi)}$$

from the *transversely* polarized proton target are found to be about 10% for positive and neutral pions at both HERMES and COMPASS. For the *longitudinally* polarized target we obtain for COMPASS $A_{UL}^{\sin\phi} \sim 0.5\%$ and $A_{UL}^{\sin 2\phi} \sim 1.5\%$. The preliminary data from HERMES agree with the predictions for π^+ (see figure), but some disagreement is seen for π^- and especially for π^0. The reason for this is yet unclear [5].

The way of «translating» some singular long–range asymptotic behaviors to the infrared (IR) momentum region was proposed. It is based on the Tauber theorem and has a direct relation to interpretation of some recent results on the IR behavior of the QCD effective coupling obtained by the ALPHA collaboration by lattice simulation of the functional Schrödinger integral [6].



The new nonperturbative QCD inputs, the light cone distributions of the pairs of vector mesons, were introduced and successfully applied to the description of the recent data released by the L3 collaboration [7].

The Bethe–Salpeter equation within a scalar theory in the ladder approximation is written in the form of an integral equation in the configuration Euclidean x-space with the kernel which for stable bound states is a self-adjoint positive operator. The solution of the Bethe–Salpeter equation is formulated as a variational problem, and the analytical form of test functions for which the accuracy of calculations of bound state masses is better than 1% in comparison with the available numerical calculations is found [8].

In the wake of exploring CP violation in the decays of B and B_c mesons, a straightforward calculation of their nonleptonic decay rates was performed within a relativistic quark model. It was confirmed that the decays $B \to D_s$ anti-D_0 and $B_c \to D_s D_0$ were well suited to extract the Cabibbo–Kobayashi–Maskawa angle γ through the amplitude relations, because their decay widths were of the same order of magnitude. In the b–c sector the decays $B \to DK$ and $B_c \to DD$ lead to squashed triangles, which are therefore not so useful to determine the angle experimentally. The rates for other nonleptonic B_c decays are also determined and the obtained results are compared with the results of other studies [9].

The contribution of instantons to the electromagnetic form factors of constituent quark was calculated. This contribution allows one to explain new data on scaling violation in deep-inelastic scattering [10].

The nonlocal quark model with confinement was constructed. The strong decays of the ρ and a_1 mesons and electromagnetic form factor of the pion were described [11].

The higher twist corrections $h^N(x)/Q^2$ to the spin-dependent proton and neutron structure functions $g_1^N(x, Q^2)$ were extracted in a model independent way from the world experimental data on g_1^N and found to be nonnegligible [12].

On the basis of the quark–hadron duality sum rules in the resonance region, new relations were derived for the two-photon widths of light and heavy scalar and pseudoscalar mesons and a new scheme was proposed of the quark–diquark–glueball configuration mixing for the low-lying scalar mesons [13].

The origin of recently reported anisotropy of the local velocity field of nearby galaxies (velocities $<$ 500 km/s corresponding to the distance less than 8 Mpc) was studied. The formation mechanism of galaxies and their clusters in the presence of the central gravitational field was proposed. It was shown by the simplest model that galaxies and their clusters would have a periodical structure that can be connected with the large-scale structures of the Universe [14].

MODERN MATHEMATICAL PHYSICS

The topics of main focus in the theme were:

- Supersymmetry and superstrings;
- Quantum groups and integrable systems;
- Quantum gravity and cosmology.

Below are presented some results obtained in 2003 on these subjects.

A specific quantum Lax operator L, forming a quantum chain model, was suggested and the corresponding intertwining RLL relation was proved. This L operator is important for reformulation of the auxiliary linear problem of 3-dimensional quantum integrable models [15].

Three-dimensional exactly solvable spin models and the relevant discrete classical systems on the cubic lattice were investigated. The solution of classical systems were found by the methods of algebraic geometry and were parametrized by the compact algebraic curves of the finite genus. These results were used to get parametrization for the Boltzmann weights of the spin models which satisfy the modified tetrahedron equation [16].

A new algebraic approach (which uses the methods of quantum integrability) to analytical calculations of perturbative integrals for multiloop Feynman diagrams was proposed. It was shown that an important class of perturbative integrals for ladder massless diagrams was given by the Green function for the conformal quantum mechanics [17].

