

# **Programme Advisory Committee for Condensed Matter Physics**

**57th meeting, 15–16 June 2023**

## **Recommendations**

### **I. Preamble**

The Chair of the PAC for Condensed Matter Physics, D. L. Nagy, welcomed the PAC members, the ex officio members from JINR, as well as the members of the JINR Directorate. The Chair presented an overview of the implementation of the recommendations made at the previous PAC meeting concerning the JINR research in the area of condensed matter physics.

JINR Vice-Director L. Kostov informed the PAC about the resolution of the 133rd session of the JINR Scientific Council in February 2023 and the decisions of the Committee of Plenipotentiaries of the Governments of the JINR Member States in March 2023.

### **II. Reports on projects to be included in the Topical Plan for JINR Research and International Cooperation from 2024**

The PAC took note of the proposal to open a new large infrastructure project (LIP) “Pulsed neutron source and spectrometers” and a project “Development of the IBR-2 facility with a complex of cryogenic neutron moderators” presented by E. Lychagin. The main objective of the project is to increase the efficiency of the use of the IBR-2 nuclear research facility in implementing the experimental research programme, to ensure the operational reliability and safety of the reactor. During the period of implementation of the project, scientific and technical support services will be provided to ensure the safe operation of the reactor facility, and a large amount of scientific and technical work and experimental studies related to the commissioning of the cryogenic moderator complex will be performed.

Recommendation. The PAC supports the opening of the new LIP “Pulsed neutron source and spectrometers” and the project “Development of the IBR-2 facility with a complex of cryogenic neutron moderators” for the period 2024–2028.

The PAC took note of the proposal to open a project “The new advanced neutron source at JINR” presented by M. Bulavin. In accordance with the work plans, the following research and development work is being carried out: study of the pulsed reactor dynamics, development of neptunium nitride fuel and the fuel rods based on it, optimization of the design of the reactivity modulator and the reactor vessel in terms of reducing thermal loads and shape changing, development and implementation of a list of R&D to support the development of a preliminary design, including the main systems of the reactor facility, a

complex of cryogenic moderators, development of a scientific programme, and a complex of spectrometers based on it. The PAC is satisfied with the detailed description of the work plans for the implementation of the project.

Recommendation. The PAC recommends opening the project “The new advanced neutron source at JINR” for the period 2024–2028.

The PAC took note of the report by V. Bodnarchuk with the proposal to open a project “Scientific and methodological research and developments for condensed matter investigations with IBR-2 neutron beams” in the frame of the LIP “Pulsed neutron source and spectrometers”. The project is dedicated to improving the parameters and performance of experimental setups, expanding the scope of their applications as well as to the development of their elements and components.

Recommendation. The PAC supports the opening of the new project “Scientific and methodological research and developments for condensed matter investigations with IBR-2 neutron beams” for the period 2024–2028.

The PAC took note of the report by D. Kozlenko with the proposal to open a project “Investigations of functional materials and nanosystems using neutron scattering” with subprojects “Study of the structure and dynamics of functional materials and nanosystems at the IBR-2 spectrometer complex” and “Development of an inelastic neutron scattering spectrometer in inverse geometry at the IBR-2 reactor” in the framework of the LIP “Pulsed neutron source and spectrometers”. The PAC notes that understanding the connection between the matter’s structure and its physical and chemical properties at the microscopic and atomic scale is crucial in various scientific disciplines such as condensed matter physics, materials science, chemistry, geophysics, engineering, biology, and pharmacology. Neutron scattering methods, among other experimental techniques, offer undeniable advantages in investigating the characteristics of functional materials and nanosystems consisting of light atoms, isotopically enriched nanomaterials, magnetic orderings, biological entities, and polymers. The research results of the authors, obtained since the beginning of 2021, have demonstrated the high efficiency of neutron scattering for the successful solution of the above-described problems and have resulted in more than 300 research papers and one patent. The high research quality has also been recognized with 5 JINR prizes.

Recommendation. The PAC recommends opening the project “Investigations of functional materials and nanosystems using neutron scattering” with the subprojects “Study of structure and dynamics of functional materials and nanosystems at the IBR-2 spectrometer complex” and “Development of an inelastic neutron scattering spectrometer in inverse geometry at the IBR-2 reactor” for the period 2024–2028.

