

ACADEMIC PLAN
the education programme of higher education

«Condensed Matter Physics at MEGA-Science Facilities»

Level:	<i>Master program</i>
Subject field:	<i>Physics</i>
Mode of study:	<i>Full-time</i>
Language of instruction:	<i>English</i>
Duration of study:	<i>2 years</i>

Abstract

The Master of Science degree in Experimental Techniques in Condensed Matter Physics with MEGA-Science Facilities program provides students with the experimental and theoretical aspects of condensed-matter physics. The program covers the fundamental principles of the theory in terms of neutron scattering and synchrotron radiation. It is also supplemented with recent advances in nano-, bio-, database, and cognitive technologies. The MSc degree program aims to provide professional expertise in the field of condensed-matter physics that enables graduates to handle research and engineering problems in various areas of physics, chemistry, biology, material sciences. Students are supposed to do a piece of fundamental research making full use of MEGA-Science Facilities. Accordingly, tremendous attention in the program is paid to a detailed study of the interaction of neutron and synchrotron radiation with matter. The program is delivered in the English language.

The MSc degree holders are experts on the foundations of interaction of neutron and synchrotron radiation with matter (solid state matter, polymers, nature objects, nano- and heterostructures), as well as physics-mathematical apparatus, which describes the processes of generation, propagation and scattering of coherent radiation and those of controlling the parameters of the neutron and synchrotron radiation beamlines.

Having qualified in the program, graduates develop the necessary skills to collect, process and analyze data obtained with neutron and synchrotron stations. In addition, they acquire new methods to record and handle images, to detect different bodies and processes, and to study fundamental matter properties. The MSc degree holders are able to investigate novel functional materials by modern methods using neutron and synchrotron radiation. Graduates of the program will be capable of effectively functioning as physicist-researchers, physicist-engineers, as well as being successfully employed in areas of science and technology, specifically, at MEGA- Science Centers for Neutron and Radiation for Condensed Matter Studies across Russia and worldwide, as well as in the areas of data processing, nano-, biotechnologies, sectors of light and heavy industry, engineering.

Mission of the education program (development strategy)

The Master of Science degree in Condensed Matter Physics at the MEGA-Science Facilities program focuses on the delivery of professional competencies in a chosen field required to study, develop, introduce and implement cutting edge technologies. It allows graduates to effectively function in a chosen field as well as getting successfully employed in areas of both academia and industry. The development strategy of the program envisages its implementation in the "two diplomas" format on the basis of international cooperation with partner universities.

Advantages of training in the educational program

The main advantages of this educational program are:

1. Practical-oriented nature - the curriculum of the program provides for several types of practice (practice in synchrotron physics, practice in neutron physics, practice in condensed matter physics, pre-diploma practice, etc.) with a total volume of 40 ECTS. At the same time, practical exercises are carried out not only in the laboratories and resource centers of the Science Park of St. Petersburg State University, but also in the existing scientific centers of the MEGA class at the territory of Russian Federation - the Petersburg Nuclear Physics Institute named after B.P. Konstantinov (St. Petersburg), the National Research Center "Kurchatov Institute" (Moscow), the Joint Institute for Nuclear Research (Dubna);
2. Deep research component - research work and scientific seminars of undergraduates make up 23 ECTS. The supervisors of scientific research work of undergraduates are top scientists of the world science in the field of neutron and synchrotron physics. The Council of the educational program includes well-known scientists, representing such research centers as the Petersburg Nuclear Physics Institute (St. Petersburg), the National Research Center "Kurchatov Institute" (Moscow), the Joint Institute for Nuclear Research (Dubna), the Jülich Center for Neutron Science (JCNS) of Heinz-Mayer-Leibniz Center, the Swiss-Norwegian Synchrotron Radiation Line (SNBL) at the European Synchrotron Research Center (ESRF), Utrecht University, the Federal Research Center "Crystallography and Photonics" of the Russian Academy of Sciences, the State Atomic Energy Corporation "Rosatom";
3. Close contact with representatives of employers in the course of training throughout the implementation of the educational program - the most important issues of the development strategy of the educational program and the prospects for employment of graduates are considered at the meetings of the Council of the educational program. The themes of graduation thesis of undergraduates are subject to mandatory agreement with representatives of employers in the field of neutron and synchrotron physics. More than 70% of the members of the State Examination Committee are also representatives of employers' organizations.
4. The program has additional options for universal competencies, acquired by graduates - the curriculum provides study of the elective course "Russian as a foreign language", mastering the skills of teaching and self-study of a number of disciplines in the format of online courses with the possibility of their re-registration.
5. Finally, in order to increase the entrance knowledge level and facilitate the learning process for this educational program, applicants are provided with the so-called "pre-training" in the framework of a short-term supplementary educational program ("Advanced Education for Master's Programs of St. Petersburg State University").