The pp-wave string bit model was analyzed in the framework of the Yang–Mills pp-wave correspondence. We found the inconsistency of the above model due to a spectrum doubling in the fermionic sector. A way to avoid this inconsistency was also proposed [18].

Further investigations of a new class of special functions of mathematical physics proposed earlier were performed. A general theory of integrals of hypergeometric type associated with the Jacobi theta functions was developed. A theta analog of the univariate Meijer function was defined. New multiple elliptic beta integrals associated with the root systems A_n and C_n were constructed. Main properties of the elliptic biorthogonal functions analogous to the Askey–Wilson polynomials in the theory of orthogonal polynomials were investigated [19].

On the Grassmann-odd coset space $SU(n|1)/U(n)$ the Chern–Simons mechanics of a particle was considered. A new quantization of this model was implemented, for which the states with nonzero norm transform as a representation of $SU(n|1)$. For $n = 2$ the wave function can be interpreted as a BRST superfield [20].

A new reduction mechanism was proposed for constructing n-particle (super)conformal theories with pairwise interaction. It was used to derive $N = 4$ superconformal extension of a complexification of the Calogero model and a $D(2, 1|\alpha)$-invariant n-particle system [21].

It was shown that the quantization of a superparticle propagating in $N = 1$, $D = 4$ superspace extended with tensorial coordinates results in an infinite tower of massless spin states satisfying the Vasiliev unfolded equations for free higher spin fields in flat and AdS_4 $N = 1$ superspaces. The model is manifestly invariant under OSp($N|8$) ($N = 1, 2$) superconformal symmetry [22].

Bi-Hamiltonian structure and Lax pair formulation with the spectral parameter of the generalized fermionic Toda lattice hierarchy, as well as its bosonic and fermionic symmetries for different (including periodic) boundary conditions, were described. Its two reductions — $N = 4$ and $N = 2$ supersymmetric Toda lattice hierarchies — in different (including canonical) bases were investigated. Its r-matrix description, monodromy matrix, and spectral curves were discussed [23].

It is well known that due to vanishing theorems there are no nontrivial finite action solutions to the Abelian Seiberg–Witten (SW) monopole equations on Euclidean four-dimensional space R^4. It is shown that this is no longer true for a noncommutative version of these equations, i.e., on a noncommutative deformation R^4_θ of R^4 there exist smooth solutions to the SW equations having nonzero topological charge. The action functionals for the noncommutative SW equations were introduced, and explicit regular solutions were constructed. All these solutions have finite energy. The obtained solutions were interpreted as codimensional four vortex-like solitons representing $D(p\text{-}4)$- and anti-$D(p\text{-}4)$-branes in a Dp–anti-Dp brane system in type-II superstring theory [24].

A derivation of the entropy of black holes in induced gravity models based on conformal properties of induced gravity constituents near the horizon was given. The four-dimensional (4D) theory was first reduced to a tower of two-dimensional (2D) gravities such that each 2D theory was induced by fields with certain momentum p along the horizon. It was then demonstrated that in the vicinity of the horizon the constituents of the 2D induced gravities were described by conformal field theories (CFTs) with specific central charges depending on spin and nonminimal couplings and with specific correlation lengths depending on the masses of fields and the momentum p. This enables one to use CFT methods to count partial entropies $s(p)$ in each 2D sector. The sum of partial entropies correctly reproduces the Bekenstein–Hawking entropy of the 4D induced gravity theory. These results indicate that earlier attempts to derive the entropy of black holes based on a near-horizon CFT may have a microscopic realization [25].

A consistent method was developed for constructing the integral equations determining the heat kernel for compound media (the material characteristics of such media have jump discontinuities at the interface between the media). The method is based on employment of the heat potentials which are, in the case of heat equation, the analog of the Newtonian, or electrostatic, potentials widely used in the Laplace equation theory. In the case of compound media the principal part of the differential operator, governing the dynamics of quantum fields, is not smooth. As a result, the traditional methods of constructing and investigating the heat kernel do not work here. The method proposed is in fact a unique one in this filed of studies [26].

The results, obtained before for the models of relativistic particles described by the Lagrangians with higher derivatives, have found a direct application in studies of statistical properties of polymers and proteins. In particular, proceeding from the general properties of the protein chains, one succeeded in constructing the functional of the effective free energy for helical proteins. In this case, the inverse variational problem was solved; namely, for typical configurations of the protein chains the relevant effective free energy was recovered, the extrema of which are only the observed configurations of the protein molecules (the helices in our case) [27].

