Theoretical Physics

01-3-1028-99/2008	Priority: 1
	Status: In-progress

Fields and Particles

Leader from JINR: D. Kazakov, O. Teryaev

Participating countries and international organizations: Armenia, Azerbaijan, Belarus, Bulgaria, Canada, CERN, Czech Republic, Finland, France, Georgia, Germany, Hungary, ICTP, Italy, Japan, JINR, Kazakhstan, Mexico, Mongolia, New Zealand, Norway, Poland, Republic of Korea, Russia, Slovak Republic, Spain, Sweden, Switzerland, the USA, Ukraine, the United Kingdom, Uzbekistan, Vietnam, Yugoslavia.

Main directions of research are:

Further development of the quantum field theory approach in the framework of the Standard Model of fundamental interactions and its extensions. Lattice simulations for obtaining nonperturbative results in gauge theories. Elaboration of the multiloop calculations in QCD, Electroweak theory and Minimal Supersymmetric Standard Model. Theoretical predictions concerning the experimental observation of supersymmetry, the Higgs boson, investigation of the spin structure of the nucleon, T-odd spin effects, jet handedness, heavy flavor physics, vacuum structure in QCD, hadron properties in dense and hot media. Elaboration of new phenomenological models to describe the hadron dynamics in the framework of general principles of quantum field theory incorporating basic experimental patterns.

A new field of research will be related to astroparticle physics and cosmology.

Theoretical support of current and future experiments at JINR, IHEP, CERN, DESY, GSI, FNAL, BNL and other physics centers.

Collaboration: scientific centers of the JINR Member States and other countries including Germany (the Heisenberg-Landau Programme), the INFN sections (Italy), IN2P3 Institutes (France), CERN TH.

Accent is made on the support of young researches and their promotion. International schools and workshops on the problems of particle physics are organized annually.

01-3-1029-99/2008	Priority: 1
	Status: In-progress

Nuclear Theory

Leader from JINR: V. Voronov, R. Jolos

Participating countries and international organizations: Austria, Belarus, Belgium, Brazil, Bulgaria, Canada, Czech Republic, Egypt, France, Germany, Greece, Hungary, Italy, Japan, JINR, Kazakhstan, Moldova, Norway, Poland, Portugal, Republic of Korea, Romania, Russia, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Taiwan, the USA, Ukraine, Uzbekistan.

The main goals are to investigate properties of atomic nuclei at high excitation energies and angular momenta as well as large deformation and isotopic asymmetry values; to study dynamics of nuclear reactions and mechanisms of producing superheavy nuclei and nuclei that are close to the drip line; to investigate fundamental properties of few-body systems like mesomolecules, antiprotonic atoms, and exotic nuclei; to apply nuclear theory methods to analyze other finite Fermi-systems; to investigate the behaviour of nuclear matter under extreme conditions and its phase transitions; to evaluate new methods of relativistic nuclear physics and apply them to analysis of subnuclear and spin effects in few-nucleon systems.

This research programme is related to the experiments in nuclear structure and heavy ion physics at the DLNP, FLNR, FLNP and LHE, JINR.

Collaboration: scientific centers of the JINR Member States and other countries including Germany (the Heisenberg-Landau Programme), the INFN sections (Italy), IN2P3 Institutes (France).

International conferences on nuclear structure and related topics, regularly organized in Dubna, are attended by scientists from many nuclear centers.

01-3-1030-99/2008	Priority: 1
	Status: In-progress

Theory of Condensed Matter

Leader from JINR: N. Plakida, V. Priezzhev

Participating countries and international organizations: Armenia, Azerbaijan, Belarus, Belgium, Brazil, Bulgaria, Canada, Czech Republic, France, Germany, Hungary, ICTP, India, Ireland, Italy, JINR, Mexico, Moldova, Mongolia, Poland, Russia, Slovak Republic, Slovenia, Spain, Switzerland, Taiwan, the USA, Ukraine, the United Kingdom, Uzbekistan, Vietnam, Yugoslavia.

The following topics in the theory of condensed matter are to be studied:

Multi-particle models of solids taking into consideration strong electron correlations, Electron-lattice and spin interactions to describe spectra of quasiparticle excitations, phase transitions and kinetic phenomena in solids. In equilibrium and nonequilibrium media with strong correlations such as liquids and nuclear matter the processes of multifragmentation, clusterization in phase transitions and the influence of surface effects on properties of clusters. In the theory of superconductivity, nonstandard mechanisms of pairing in metal-oxides, the problem of bipolaron stability in a polaron gas environment, the influence of strong electric fields and temperature gradients on elastic, magnetic, and thermal properties of granular superconductors. For the study of mechanisms of phase transitions caused by charge, orbital, and magnetic ordering in magnetic semiconductors and in metals with a large magnetoresistance, experimental data obtained at the Laboratory of Neutron Physics, JINR, by neutron scattering and the μSR method will be used.

Nonlinear problems in multi-particle theory will be studied by using modern methods of the renormalization group theory, the inverse scattering problem, fractal geometry, and the conformal field theory. The main subjects of the study are integrable systems, equilibrium systems of the statistical mechanics and dissipative systems far from the thermodynamic equilibrium. The aim of these investigations is to reveal the common properties of the multi-particle systems associated with the ideas of self-similarity and universality.

