Theoretical Physics

Scientists of the Bogoliubov Laboratory of Theoretical Physics (BLTP) have accumulated unique experience of research in several fundamental areas of theoretical physics: quantum field theory and elementary particle physics, nuclear theory, theory of condensed matter and methods of mathematical physics. The studies conducted at BLTP are interdisciplinary; they are directly integrated into international projects with the participation of scientists from major world research centres and are closely coordinated with JINR experimental programmes. With the launching of the research and education project "Dubna International Advanced School of Theoretical Physics" (DIAS-TH) and with the opening of new departments of theoretical physics at the Moscow Institute of Physics and Technology and at the Dubna International University, closely associated with the JINR University Centre, BLTP has considerably increased its role of an international educational centre for young scientists and students.

In the forthcoming years, the efficiency of work in the above-mentioned directions will be enhanced along the lines shown in the corresponding programme sections below. Research is planned to be enhanced in nuclear and particle astrophysics, hadron physics under extreme conditions (in connection with experimental programmes of the NICA/MPD project, current and future experiments at RHIC, LHC and FAIR), lattice QCD calculations. Studies in condensed matter physics will be more directly coordinated with the requirements of modern nanotechnology development.

The table illustrates the financial resources to provide for research in theoretical physics on the following topics: quantum field theory and elementary particle physics, nuclear theory, theory of condensed matter, modern mathematical physics, and the research and education project "DIAS-TH".

Funding (k$)

2010	2011	2012	2013	2014	2015	2016
370	410	435	460	485	510	530

Quantum field theory and particle physics. The milestones in theoretical research in the field of particle physics will be determined by the physics programmes of major international collaborations (LHC, RHIC, FAIR, K2K, etc.) and those at the JINR basic facilities, primarily, of the NICA/MPD project. Major attention will be paid to precision tests of the Standard Model, new physics beyond the Standard Model, hadron structure and spin physics, phase transitions in hot and dense hadronic matter and mixed quark-hadron phase, heavy flavour physics and hadron spectroscopy, neutrino physics, the dark matter problem, and astrophysical aspects in elementary particle physics.

Nuclear theory. The main direction of nuclear studies at low energies in the coming decade will be studies of the properties of nuclei far from the valley of stability, which is an integral part of the physics programme of the DRIBs project (JINR) and practically all existing and scheduled projects at large facilities in Europe, the USA, and Japan. Theoretical research in this domain of nuclear physics will develop respectively. It is planned to proceed with the elaboration of nuclear structure self-consistent microscopic models with density-dependent effective forces, finite-range effective interactions beyond the mean-field and random phase approximations. Nuclear structure models will be applied to the prediction for the rates of weak processes in stellar matter and other astrophysical problems. In the theory of reactions, collisions of ultracold atoms and molecules in optical and magnetic traps, and fusion reactions in crossing low-energy beams of light nuclei channeled inside a crystal will be investigated. Studies of processes of heavy-ion interactions at intermediate and high energies will be mainly oriented to the NICA/MPD project. Nucleon and nucleus structure functions will be studied using the experimental data obtained at JINR, GSI, JLab, and J-PARC.

Theory of condensed matter. Theoretical research will be focused on the analysis of systems with strong electronic and magnetic correlations (layered cuprates in their normal and superconducting state, transition metal oxides, in particular, magnetoresistive manganites and geometrically frustrated antiferromagnetic spinels, and fullerene clusters and lattices, etc.), which involves studies of novel cooperative phenomena, new forms of order, low-dimensional magnetism, and quantum criticality. Research in this field will be aimed at supporting the experimental studies of these materials conducted at the Frank Laboratory of Neutron Physics. Studies of the electronic, magnetic, thermal and transport characteristics of various nanoscale materials and nanostructures will be the key research direction. Carbon nanostructures are of particular interest.

Modern mathematical physics. Superstring theory, the most serious and worldwide pursued candidate for the unification of all fundamental interactions including quantum gravity, will be the central topic in mathematical physics studies at BLTP. A wide range of precise classical and quantum superstring solutions, application of modern mathematical methods to the fundamental problems of supersymmetric gauge theories, development of microscopic description of black hole physics, elaboration of cosmological models of the early Universe will be studied. To apply and develop new ideas generated with the string theory, it is crucial to use mathematical methods of the theory of integrable systems, quantum groups and noncommutative geometry.

Research and education project "Dubna International Advanced School of Theoretical Physics (DIAS-TH)". The general objective of the continuously running BLTP project "Dubna International School of Theoretical Physics (DIAS-TH)" will be the promotion of scientific and educational programmes at JINR. The unique feature of DIAS-TH is its coherent integration into the scientific life of BLTP which will ensure regular and natural participation of the leading scientists in education and training activities. Cooperation of DIAS-TH with international and Russian foundations (UNESCO, DAAD, DFG, RFBR, Dynasty, etc.) and state organizations (BMBF, INFN, CNRS) will be an important prerequisite for the successful implementation of this project.