The duality transformation in 1D quantum mechanics on sphere S_1 was established. It was shown that the complex mapping of $S_{1C} \to S_1$ generalized the Hurwitz-type transformations well known from 1D Euclidean space. As in the case of flat space, this mapping leads to a duality of Coulomb and Calogero–Moser systems [28].

The form of the Wigner distribution functions for Hamiltonian systems on the n-dimensional sphere S_n was proposed. An essential part of this construction is the use of the Sherman and Volobuev functions, which are an overcomplete set of plane-wave-like solution of the Laplace–Beltrami equation for this space [29].

THEORY OF NUCLEI AND OTHER FINITE SYSTEMS

In 2003, 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*:

Starting with an effective interaction of the Skyrme type, the finite-rank separable approximation was proposed for the residual particle–hole interaction. It allows one to perform numerical calculations of the structure of heavy nuclei in very large particle–hole spaces. The approach was extended to take into account effects of pairing correlations as well as a coupling between one- and two-phonon configurations. The energies and transition probabilities for the 2^+ and 3^- states in the neutron-rich Sn isotopes were calculated and were found to be in reasonable agreement with available experimental data [30].

An equivalence between the pairing correlations and the vortical currents in reducing the nuclear moments of inertia was established. This finding results from the comparison of microscopic calculations within the HFB method and the microscopic calculations within the HF calculations (without pairing) constrained to have the same Kelvin circulation expectation value. It was shown in several mass regions, pairing regimes, and for various spin values that the two procedures yielded practically identical moments of inertia, angular velocities, and current distributions [31].

The excitation spectra and the electromagnetic decay properties of the superdeformed band in ^{60}Zn, including a decay to the ground state band, were studied in the framework of the dinuclear system model, which is a variant of a cluster model. The Hamiltonian of the model contains a degree of freedom of mass asymmetry motion. It was shown that the states of the superdeformed band are described mainly as Be-cluster configurations, whereas the states of the ground state band have a significant contribution of an α-cluster component [32].

A self-consistent version of the thermal random phase approximation (TSCRPA) was derived within the Matsubara Green function formalism. The new approximation was applied to the many-level pairing model. The temperature dependences of correlation and excitation energies, specific heat, and level densities were studied. The agreement with the exact results calculated for the grand canonical ensemble is within the couple of per cent level. Particularly interesting is the fact that the single-particle Green function is calculated consistently within TSCRPA. Due to this, the evolution of the single-particle level density with temperature was traced for the many-level pairing model for the first time [33].

The impact of nuclear deformation on momentum distribution of deep hole states in ^{238}U was studied for different mean fields, including those based on the Hartree–Fock calculations with the SkM effective force. It was shown that $K^\pi = 1/2^+$ states with a large $\ell = 0$ component can be discriminated in knock-out experiments. This can provide valuable information about the deep hole domain of the mean field [34].

Moreover, new results were obtained in theoretical investigations of *nucleus–nucleus collisions*.

The production cross sections and excitation functions for different neutron-deficient isotopes were analyzed in the framework of the dinuclear system model. The low energy tails of the excitation functions in the $6n + 7n$, $p3n$, and $\alpha 4n + \alpha 4n$ evaporation channels appear to be sensitive to contaminations of the target by other isotopes or the neighboring nuclei. Few reactions were proposed for the production of very neutron-deficient Ba isotopes with quite large cross sections for the study of cluster radioactivity [35].

The role of the entrance channel in fusion–fission reactions ^{86}Kr + ^{130}Xe, as well as ^{124}Sn + ^{92}Zr reactions, leading to the same compound nucleus ^{216}Th* was studied. At nearly the same excitation energy the evaporation residue formation cross section for the latter reaction appears to be four times larger than for the former one, which is characterized by larger mass asymmetry. The calculations taking into account the shell structure of interacting nuclei showed that the partial fusion cross section is also larger for the reaction ^{124}Sn + ^{92}Zr, because its intrinsic fusion barrier is smaller [36].

