Installations of the Mega-Science class in Russia and abroad

Лекторы:
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faculty of PHYSICS

Язык:
English

Трудоемкость:
3 з.е.

Форма контроля:
Зачет

Образовательная программа:

Nanophotonics
1, 3 семестры

Hybrid Materials
1, 3 семестры

Quantum Materials
1, 3 семестры

Computer Modeling of quantum and nanophotonic systems
1, 3 семестры

Пререквизиты:

Квантовая механика
Quantum Optics
Классическая электродинамика
Квантовая электродинамика

Лекции (ак.час)*	Практические занятия (ак.час)	Лабораторные занятия (ак.час)
	64	
*1 академический час = 45 минутам		

If you want to better understand what scientists working at the Large Hadron Collider, the Joint Institute for Nuclear Research in Dubna, or the European x-ray free electron laser project in Hamburg are doing (and perhaps become their collaborators), then this course is for you. It will focus on cyclic and linear accelerators used both for fundamental research in particle physics, atomic and nuclear physics, and for a number of applied problems in chemistry, physics of materials, biology and medicine. We will study nuclear reactors and the ongoing research on neutron optics and neutrino physics, talk about the super-powerful lasers being built in Russia and Europe and how physicists are going to use them to make the vacuum bubble. We will also consider the fundamental design of interferometers used to detect gravitational waves, and how it is possible to increase their sensitivity using compressed light.

Содержание курса

План курса

Структура курса

Part 1. Non-accelerator particle physics experiments: axions, dark photons, etc.

Part 2. Elements of accelerator physics and sources of synchrotron radiation.
2.1. Cyclic accelerators: basic elements of the device, application in fundamental and applied research, types: synchrotrons, cyclotrons, betatrons, microtrons, etc.

Practice 1: calculation of accelerator parameters for use in biology, medicine, flaw detection, etc.

2.2. Synchrotron radiation sources: application in fundamental and applied research, review of the most important facilities: ESRF (Grenoble), PETRA III (DESY), Spring-8 (Japan), SSRC (Novosibirsk), USSR project, etc.
2.3. Linear accelerators: basic elements of the device, application in fundamental and applied research, overview of the most important installations: SLAC, AWAKE plasma accelerator project, etc.
2.4. Free electron lasers: basic elements of the device, application in fundamental and applied research, overview of the most important installations: European XFEL, LCLS, SLAC, Swiss FEL, Novosibirsk THz FEL, etc.

Practice 2: calculation of collider parameters and synchrotron radiation losses.

2.5. Heavy ion accelerators: RHIC, FAIR, NICA, etc.
2.6. Future accelerator projects: CLIC, ILC, HL-LHC, photon colliders, muon colliders, wake-field accelerators.

Practice 3: comparison of cross sections of various processes and calculation of luminosity of next generation colliders

Part 3. Gravitational wave detectors:
3.1. Principles of gravitational wave detection: interfermeters, shot noise and the use of compressed light.
3.2. LIGO, Virgo experiments and their achievements, IndIGO projects, etc.

Part 4. Neutrino physics:
4.1. Mass and flavor neutrinos, oscillations, PMNS mixing matrix, types: reactor, atmospheric, solar, geo-neutrinos, etc.
4.2. Reactor neutrinos, experiments JUNO, Daya Bay, at the Kalini NPP, etc.
4.3. Neutrino telescopes: Ice Cube and Baikal-GVD.
4.4. Other experiments and projects: Super-Kamiokande, BOREXINO, etc.

Practice 4: features of statistics and accounting of background processes in Ice Cube and Baikal-GVD.

Part 5. Powerful lasers**:**
6.1. Quantum physics in ultra-powerful electromagnetic fields
6.2. Extreme Light Infrastructure (Europe): applications in basic and applied research.
6.3. Project XCELS (Nizhny Novgorod), etc.

Practice 5: Nonlinear QED Processes

Part 6. Cold neutron installations**:**
6.1. Introduction to neutron optics and interferometry: applications in basic and applied research.
6.2. Installations at NIST (USA), PSI (Switzerland), PIK Project (PNPI), etc.
Practice 6: calculation of quantum processes with cold neutrons (scattering on nuclei, etc.)
Part 7. MRI installations in ultra-high fields: Iseult (France)

The course includes lectures, practical exercises based on the results of each part of the course (preliminarily 3 practices per semester) and assignments for student essays with oral presentations (2 per semester).