The PAC took note of the report on concluding the project “Biophotonics” and opening a new project “Nanobiophotonics” presented by G. Arzumanyan. Based on the results presented in the report, the PAC notes significant progress in the implementation of activities on this project and especially the advances in the field of life sciences. The PAC considers the research programme of the proposed new project as promising and modern, interdisciplinary in nature, and aimed at both fundamental and practical studies. The PAC welcomes the start of closer collaboration on these topics with other JINR laboratories and with external biomedical organizations as well.

Recommendation. The PAC recommends opening the new project “Nanobiophotonics” for the years of 2024–2028.

The PAC took note of the report on extending the project “Novel semiconductor detectors for fundamental and applied research” presented by G. Shelkov. The PAC notes that the project is highly qualified and has a long-term experience in international cooperation and activities within the Medipix Collaboration. The accumulated knowledge and experience will provide a solid background for the further R&D activities of the project. This project aims to create hardware and software components for the development of detection systems based on novel energy-sensitive hybrid pixel detectors and radiodiagnostic equipment based on them. The PAC notes that, in particular, the proposed activities mainly focus on the development of the in-house microchip and the manufacture of new energy-sensitive semiconductor X-ray image detectors and devices. The proposed extension of the project is actual and can be successfully implemented.

Recommendation. The PAC recommends the extension of the project “Novel semiconductor detectors for fundamental and applied research” for the period 2024–2028.

The PAC took note of the proposal to extend the project “Precision laser metrology for accelerators and detector complexes (PLI)” presented by M. Lyablin. The proposal is a continuation of the ongoing support project for the NICA collider complex. The project has two goals: first, long-term monitoring of the surface under the NICA accelerator and of the influence of microseismic noise, and the improvement of stabilization. Second, a network of inclinometers will be installed in the regions of seismic activity to measure variations in the angles of inclination. The scientific objective and technical approach are well presented and seem feasible within five years. The PAC also notes the risks stated by the authors, which are difficulties in acquiring equipment. As a solution, it is proposed to manufacture some parts at JINR and to develop a new type of CPLI based on available equipment.

Recommendation. The PAC recommends that the project “Precision laser metrology for accelerators and detector complexes (PLI)” be extended for the period 2024–2028, addressing the issues raised by the reviewers.

The PAC took note of the report on extending the project “Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)” presented by A. Sidorin. The PAC notes the high demand for PAS methods, including the DBAL method on a beam as well as the PALS method in the classical formulation. The importance of the obtained scientific results is confirmed by publications in highly rated journals. The PAC welcomes the involvement of employees from other countries in the work on the project. The implementation of the programme presented in the project will bring this facility to a qualitatively new level, opening up new opportunities for experimental research in the field of condensed matter physics and materials science.

Recommendation. The PAC recommends that the project “Development of experimental techniques and applied research with slow monochromatic positron beams (PAS)” be extended for the period 2024–2028.

The PAC took note of the proposal to open a project “Design and development of a test zone for methodological studies of detectors at the linear electron accelerator in DLNP” presented by S. Abou El-Azm. The project is dedicated to the development of scientific infrastructure for experimental studies with accelerated electron beams of the LINAC-200 accelerator. The two channels of LINAC-200 will be used for equipment testing and for other applied and educational purposes. The PAC notes that it is necessary to have an electron beam with all diagnostics for monitoring the beam parameters, as well as the necessary equipment to deal with target control and data analysis with target.

Recommendation. The PAC recommends opening the project “Design and development of a test zone for methodological studies of detectors at the linear electron accelerator in DLNP” for its implementation in 2024–2028.

The PAC took note of the proposal to open a project “Protection against physical and chemical stresses with tardigrade proteins (TARDISS)” presented by M. Zarubin. The PAC notes the ambiguity of the goals of studying the radio- and cryoprotective properties of the Dsup protein in living systems and *in vitro*, developing model living systems with induced expression of the Dsup protein, and creating high-tech materials modified with this protein. The PAC notes that the objectives of the project are clearly stated, allowing the development of approaches for the practical application of the Dsup protein.

Recommendation. The PAC recommends opening the project “Protection against physical and chemical stresses with tardigrade proteins (TARDISS)” for its implementation in 2024–2028.