Various problems were investigated within the project *Few-Body Physics*. The corresponding results are:

The six-dimensional Schrödinger equation for a three-body system with two-body central potentials of a more general type than the Coulomb ones was studied. The regular general and particular physical solutions of this equation were represented as infinite asymptotic series in integer powers of the distance between two particles and the sought functions of the other three-particle variables. In the angular basis formed by the spherical and bispherical harmonics or the symmetrized Wigner D-functions, the construction of these functions was reduced to solving simple algebraic recurrence equations. For the projections of the physical solutions onto angular basic functions, the boundary conditions at the two-body collision point were derived [37].

A new representation for the solution to the operator Sylvester equation in the form of a Stieltjes operator integral was obtained. Also new sufficient conditions for the strong solvability of the operator Riccati equation were found. These conditions simultaneously ensure the existence of reduced graph subspaces for block operator matrices. Next, the concept of the Lifshits–Krein spectral shift function associated with a pair of self-adjoint operators was extended to the case of pairs of admissible operators that are similar to self-adjoint operators. Based on this new concept the spectral shift function arising in a perturbation problem for block matrix Hamiltonians was expressed in terms of the angular operators associated with the corresponding perturbed and unperturbed eigenspaces [38].

A self-consistent analysis of pion scattering and pion photoproduction within a coupled-channel dynamical model was performed. The results indicate the existence of the third and the fourth S_{11} resonances with the masses (1803 ± 7) and (2117 ± 64) MeV. This is consistent with the predictions of the recent constituent-quark models. In the case of pion photoproduction, large negative background contributions to the imaginary part of the S-wave multipole were obtained. Due to this fact, much larger resonance contributions are required to explain the results of the recent multipole analysis. In particular, for the first $S_{11}(1535)$ resonance the following value of the dressed electromagnetic helicity amplitude is obtained: $A_{1/2} = 72 \pm 2 \cdot 10^{-3}$ GeV$^{-1/2}$ [39].

On the basis of a finite-rank approximation approach, photoproduction of η mesons on the three-nucleon nuclei was studied numerically. Calculations were performed for the coherent photoproduction near the threshold. Target wave functions were computed by making use of Faddeev-type equations with the Malfliet–Tjon NN potentials. The results indicate a strong final-state interaction of the η meson with the residual nucleus [40].

The main results of the project *Relativistic Nuclear Dynamics* are:

A theoretical model as well as a code for numerical calculations were developed to study the ϕ-meson photoproduction. The diffractive ϕ-meson photoproduction amplitude is dominated by the Pomeron exchange process and contains the terms that govern the spin–spin and spin-orbital interactions. It was shown that these terms were responsible for the spin-flip transitions at forward photoproduction angles and appear in the angular distributions of the $\phi \to K^+K^-$ decay in reactions with unpolarized and polarized photon beams. At large momentum transfers, the main contribution to the ϕ-meson photoproduction was found to be due to the excitation of nucleon resonances [41].

The final-state interaction effects (FSI) in semi-exclusive deep-inelastic scattering of electrons off the deuteron were analyzed and the extreme kinematic regions were found, where FSI was minimized so that the quark distribution of bound nucleons could be investigated. The other region is revealed, where the re-interaction of the produced hadrons with the spectator nucleon was maximized, which would allow one to study the mechanism of hadronization of highly virtual quarks. The calculations were performed to establish the respective kinematic conditions at JLab (BONUS collaboration E03-012) and HERA (HERMES collaboration) [42].

The realistic quasiparticle-based description of the quark-gluon matter in thermodynamics was given, and the method was developed for treating the string screening in the dense matter of unbound color charges. The proposed method yields an integrable effective pair potential which can be incorporated into the mean-field picture. The results of its application are in reasonable agreement with lattice data on the QCD thermodynamics [43].

The high-energy approach to the microscopic calculations of the total nucleus–nucleus reaction cross sections at intermediate energies was developed based on the realistic nuclear density distributions taken, e.g., from the electron scattering data. This allows one to make calculations without free parameters. The role of in-medium and distortion effects are studied, and the respective theoretical bars are estimated when comparing calculations with experimental data [44].

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.

The following main results on the problem of *strongly correlated systems* were obtained:

The phenomenological theory of the orbital phase transitions in the $Pr_{1-x}Ca_xMnO_3$ manganite is developed. It is shown that two different phases in this compound observed in recent neutron diffraction experiments are essentially two different orbital phases, which can be accompanied by the charge ordering phase transition [45].

