UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Dipartimento di Scienze Fisiche, Informatiche e Matematiche

Study plan in

Physics of Biological Systems

Master's Degree Program in Physics – Curriculum Experimental Nano- and Bio-physics

Overview

This study plan is designed to train students in the investigation of how biologically relevant systems - from DNA, to proteins, to entire cells - work and interact, using both the concepts of physics and advanced techniques favoring the quantitative approach.

Students following this study plan will be able to understand and develop analytical physical models. Specific examples, where the predictions derived from these models can be experimentally verified, will be considered. At the same time, students will get familiar with experimental advanced techniques, particularly nanotechnological ones, which are exploited to investigate biological systems from the single molecule up to the cellular scale.

Opportunities

The multidisciplinary background gained with this study plan allows to continue the academic training within a PhD program in Physics, Nanotechnology or Biotechnology, such as the Graduate School in Physics and Nanoscience offered at UNIMORE.

First Year

Laboratory of condensed matter physics

A course to become familiar with some of the most used experimental techniques in material research (electron microscopies, X-ray diffraction and electronic spectroscopies), challenging your experimental skills by designing and performing experiments from scratch.

Laboratory of nanofabrication

A hands-on course introducing the main nanofabrication techniques employed in nanoscience research and in the semiconductor industry. The presentation of top-down and bottom-up approaches will be followed by a laboratory activity with optical, electron-beam and ion-beam lithographies, and with nanocluster deposition.

Biological physics with laboratory

An introduction to the quantitative analysis of biological processes with the methods of physics and mathematics, together with hands-on experiences using the most advanced biophysical techniques. Students learn how to predict the behavior of some biological phenomena and how to analyze in a quantitative way experimental data.

Chemical Physics of Biomolecules

A unique, multidisciplinary course to acquire advanced theoretical understanding of chemical physics, with emphasis on biomolecules, colloids and their application to nano-biophysics and nano-medicine.

Quantum physics of matter

An advanced course on matter-light and matter-electron interactions, using quantum linear response theory to discuss elementary excitations of material systems and their spectral features: electronic and phonon excitations, excitons, plasmons, polaritons.

Synchrotron radiation: basics and applications

A course on the working principles of synchrotrons and the use of emitted radiation, from description of single ultra-relativistic particles sources to essentials of storage rings, bending magnets, wigglers and undulators, free electron lasers, beam lines. Examples of ensuing popular techniques, as X-ray diffraction, scattering, absorption and X-ray microscopy, are discussed and a visit to to ELETTRA labs in Trieste ends the course.

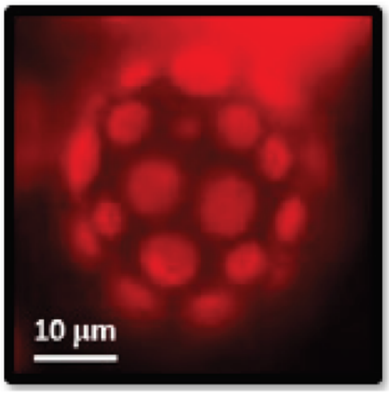

Image: Epi-fluorescence microscopy image of a Giant Unilamellar Vesicle (GUV) presenting a phase separation with Liquid Disordered domains (the red ones) and Liquid Ordered domains (the darker ones).

Study plans help you to choose courses within a curriculum leading to an in-depth training in a given area of physics. The suggested choices can be tailored to the students' scientific interests. The program coordinator and the Study plan coordinator may give you further indications.

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This study plan will allow students a smooth entry in many production sectors of a modern economy in an international context, and it is also connected to ongoing research activities carried out in collaboration with several research centers in Italy and worldwide, including Univ. of Bologna (Italy), the School of Medicine, Washington University, St Louis (USA), and the Institute for Nanoscience CNR-NANO located in Modena (www.nano.cnr.it) which also collaborates to the courses. Finally, a specific course allows to aim for a professional future in medical physics.

The thesis project will be carried out within one of the groups active in the biophysical research at the department and/or in collaborating research groups, possibly within the Erasmus program.

Notes

Student may want to include specific courses from the Biology or Engineering programs as free choice courses.

Ask the Study plan coordinator for further indications.

Nanoscience and quantum materials

Nanosystems are both quantum worlds with astonishingly new properties and the basis of new nanodevices. The course provides a conceptual and practical framework dealing with the physics and description of a set of prototype nanosystems, from nanotubes and graphene structures to nanocrystals, quantum wells, wires and dots.

Physics of semiconductors

A course providing all the necessary ingredients to understand the fascinating physical properties of semiconductors, from their electronic structure description to transport phenomena, and how to exploit them in devices like transistors, or to observe novel states of matter like the quantum Hall liquid.

Laboratory of Quantum Simulation of Materials

Frontal lectures and hands-on tutorial sessions introduce attendees to theoretical/computational techniques for the electronic structure simulation of condensed matter systems. Special emphasis is given to Density Functional Theory, the present state-of-the-art, parameter-free and atomistic scheme for the predictive description of materials.

Medical physics

A course which provides the attendees with a basic knowledge of some of the principal diagnostic techniques making use of ionizing and non-ionizing radiation in humans from a physical (technical) point of view.

Second Year

Statistical mechanics and phase transitions

An advanced course in statistical mechanics, from theoretical foundations to phase transitions and critical phenomena, including quantum condensates (BEC, superfluids, superconductors). Attendees are introduced to modern theoretical methods, from the Ginzburg-Landau theory to the statistical field theory and the renormalization group approach.

Nano-mechanics as free choice course

An experimental insight on the methods, procedures and apparata used in advanced research to investigate mechanical properties of materials at the nanoscale, with detailed case studies. Experiments on nano-objects are carried out in the lab, aiming at defining their intrinsic tribological properties and their macroscopic effect.

Numerical algorithms for signal and image processing as free choice course

A course to introduce the basic properties of Fourier transform as a tool for signal analysis, from continuous to discrete settings. Applications to signal and image filtering and compression will be presented also with some laboratory activity in the Matlab environment.

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