The PAC took note of the proposals to open projects “Molecular, genetic and organismal effects of ionizing radiation with different physical characteristics” and “Radiation biophysics and astrobiology research” presented by P. Lobachevsky and A. Chizhov, respectively. The aim of the first of these projects is to study the regularities and mechanisms of molecular, genetic and organismal effects of ionizing radiation with different physical characteristics. The second project is aimed at solving a number of fundamental problems in radiobiology and astrobiology, as well as practical tasks related to the development of radiation medicine.

Recommendation. Given the complexity of the projects as well as the module in which the authors convince of their feasibility, the PAC recommends opening the projects “Molecular, genetic and organismal effects of ionizing radiation with different physical characteristics” and “Radiation biophysics and astrobiology research” for their implementation in 2024–2028.

The PAC took note of the proposal to open projects “Radiation tolerance of materials to high intensity heavy ion beams impact” and “Nanocomposite and functional track-etched membranes” presented by P. Apel. The first project is focused on the systematic study of the structural effects caused by swift heavy ions in materials with potential nuclear and nanotechnological applications in order to shed light on the fundamental mechanisms and sub-picosecond kinetics of the resulting excitations. The second project on track-etched membranes (TMs) demonstrates an example of industrial application of ion-track technology. TMs offer distinct advantages over conventional membranes due to their precisely defined structure. The existing and future heavy-ion accelerator facilities at FLNR, JINR offer unique opportunities for interdisciplinary research, especially in the field of materials science and nanotechnology. The PAC considers the applications of TMs in biotechnology and medicine to be particularly important. The project outcomes will include the implementation of new and elaboration of existing routes of membrane modification for the production of composite and hybrid TMs for targeted applications in nanofluidics, sensing technologies, green energy harvesting, and biomedicine.

Recommendation. The PAC recommends opening the projects “Radiation tolerance of materials to high intensity heavy ion beams impact” and “Nanocomposite and functional track-etched membranes” for their implementation in 2024–2028.

The PAC took note of the written proposals to open or extend the projects “Methods of computational physics for the study of complex systems” for 2024–2026, and “Complex materials”, “Mathematical models of statistical physics of complex systems”, “Nanostructures and nanomaterials”, “Quantum field theory methods in complex systems” for 2024–2028.

Recommendation. The PAC recommends that these projects be opened or extended for the requested periods.

### **III. Scientific report**

The PAC heard with interest the scientific report “Neutron-diffraction studies of structural phase transition in alloys” presented by T. Vershinina. The PAC thanks the speaker for the excellent report.

### **IV. Virtual presentations by young scientists**

The PAC reviewed 12 virtual presentations made by young scientists in the field of condensed matter physics and related fields. The virtual poster presentation “Proximity effects at superconducting and ferromagnetic heterostructures” made by V. Zhaketov was selected as the best presentation of the session. The PAC also noted two more virtual poster presentations of a high level: “High pressure effect on crystal, magnetic structure and vibrational spectra of van der Waals material” by O. Lis, and “The effects of high pressure on the crystal structure and vibration spectra of layered perovskite-like  $\text{Nd}_2\text{Ti}_2\text{O}_7$ ” by A. Asadov. All three authors will be awarded diplomas of the PAC.

Recommendation. The PAC recommends the poster “Proximity effects at superconducting and ferromagnetic heterostructures” to be presented at the session of the JINR Scientific Council in September 2023.

### **V. Next meeting of the PAC**

The next meeting of the PAC for Condensed Matter Physics is scheduled for 25–26 January 2024.

The preliminary agenda for the next meeting of the PAC includes:

- report by the PAC Chair on the implementation of the recommendations above;
- report by the JINR Directorate on the sessions of the Scientific Council in September 2023 and of the Committee of Plenipotentiaries in November 2023;
- progress in the development of the concept for a new neutron source of JINR;
- status reports on the upgrade of FLNP instruments;
- status and future of the FLNP user programme;

- discussion of the project assessment template;
- information about scientific meetings;
- scientific reports (not more than three);
- poster (or virtual presentation) session.

D. L. Nagy

Chair of the PAC  
for Condensed Matter Physics

O. Belov

Scientific Secretary of the PAC  
for Condensed Matter Physics