A superexchange theory for the insulating double-perovskite compound Sr_2FeWO_6 was developed based on an effective spin-orbital Hamiltonian formulated in terms of spin ($S = 2$) and orbital pseudo-spin ($\tau = 1$) degrees of freedom of the Fe ion. It was shown that for realistic values of the model parameters the ground state was antiferromagnetic, as experimentally observed [46].

The spectral density functional theory for electronic structure calculations of strongly correlated materials where the single–particle description breaks down is developed. Within this method several examples of systems near metal-insulator transition, near volume collapse transition, and systems with local moments are considered [47].

In the field of the theory of *dynamical systems: chaos, integrability, and self-organization*, the first complete nonstationary solution of the master equation for a system of interacting particles of finite density is presented. By using a new form of the Bethe ansatz, the totally asymmetric exclusion process on a ring is solved for arbitrary initial conditions and time intervals [48].

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

An instanton approximation to the continuous-time spin coherent-state path integral was used to obtain the tunnel splitting of classically degenerate ground states. The method was applied to the description of the molecular magnet Fe8 in a transverse field [49].

Within a 2D model of Josephson junction arrays, a few novel effects expected to occur in intrinsically granular material are predicted including: (i) Josephson chemomagnetism (chemically induced magnetic moment in zero applied magnetic field) and its influence on a low-field magnetization (chemically induced paramagnetic Meissner effect), and (ii) magnetoconcentration effect (creation of oxygen vacancies in applied magnetic field) and its influence on a high-field magnetization (chemically induced analog of «fishtail» anomaly) [50].

A variant of a gauge theory was formulated to describe the electronic states due to topological defects in variously shaped carbon nanoparticles. The local and total density of states (DOS) near the pentagonal defects (disclinations) were calculated for three geometries: sphere, cone, and hyperboloid. The appearance of enhanced charge density near the Fermi level for nanocones with a 60° opening angle was predicted [51].

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.

The general measure of entanglement generated by an arbitrary operator (statistical operator, field operator or spin operator) was defined. The measure is valid for any system, pure or mixed, bipartite or multipartite, equilibrium or nonequilibrium. The relation between the entanglement production and phase transitions in statistical systems was elucidated by the examples of Bose–Einstein condensation, superconducting, and magnetic transitions by invoking the concept of operator order indices [52].

COMPUTER FACILITIES

The stack of network switches was extended by installation of additional Fast Ethernet modules and new routing switch. This made it possible to complete transfer from the old coaxial network to the new high-performance network based on UTP. Most of the PCs at the Bogoliubov Laboratory of Theoretical Physics are connected to Fast Ethernet network. Transfer of main servers to Gigabit Ethernet is close to its completion. Routing capabilities of a new switch were used to speed up data exchange between the BLTP network and JINR backbone network. The dual-processor computer equipped with Pentium 4 Xeon 3 GHz, 2 GB DDR RAM, 170 GB disk space was purchased to become a new main server of BLTP. The server has wide possibilities for further extension of RAM and disk space. Sixteen personal computers based on Pentium 4 were acquired for work places upgrade. New WWW resource was created: http://thproxy.jinr.ru/diastp/. Video records and slides of lectures given by well-known scientists at the Advanced Summer School on Modern Mathematical Physics were presented to visitors' attention.

MEETINGS, SCIENTIFIC COLLABORATION

In 2003, the Laboratory participated in 13 international conferences, workshops, and schools held in Dubna, Prague, and Yerevan.

On 8–11 June, the XII International Conference on Selected Problems of Modern Physics dedicated to the 95th anniversary of the birth of D. I. Blokhintsev (1908–1979), the outstanding Russian scientist, first JINR director who contributed a lot to the development of a great variety of research fields in modern physics, and the initiator of creation of pulsed research reactors, was held in Dubna. The conference was opened by the memorial session at which V. G. Kadyshevsky, A. V. Zrodnikov, A. A. Logunov, S. N. Sissakian, and E. P. Shabalin shared their reminiscences of D. I. Blokhintsev.