In the theory of disordered structures, materials with the structural disorder (amorphous bodies, glasses, quasicrystals) will be studied. A special attention will be devoted to an analysis of topological models of disorder, the role of topological defects in the formation of glassy state as well as their influence on the low-temperature properties of glasses and quasicrystals. The field-theory and geometrical methods in problems of condensed matter physics will be developed. In particular, the gauge theory of topological defects on arbitrary curved surfaces will be investigated, which is of importance in a study of nanostructures (fullerenes, nanotubes, nanocones, etc.).

In the theory of finite quantum systems, local and low-dimensional states of matter obtained in modern experiments will be investigated. In particular, properties of quasiparticles in mesoscopic systems and the Bose-Einstein condensation in atomic traps will be studied.

Collaboration: scientific centers of the JINR Member States and other countries including Germany (the Heisenberg-Landau Programme), the INFN sections (Italy).

01-3-1047-2003/2007	Priority: 1
	Status: In-progress

Modern Mathematical Physics

Leader from JINR: A. Filippov, A. Isaev

Participating countries and international organizations: Armenia, Australia, Belgium, Brazil, Bulgaria, Canada, CERN, Czech Republic, France, Georgia, Germany, Greece, Hungary, ICTP, India, Italy, Japan, JINR, Mexico, Norway, Poland, Russia, Romania, Turkey, Ukraine, the United Kingdom, the USA, Yugoslavia.

Superstring Theory is the most serious and worldwide pursued candidate for a unified theory of all fundamental interactions, including Quantum Gravity, and thus, it is the principal source of the problems which are the subject of modern mathematical physics. The development of the theory involves the study of its surprisingly wide spectrum of possible modes, vacua and exact classical and quantum solutions. Furthermore, the theory has applications in many directions including the nonperturbative mode of supersymmetric gauge theories, the mechanics and thermodynamics of black holes and cosmological models of the universe expansion. There are unique laboratories to check general ideas from unified theories. In particular, in order to accommodate and develop the new ideas in these sectors inspired by String Theory it is crucial to use the powerful mathematical methods provided by the theory of Integrable Systems, Quantum Groups and Non-Commutative Geometry. The goals of the present new theme precisely belong to the bridging these fields and further development of suitable schemes to be applied in this context.

Collaboration: scientific centers of the JINR Member States and other countries including Germany (the Heisenberg-Landau Programme), the INFN sections (Italy), IN2P3 Institutes (France), CERN TH.

Accent is made on the support of young researchers and their promotion. International schools and workshops on the problems of modern mathematical and theoretical physics are organized annually.

01-3-1053-2004/2008	Priority:
	Status: New

Dubna International Advanced School of Theoretical Physics (DIAS-TH)

Leader from JINR: A. Filippov, A. Sorin

Participating countries and international organizations: Armenia, Austria, Belarus, Brazil, Bulgaria, Canada, CERN, Czech Republic, France, Georgia, Germany, Greece, Hungary, India, ICTP, Italy, Japan, JINR, Mexico, Poland, Romania, Russia, Slovak Republic, Turkey, Ukraine, the United Kingdom, the USA, Yugoslavia.

The Bogoliubov Laboratory of Theoretical Physics (BLTP) has a good record of organizing international workshops and schools in Dubna. DIAS-TH organizes and supervises all educational programs for students, postgraduates, and young scientists at BLTP. It should function continuously and the standard short schools (about 3–4 in a year) should be organized coherently. Other educational programs in Dubna, such as the JINR University Center may also be correlated with DIAS-TH (common programs on modern theoretical physics, workshops for students and young scientists, etc.).

The main goals of DIAS:

- Training courses for students, graduates, and young scientists in the JINR Member States and other countries (according to special agreements and grants);
- Looking for and supporting gifted young theorists in the JINR Member States; creating databases of students and young researchers;
- Organization of schools of different levels in Dubna and coordination with similar schools in Russia, Germany, and other European countries;
- Support of the JINR experimental programs by organizing lecture courses and review lectures on new trends in modern physics;
- Cooperation with the JINR University Center in training students and postgraduates as well as in organizing schools for students;
- Cooperation with existing training programs in mathematics and physics for gifted schoolchildren (there are at present two such high — level programs acting in Dubna);
- Coordination of the research — training programs with workshops and conferences at JINR;
- Coordination with the schools and workshops supported by the European community, UNESCO and other organizations;
- Participation in nets of workshops and schools in Europe;
- Publication of lectures and discussions in different forms, in particular, with the use of modern electronic equipment, etc.;
- Supporting the WEB page of DIAS-TH which should become the organizing center of the programs related to DIAS-TH.

The main topics of the activity of DIAS should be centered around the most important directions of research at BLTP: Particles and Fields; Nuclear Theory; Theory of Condensed Matter; Modern Mathematical Physics.

The unique features of DIAS-TH will be the following: wide participation of students from Europe (Germany, Poland, Czechia, Slovakia, Bulgaria, Romania, possibly, Italy, France), Russia and the Former Soviet Union states; participation of the leading physics institutes of Russia and of the Former Soviet Union states with which JINR is connected by different agreements; support of special programs in the framework of the JINR budget (Heisenberg–Landau, Bogoliubov–Infeld, Blokhintsev–Votruba Programmes). In addition to the mentioned programs, one can hope to get support from BMBF, UNESCO, RFBR, and to eventually obtain some support from CNRS and INFN. One also has to look for other sources.