The list of disciplines of the Master program

1 year, 1 semester

№	Discipline	ECTS ²	Attestation	Workload (hours)
1	Elective course: <ul style="list-style-type: none"> English for Professional Communication Russian as a Foreign Language 	2	test for credit	72
3	History and Methodology of Physics	2	test for credit	72
4	Quantum Mechanics in Solid State Physics	3	exam	108
5	Crystal Structure and Fourier Transformation	2	test for credit	72
6	Theory of Interaction of Neutrons with Matter	2	exam	72
7	Theory of Interaction of Synchrotron Radiation (X-Rays) with Matter	2	test for credit	72
8	Science at Large-Scale Facilities	3	exam	108
9	Elective course: <ul style="list-style-type: none"> Nanosystems and Physical Fundamentals of Nanotechnology Structure and Properties of Macromolecules, Liquid Crystals, Colloids and Biological Molecules 	2	exam	72
10	Research Work	7	test for credit	252
11	Practice in Condensed Matter Physics	5	test for credit	180

² Total workload for the education programme = 120 credits (30 credit units per semester), 1 credit unit = 36 academic hours (including self-guided work)

1 year, 2 semester

№	Discipline	ECTS	Attestation	Workload (hours)
1	Elective course: <ul style="list-style-type: none"> English for Professional Communication Russian as a Foreign Language 	3	exam	108
2	Atomic and Molecular Dynamics: Inelastic Neutron and X-Ray (Synchrotron Radiation) Scattering	2	exam	72
3	Atomic Structure of Matter: Diffraction of Neutron and Synchrotron Radiation	3	exam	108
4	Crystallography and Crystal Physics	2	test for credit	72
5	Layered Structures, Polymers, and Colloids: Small-Angle Scattering and Reflectometry of Neutrons and Synchrotron Radiation	2	exam	72
6	Topics in Modern Physics	2	test for credit	72
7	Electron and Scanning Probe Microscopy	2	exam	72
8	Elective course: <ul style="list-style-type: none"> Introduction to Physics of Partially Ordered Matter 	2	test for credit	72

	• Magnetism and Superconductivity			
9	Research Work		test for credit	144
10	Practice in Synchrotron Physics	3	test for credit	108
11	Practice in Condensed Matter Physics	5	test for credit	180

2 year, 3 semester

№	Discipline	ECTS	Attestation	Workload (hours)
1	Simulation of Neutron Instruments and Neutron Scattering Processes	2	test for credit	72
2	Problems of Modern Philosophy	2	test for credit	72
3	Techniques and Methods of Polarized Neutron Scattering	2	exam	72
4	Physics of Magnetism and Scattering of Polarized and Unpolarized Neutrons	2	exam	72
5	Elective course: <ul style="list-style-type: none"> Local Structure and X-Ray Absorption Spectroscopy Order and Disorder in Solids: Diffuse Scattering 	2	exam	72
6	Elective course: <ul style="list-style-type: none"> Elastic, Electronic and Magnetic Properties of Multiferroics and Magnetic Materials Structure of Fractal Systems 	2	exam	72
7	Scientific Seminar "Role of Social Sciences and Humanities in Contemporary Natural Science"	2	test for credit	72
8	Research Work	9	test for credit	324
9	Practice in Neutron Physics	3	test for credit	108
10	Practice in Condensed Matter Physics	4	test for credit	144

2 year, 4 semester

№	Discipline	ECTS	Attestation	Workload (hours)
1	Elective course: <ul style="list-style-type: none"> Metamaterials and Study of Their Properties by Small-Angle Diffraction Methods Data Processing and Presentation of Results 	2	exam	72
2	Elective course: <ul style="list-style-type: none"> Basics of Detection of Neutrons and Synchrotron Radiation Basic Research with Neutrons 	2	exam	72
3	Seminar on Graduation Projects	1	test for	36

			credit	
4	Pregraduation Practice	20	test for credit	720
5	Qualification Research Paper Defense	5		180

List of the competencies forming as a result of mastering of the educational program

List of the professional competencies forming the academic component of the training results
The graduates are able to freely apply the fundamental chapters of physics to solve the research tasks of the profile training
The graduates own the knowledge of the structure and principles of operation of the modern neutron reactors and synchrotrons. They know at a professional level the device and characteristics of typical equipment of neutron stations of the research reactors and synchrotron radiation lines, have the skills of setting up a physical experiment around Mega-Science facilities.
The graduates are capable to freely own the professional knowledge in the field of information technology, to use of modern computer networks, software and resources of Internet to solve problems of the professional activity, including the problems being beyond the profile training.
The graduates know the scientific programs of the leading international MEGA-science facilities and the principles of international scientific cooperation.
List of the professional competencies forming the practical component of the training results
The graduates are capable to use their knowledge and their skills in new fields of knowledge and in practical activity acquired independently through information and educational technologies.
The graduates are able to apply in practice the fundamental knowledge about the physical phenomena underlying the diffraction methods, small-angle scattering and reflectometry which is used to study of the condensed state. They use the modern methods of studying the structure and properties of materials with help of the neutrons and synchrotron radiation.
The graduates are capable to use the existing software and databases for solving professional tasks taking into account the basic information security requirements.
List of the universal competencies forming the general cultural and social component of the training results
The graduates perform a systematic analysis of problems (professional problem situations) and develops a strategy to resolve them.
The graduates are able to define the range of tasks, to plan and to implement its own project in the professional sphere.
The graduates implement effectively the assigned role in the working group.
The graduates organize the business communication in oral and written forms in foreign language(s)
Communicates in the areas of compulsory use of the state language of the Russian Federation in oral and written forms, taking into account the peculiarities of different styles of the language; is able to provide information about professional activities in a language understood by non-specialists.
The graduates are able to interact with representatives of different culture
The graduates define and implement the priorities of its academic and future professional activities