Further work of the conference proceeded in two parallel sections: «Problems of Quantum Field Theory» and «Physical Investigations at Pulsed Reactors». The section «Problems of Quantum Field Theory» was a continuation of a series of conferences on nonlocal, nonlinear, and nonrenormalizable field theories which were organized at the initiative of Dmitrii Ivanovich Blokhintsev. The first conference of this series was held in Dubna in 1967. During this section 90 talks were given on the following themes: quantum mechanics, quantum field theory, quantum chromodynamics, hadron physics, gravitation, and cosmology; 117 scientists from Russia, Germany, Georgia, Italy, Mongolia, Poland, Romania, Slovakia, the USA, Uzbekistan, Ukraine, and the Czech Republic took part in this section.

The international workshop «Supersymmetries and Quantum Symmetries 2003» (SQS'03) was held at the Bogoliubov Laboratory of Theoretical Physics from 24 to 29 July. This series of biennial international workshops was founded by Professor V. I. Ogievetsky in the late 1980s. Their program traditionally covers such «hot» directions of modern theoretical physics as superstrings and superbranes, quantum and geometric aspects of supersymmetric theories, supersymmetric integrable models, higher spins, quantum groups and noncommutative geometry, as well as the Standard Model and its supersymmetric extensions. This time the attendance numbered some 100 participants from many countries of Western and Eastern Europe. A characteristic feature of the SQS'03 workshop was active participation of the new generation of talented young theorists, from both the West and the East. This supports the belief that the SQS workshops have good prospects for the future. In 2003, the workshop was special: it was dedicated to the 75th anniversary of the birth of its founder V. I. Ogievetsky (1928–1996). In commemoration of this remarkable scientist there took place inauguration of the memorial plaque at BLTP on the wall next to the former office of V. I. Ogievetsky.

An international conference «Nuclear Structure and Related Topics» was held in Dubna, at the Ratmino holiday hotel on 2–6 September. A tradition to organize international conferences and schools on selected topics in nuclear structure was established in Dubna in the 1960s. Among 90 participants of the conference were nuclear scientists from JINR, JINR Member States, many European countries as well as from China, Japan and the United States. The conference programme included 50 oral reports where the very recent results of current nuclear studies were presented. At present, the main part of nuclear studies is concentrated on properties of nuclei far from stability. This specified to a great extent the conference programme. The sizeable part of theoretical reports was devoted to self-consistent microscopic models since predictions of these models are most reliable. Lively discussions took place at the session devoted to «cluster» properties of heavy nuclei and theoretical approaches describing them. An application of nuclear physics to the astrophysical problem, nucleosynthesis in particular, was discussed at the special session.

From 16 to 20 September BLTP hosted the 10th Workshop on High Energy Spin Physics. It continued a series of similar meetings, the first of which took place in 1981 under the initiative of an outstanding theoretical physicist Lev I. Lapidus. Since then each odd year similar meetings have been held in Dubna or Protvino: in even years international spin symposia were organized and these meetings made it possible to discuss information accumulated during the year. Another important feature has always been an opportunity for many physicists from the former USSR, for whom distant trips were complicated for financial reasons, to participate in these symposia. As well as the previous one, the present meeting was held as a joint JINR–Polish workshop: co-chairmen were professors A. V. Efremov (Dubna) and J. Nassalski (Poland), also five participants from Poland were supported by the Bogoliubov–Infeld programme. A specific feature of the present meeting was a greater, than usual, number of participants and the countries they represented: France — 2, Armenia — 1, the USA — 8, Italy — 1, Ukraine — 2, Japan — 4, China — 1, Germany — 6, Belarus — 3, Bulgaria — 1, Russia — 19. As usual, many (about 50) physicists from JINR participated. It became possible to organize this workshop owing to the support of the Russian Foundation for Basic Research, the International Organizing Committee of symposia on spin physics, the Heisenberg–Landau programme, and for the first time for these meetings, the NATO research programme. The NATO supported the workshop provided that it would last five days, which led to a very compressed programme. The reason for increased popularity of the meeting was apparently that a lot of new experimental results have been obtained in 2003 and even more is expected in the near future.

