Bogoliubov Laboratory of Theoretical Physics of the Joint Institute for Nuclear Research

The Bogoliubov Laboratory of Theoretical Physics (BLTP) is a part of the Joint Institute for Nuclear Research (JINR), a huge international center comprising experimental facilities of nuclear and high energy physics located at Dubna near Moscow.

Nowadays, BLTP is a big research institution in theoretical physics with scientific staff of about 170 researchers, half of them working on fixed-term contracts. Since its creation more than 45 years ago, our Laboratory has been the nest of the prominent schools in quantum field theory, theoretical nuclear physics, and statistical physics founded by Blokhintsev, Bogoliubov, and Markov. Among the merits of the Bogoliubov Laboratory are the practice of interdisciplinary research in these fields of theoretical physics and the interaction between theorists and experimentalists.

Computer facilities of BLTP include more than a hundred PC's and workstations joined by local network. They are regularly upgraded to maintain the international standard level. Via the JINR network, our Laboratory is connected with major world communication and information networks.

The Joint Institute at Dubna is an indispensable center of international cooperation in fundamental physics for scientists of the countries from the former Soviet Union (FSU), European and some Asian countries. Its developed infrastructure, comfortable location (130 km north of Moscow, 90 km of International Sheremetyevo airport, and 5 km of earth satellite station) on the bank of the Volga river and picturesque surroundings make it an outstanding place in Russia for hosting international meetings.

The BLTP has a great deal of international contacts. We organize numerous conferences, schools, and workshops on different topics in theoretical physics. Traditionally, we have good relations with leading theoretical institutions of the JINR Member States and many other countries.

An important part of JINR's activities is connected with the education and training of young scientists and students. The JINR has a special training center for M.Sc. and Ph.D. students, with members of the BLTP staff participating in the teaching process. About 20 graduate students have completed their doctoral theses at the Bogoliubov Laboratory for the last two years. Many of our senior staff members are supervising doctoral theses, professors of the staff are lecturing at Moscow, Tver', Ivanovo State Universities and some other Educational Institutions.

The BLTP actively participated in the organization of Chairs of Physics at the International University “Dubna”. In the summer of 2003 the Chairs of Theoretical and Nuclear Phisics were established. Owing to the interaction with JINR the Chairs can form their curriculum taking into consideration the requirements put forward by the scientific community to a specialist in physics. As a result, students get modern education; whereas JINR, a possibility to attract talented students to research.

PREFACE

This booklet is the report on the scientific activity of the Bogoliubov Laboratory of Theoretical Physics (BLTP) of the Joint Institute for Nuclear Research (JINR) during the years 2003 –2004. It contains information on the structure and the personnel of the Laboratory, a practically complete list of publications, a brief description of the international collaboration of BLTP, and a selection of scientific results obtained in those years.

The diversity of interests of our theorists allows the Laboratory to keep high standard of research in main directions of modern theory. **Collaboration of theorists with Institute's experementers became closer over the last two years. Noteworthy also is the realization of the educational programme «Dubna International Advanced School of Theoretical Physics (DIAS-TH)».**

Though the inflows to the JINR budget considerably increased in 2003 – 2004, limited financing strongly requires that studies be concentrated on the most important and ambitious fields of research. Work has been begun on a strategic programme “road map” at the Institute. The Laboratory’s proposals to this programme were presented at sessions of the Programme Advisory Committees for Particle Physics, Nuclear Physics, and Condensed Matter Physics in April 2005.

Development of *particle physics* in the near future will be dominated by existing accelerators and non-accelerator facilities and the new projects which are under construction. We are already involved in many experimental collaborations, and provide theoretical support to several experiments. Research at BLTP is mainly concentrated in the area of hadron physics, precision tests of the Standard Model (SM) and physics beyond the SM, first of all search for supersymmetry. In the following decade, beside these traditional areas, theoretical research will also be concentrated on neutrino physics, astroparticle physics, and heavy-ion collisions. Of special interest is a search for the mixed phase of the strongly interacting matter corresponding to the first order chiral and deconfinement phase transitions, using Nuclotron heavy ion beams. This will open a new perspective in the Nuclotron physics programme, results obtained on this way could be relevant for world leading centers on high energy physics and be used in both current and future experiments.

In *modern mathematical physics*, development of theories of supersymmetry, supergravity, superstring and branes will be one of the main goals of theorists in coming years. On the other hand, the new dramatic discoveries in astronomy and astrophysics have recently excited vigorous attempts to construct a mathematical cosmology based on string theory as well as renewed interest in higher dimensional theories of gravity. Another application of ideas and results of the string theory is to nonperturbative supersymmetric gauge theories that, hopefully, may allow one to eventually find a way to understanding nonperturbative aspects of QCD.

The scientific programme of BLTP in the field of *nuclear theory* will be linked with theoretical understanding of the nuclear many-body system. Many essential questions will be addressed to the nuclear structure and dynamics, nuclear astrophysics. Much of what we know about nuclei, their structure and dynamics comes from nuclear reactions. Since many-body reaction models do not exist, a synthesis between microscopic structure theory and reaction must be carried out to incorporate and imbed the important few-body and many-body correlations into the

reaction matrix elements. The study of symmetries in nuclei and how these symmetries can be broken will give guidelines to how to unify a large body of the present knowledge. In many of the astrophysical models nuclear theory has to bridge a gap between experimental data and astrophysical application.

The theoretical studies in the field of *condensed matter* will be concentrated on the following main directions: theoretical explanations of physical phenomena (high T_c superconductivity, Bose-Einstein condensation, huge magnetic resistance, etc.) in new materials; quantum effects in nanostructures including quantum wells, wires and dots; applications of theoretical methods to systems beyond the condensed matter (biophysics, quantum optics, econophysics, etc.) Extensive experimental investigations of new materials performed by neutron scattering methods at the Frank Laboratory of Neutron Physics, JINR also strongly motivate the development of theoretical investigations in the field.

Solving these problems requires combined efforts of theorists of all generations and, especially of talented young scientists. For this reason we have to be very active in organizing science educational programs at JINR directed to purposeful search for young talents. BLTP is actively developing the DIAS-TH project that now enters the new phase. The purpose is to make it a continuous educational program and provide high quality lectures and training courses useful not only to theory students and postgraduates but to all physicists of JINR and Member States.

It can be perceived from this booklet that the Bogoliubov Laboratory have done a lot of work on the development of promising lines of investigation, adequate theoretical support of experimenters, and creation of attractive educational programmes on theoretical physics.

Director BLTP,
JINR Director
(designate) A.N. Sissakian

April 2005

1. SCIENTIFIC RESEARCH

1.1 Fields and Particles

1.2 Modern Mathematical Physics

1.3 Nuclear Theory

1.4 Theory of Condensed Matter

Introduction

Reports on Selected Topics

Publications