

Report on the concluding theme “Investigations of Condensed Matter by Modern Neutron Scattering Methods” and proposal for extension of this theme for the period 2018-2020

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The main results obtained during the realization of the theme 04-4-1121-2015/2017 “Investigations of Condensed Matter by Modern Neutron Scattering Methods” during the period of 2015-2017 are reviewed. The theme was realized mostly on the basis of the Department of Neutron Scattering Investigations of Condensed Matter of FLNP JINR. The primary scientific goal of the theme was the study of structure, dynamics and microscopic properties of novel materials and nanosystems in research topics which are actual for development of modern scientific views in the fields of condensed matter physics, materials science, chemistry, geophysics, engineering sciences, biology and pharmacology, or prospective for development of modern technologies in the fields of energetics, electronics, pharmacology and medicine, by means of neutron scattering and complementary methods. The central goal of the methodical and technical works was the development of the spectrometers complex of the modernized IBR-2 reactor. Most of the research activities were realized at the spectrometer complex of the IBR-2, while some additional scientific experiments were performed in other national and international research centers with a tough collaboration with JINR Member States. Another important activity in the framework of the theme was the realization of the User Programme at the IBR-2 spectrometer complex.

The most important scientific results include:

- Observation of the novel type of the charge ordering phase transition with a formation of dimeric and trimeric electronic states in recently synthesized iron oxide Fe_4O_5 ;
- Analysis of the structural modifications during the charging/discharging processes in materials for the electrodes and chemical processes at the solid and liquid media interfaces in lithium accumulators;

- Determination of the structural features of the complexation processes between fullerenes and antitumor pharmacological ingredients;
- Determination of the structural organization of rhodopsin in photoreceptor membranes;
- Determination of the microscopic features of the domain-cluster state forming in the superconductor-ferromagnet- superconductor layered nanostructures;
- Experimental determination and theoretical analysis of the crystal structure and molecular dynamics of the pharmacological ingredient lovastatine;
- Determination of residual stresses in TRIP-steels;
- Determination of texture and microstructure of eclogite rocks focused on the analysis of the deformation processes in the paleosubduction channel in Tauern window (Austria);
- Analysis of the internal organization of cultural heritage objects by means of neutron radiography and tomography.

The most important methodical results include:

- Development and fabrication of the second circular detector module for the DN-6 diffractometer;
- The completion of basic activities of reconstruction of the DN-2 diffractometer into RTD diffractometer for real time studies;
- The major upgrade of the High Resolution Fourier Diffractometer (HRFD), including replacement of the mirrors of the neutron guide and Fourier chopper;
- The completion of fabrication and installation of the mirror curved neutron guide in the framework of the reconstruction of the REFLEX reflectometer into spin echo small angle neutron scattering spectrometer (SESANS);
- Installation of radial collimators at the Fourier Stress Diffractometer (FSD);
- Installation of the basic elements of the FSS diffractometer at the 13 beamline of IBR-2 and start of first methodical experiments.

During the reported period of 2015-2017, the JINR staff members participated in the 04-4-1121-2015/2017 theme activities, have published 287 papers in referred scientific journals and made 325 reports at conferences. The obtained scientific results were honored by 1 international prize and 2 JINR prizes.

Proposal for the extension of the theme “Investigations of Condensed Matter by Modern Neutron Scattering Methods” for the period 2018-2020

Taking into account the successful realization of the theme 04-4-1121-2015/2017, directions of the 7 year plan of the strategic development of JINR in condensed matter physics and current trends in considered research fields, it is proposed to extend the theme “Investigations of Condensed Matter by Modern Neutron Scattering Methods”, leaders D.P.Kozlenko, V.L.Aksenov, A.M.Balagurov, for the period 2018-2020. The theme will be realized on the basis of the Department of Neutron Scattering Investigations of Condensed Matter of FLNP JINR.

The priority fundamental and applied research topics within the theme include:

- Physics and Chemistry of Novel Functional Materials;
- Physics of Nanosystems and Nanoscale Phenomena;
- Physics and Chemistry of Complex Liquids and Polymers;
- Molecular Biology and Pharmacology;
- Materials and Engineering Sciences.

The main scientific directions within these topics are:

- A study of structure and properties of novel functional materials,
- A study of structure and properties of materials under extreme conditions,
- A study of fundamental regularities of real time processes in condensed matter,
- Computer modeling of physical and chemical properties of novel crystalline and nanostructured materials;
- A study of magnetic properties of layered nanostructures;
- A study of structural characteristics of carbon and silicon based nanomaterials,
- A study of molecular dynamics of nanomaterials;
- A study of magnetic colloid systems at bulk and interface state,
- Structural characterization of polymer nanodispersed materials;
- A study of structural characteristics and functional properties of biological materials,
- A study of structure and properties of lipid membranes and lipid complexes,

- A study of texture and physical properties of Earth's rocks, minerals, and constructional materials,
- Non-destructive control of residual stresses in industrial products and constructional materials,
- Neutron imaging of internal structure of industrial products, rocks and natural heritage objects,
- A study of radiation damage effects in condensed matter.

A special attention will be paid to a modernization of the spectrometers complex of the IBR-2 reactor, development of new spectrometers, upgrade of existing ones and new experimental techniques:

- Neutron optics with polarized and unpolarized neutrons (reflectometry, small angle neutron scattering, spin-echo),
- Neutron diffraction methods for structural studies of single- and poly-crystals,
- Inelastic neutron scattering methods,
- Neutron diffraction methods for studies of residual stresses and texture of materials,
- Neutron Imaging.

The realization of the User Programme will be also high priority activity in the framework of the theme.

The planned research activities will be performed mostly using the spectrometers complex of modernized IBR-2 reactor. Additional experiments using neutron scattering and complementary methods will be performed at other research centers of Russia and Europe within collaboration agreements.

The financial budget of the theme is determined in the framework of the limits of the approved 7-year plan of the strategic development of JINR in condensed matter physics for 2017-2023.

The collaboration within theme includes more than 100 research institutions from JINR Member States – Azerbaijan, Bulgaria, Belarus, Kazakhstan, Russia, Poland, Czech Republic, Slovak Republic, Romania, Moldova, Mongolia, Ukraine, Uzbekistan, Vietnam, Associated Member States – Egypt, Germany, Hungary,

Republic of South Africa, Serbia, and Non-Member States – Latvia, France, Norway, Switzerland, Taiwan, United Kingdom, Japan.