The new educational project «Dubna International Advanced School of Theoretical Physics» (DIAS-TH) was launched at BLTP in 2003. The main goals of DIAS are further development and coordination of the JINR research and educational programmes, participation in similar international projects, and organization of regular schools and workshops on the JINR priority themes for schoolchildren, students, postgraduates, and young researchers from JINR Member States and other participants of the Institute. At the 95th session of the JINR Scientific Council this project was approved as a new first-priority theme. In 2003, the following international workshops and schools were successfully held in the framework of the DIAS-TH project: Winter School on Theoretical Physics (27 January – 9 February), VII workshop «Nucleation Theory and Applications» (4–28 April), workshop and school «Calculations for Modern and Future Colliders» (13–22 June), Summer School on Modern Mathematical Physics (11–22 June), DAAD summer school «Traffic and Econophysics» (28 July – 17 August). Successful realization of the DIAS-TH project was made possible due to the financial support from DAAD, BMBF, RFBR, the Heisenberg–Landau, Bogoliubov–Infeld and Blokhintsev–Votruba programmes, and JINR.

In 2003, the Laboratory participated in the organization of conferences traditionally held in the JINR Member States: «Quantum Groups and Integrable Systems» (12–14 June, Prague) and «Symmetry Methods in Physics» (13–19 August, Yerevan).

In 2003, the international collaboration was supported by grants of the plenipotentiaries of Bulgaria, the Czech Republic, Poland, the Slovak Republic, Hungary, Romania and the JINR Directorate; the collaboration with German theorists was based on the Heisenberg–Landau programme; with Polish theorists, on the Bogoliubov–Infeld programme; and with Čzech theorists, on the Blokhintsev–Votruba programme. Agreements on collaboration in theoretical physics with scientists of Bulgaria and Romania were prepared.

Some studies were carried out in collaboration with scientists from Western Europe in the framework of the JINR–INFN, JINR–IN2P3 agreements and on the projects supported by INTAS, RFBR–DFG, RFBR–CNRS.

The agreements on collaboration between the Bogoliubov Laboratory and CERN TH, ICTP are functioning.

REFERENCES

1. *Kotikov A. V., Lipatov L. N., Velizhanin V. N.* // Phys. Lett. B. 2003. V. 557. P. 114–120.
2. *Kuraev E., Galynskii M., Il'ichev A.* // JETP Lett. 2003. V. 77. P. 256–259.
3. *Bartos E., Kuraev E. A., Dubnicka S.* // Phys. Rev. Lett. (submitted); hep-ph/0303194.
4. *Sissakian A., Shevchenko O., Ivanov O.* // Phys. Rev. D. 2003. V. 68. P. 031502(R).
5. *Efremov A. V., Goeke K., Schweitzer P.* hep-ph/0309209; Eur. Phys. J. 2003 (in press).
6. *Shirkov D. V.* // Teor. Mat. Fiz. 2003. V. 136. P. 409–423; JINR Preprint E2-2003-1. Dubna, 2003; hep-ph/0210113.
7. *Anikin I. V., Pire B., Teryaev O. V.* hep-ph/0307059; Phys. Rev. D (in press).
8. *Efimov G. V.* hep-ph/0304194; Few Body Systems (in press).
9. *Ivanov M. A., Korner J. G., Pakhomova O. N.* // Phys. Lett. B. 2003. V. 555. P. 189.
10. *Kochelev N. I.* // Ibid. V. 565. P. 131;
Dorokhov A. E., Cherednikov I. O. // Phys. Rev. D. 2003. V. 65. P. 114017.
11. *Radzhabov A. E., Volkov M. K.* hep-ph/0305272; Eur. Phys. J. A. 2004. V. 19 (in press).
12. *Leader E., Sidorov A. V., Stamenov D. B.* // Phys. Rev. D. 2003. V. 67. P. 074017.
13. *Gerasimov S. B.* hep-ph/0311080; Nucl. Phys. C. 2003 (in press).
14. *Barbashov B. M. et al.* // Theor. Math. Phys. (in press);
Biernacka M. et al. // Part. Nucl., Lett. 2004. V. 1, No. 2(119). P. 64–71; astro-ph/0206114.
15. *Isaev A. P., Sergeev S. M.* // Lett. Mat. Phys. 2003. V. 64. P. 57–64.
16. *Pakuliak S. Z., Sergeev S. M.* // Teor. Mat. Fiz. 2003. V. 136. P. 30–51.
17. *Isaev A. P.* // Nucl. Phys. B. 2003. V. 662. P. 461–475.
18. *Bellucci S., Sochichiu C.* // Phys. Lett. B. 2003. V. 564. P. 115; Phys. Lett. B. 2003. V. 571. P. 92.
19. *Spiridonov V. P.* // Algebra i Analiz (St. Petersburg Math. J.). 2003. V. 15(6). P. 161–215.
20. *Ivanov E. et al.* // Phys. Lett. B. 2003. V. 566. P. 175.
21. *Bellucci S., Galajinsky A., Krivonos S.* // Phys. Rev. D. 2003. V. 68. P. 064010.
22. *Plyushchay M., Sorokin D., Tsulaia M.* // JHEP. 2003. V. 0304. P. 013.
23. *Gribanov V. V., Kadyshevsky V. G., Sorin A. S.* nlin.SI/0311030.
24. *Popov A. D., Sergeev A. G., Wolf M.* // J. Math. Phys. 2003. V. 44. P. 4527–4554.
25. *Frolov V., Fursaev D., Zelnikov A.* // JHEP. 2003. V. 0303. P. 038.
26. *Nesterenko V. V., Pirozhenko I. G., Dittrich J.* // Class. Quant. Grav. 2003. V. 20. P. 431–455.
27. *Feoli A., Nesterenko V. V., Scarpetta G.* cond-mat/0211415. Nucl. Phys. B (submitted).
28. *Mardoyan L. G., Pogosyan G. S., Sissakian A. N.* // Theor. Math. Phys. 2003. V. 135(3). P. 808–813.
29. *Alonso M. A., Pogosyan G. S., Wolf K. B.* // J. Math. Phys. 2003. V. 44(4). P. 1472–1489.
30. *Severyukhin A. P. et al.* // Nucl. Phys. A. 2003. V. 722. P. 123c.
31. *Laftchiev H. et al.* // Phys. Rev. C. 2003. V. 67. P. 014307.
32. *Adamian G. G. et al.* // Ibid. P. 054303.
33. *Storozhenko A. et al.* // Ann. Phys. 2003. V. 307. P. 308.
34. *Nesterenko V. O. et al.* // J. Phys. G: Nucl. Part. Phys. 2003. V. 29. P. L37.
35. *Zubov A. S. et al.* // Phys. Rev. C. 2003. V. 68. P. 014616.
36. *Fazio G. et al.* // J. Phys. Soc. Japan. 2003. V. 72. P. 2509.
37. *Pupyshev V. V.* // Teor. Mat. Fiz. 2003. V. 136. P. 970.
38. *Albeverio S., Makarov K. A., Motovilov A. K.* // Can. J. Math. 2003. V. 55. P. 449.
39. *Chen G.-Y. et al.* // Nucl. Phys. A. 2003. V. 723. P. 447.
40. *Shevchenko N. V. et al.* // Nucl. Phys. A. 2003. V. 714. P. 277.
41. *Titov A., Lee T.-S.H.* // Phys. Rev. C. 2003. V. 67. P. 065201.
42. *Ciofi degli Atti C., Kaptari L. P., Kopeliovich B. Z.* nucl-th/0307052.
43. *Biro T. S.,Shanenko A. A., Toneev V. D.* // Yad. Fiz. 2003. V. 66. P. 982.
44. *Luk'yanov V. K. et al.* // Izv. RAN. Ser. fiz. 2003. V. 67. P. 55.
45. *Shakhmatov V. S., Plakida N. M., Tonchev N.* // JETP Lett. 2003. V. 77. P. 24–28.
46. *Di Matteo S., Jackeli G., Perkins N. B.* // Phys. Rev. B. 2003. V. 67. P. 184427.
47. *Kotliar G. et al.* // Rev. Mod. Phys. 2003 (in press).
48. *Priezzhev V. B.* // Phys. Rev. Lett. 2003. V. 91. P. 050601.
49. *Garg A. et al.* // J. Math. Phys. 2003. V. 44. P. 48.
50. *Sergeenkov S.* // JETP Lett. 2003. V. 77. P. 99.
51. *Osipov V. A., Kochetov E. A., Pudlak M.* // JETP. 2003. V. 123. P. 140.
52. *Yukalov V. I.* // Phys. Rev. Lett. 2003. V. 90. P. 167905; Phys. Rev. A. 2003. V. 68. P. 022109.