UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Dipartimento di Scienze Fisiche, Informatiche e Matematiche

Master's Degree Programme in Physics

Physics of Biological Systems

Curriculum
Experimental physics

Department of Physics, Informatics and Mathematics
Modena Campus

2 years
Full time
ECTS credits: 120

Description of the study plan

This study plan is designed to train students in the investigation of biologically relevant systems using both the concepts of physics and advanced techniques favoring the quantitative approach. Students attending this study plan will be able to adopt analytical physical models to describe biological processes, resulting in predictions which can be experimentally verified. Students will also gain confidence with advanced techniques, particularly nanotechnological ones, which are exploited to investigate biological systems from the single molecule to the cellular scale.

The Study Plan in Physics of Biological Systems will provide attending students with a multidisciplinary background appropriate to continue their academic training with a PhD program in Physics, Nanotechnology or Biotechnology. At the same time, students could choose courses more oriented to a career in Medical Physics including in their study plan courses on Medical Physics and, to acquire basic knowledge on image analysis, a course on Signal and Image Numerical Processing. The study plan will allow students to easily access many production sectors of a modern economy in an international context.

This study plan is connected to ongoing research activities carried out by teachers in collaboration with several research centers in Italy and worldwide, including e.g. Univ. of Bologna, Italy and the School of Medicine, Washington University, St Louis USA. Research activities are also carried out in connection with the Institute for nanoscience CNR-NANO in Modena (www.nano.cnr.it).

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

Courses

Laboratory of Condensed Matter Physics

Year: I Term: I-II Hours: 48 CFUs: 6 SSD: FIS/01

A hands-on course familiarize with the most used techniques in material research (electron microscopies, X-ray diffraction, electronic spectroscopies), designing and performing own experiments from scratch.

Characterization of nanostructures

Year: I Term: II Hours: 48 CFUs: 6 SSD: FIS/03

An advanced course on characterization of 0D (dots, clusters), 1D (stripes, wires, tubes), and 2D (surfaces, films, buried layers) quantum systems and related devices, covering dimensionally-related physical properties and technological applications, modern experimental methodologies and instruments, and current approaches to nano-fabrication, with short stages at the characterization and/or fabrication facilities of the Department.

Physics of semiconductors

Year: I Term: I Hours: 48 CFUs: 6 SSD: FIS/01

The course deals with functional concepts of modern optical and electronic devices, from carrier and defect engineering, transport and carrier recombination dynamics, nanostructured semiconductors, up to their applications to transistors, laser, and solar cells.

Quantum physics of matter

Year: I Term: I Hours: 48 CFUs: 6 SSD: FIS/03

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.

Statistical mechanics and phase transitions

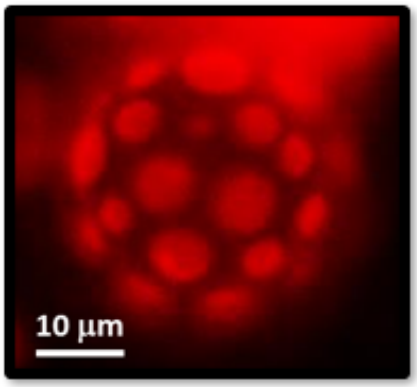
Year: I Term: II Hours: 48 CFUs: 6 SSD: FIS/03

An advanced course in classical and quantum statistical mechanics, dealing with modern theories and methods of phase transitions and critical phenomena, from mean-field to renormalization group theory, and the description of quantum condensates (BEC, superfluidity, superconductivity).

Monte Carlo methods in physics

Year: I Term: II Hours: 48 CFUs: 6 SSD: FIS/02

A random walk in the fields of Statistical and Quantum Mechanics in-



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)

troducing the Monte Carlo numerical approach, Markov processes, and Brownian motion, with “in silico” modeling of phase transitions and calculation of quantum properties of simple microscopic models.

Chemical physics of biomolecules

Year: I Term: I Hours: 36 CFUs: 6 SSD: FIS/07

A unique and multidisciplinary course devoted to students interested in acquiring advanced skills in chemical physics with an emphasis on biomolecules and their application to nano-bio-physics and nano-medicine.

Biological physics

Year: I Term: I Hours: 48 CFUs: 6 SSD: FIS/07

An introduction to the quantitative analysis of biological processes with the methods of physics and mathematics with an emphasis on statistical mechanics. The students learn how to analyze data and predict the behavior of some biological phenomena.

Experimental methods in biophysics

Year: I Term: II Hours: 48 CFUs: 6 SSD: FIS/07

A course on the operating principles of most advanced experimental techniques in biophysics, elucidating theoretical models behind the interpretation of experimental data, and hands-on experience of different techniques.

Nanomechanics

Year: II Term: I Hours: 48 CFUs: 6 SSD: FIS/01

An advanced course to provide insight into elastic, thermal and kinetic properties of nano systems and their role in nano-technology, treating nano-materials, nano-tribology (friction, wear, contact mechanics), nano-electromechanical systems (NEMS), and nano fluidics. Students will master state-of-the-art approaches to design, perform and interpret miniaturized mechanical experiments directly inside electron microscopes like SEM or TEM, or STM/AFM microscopes.

Laboratory of Computational Quantum Mechanics

Year: II Term: I Hours: 60 CFUs: 6 SSD: FIS/03

A course with hands-on tutorial sessions dealing with electronic structure computational techniques as applied to condensed matter systems, with special emphasis on Density Functional Theory, a parameter-free, atomistic and predictive description of materials.

Professionalizing Courses

Good Practices in Research

Year: II Term: I Hours: 18 CFUs: 3

A practical introduction to soft skills needed in industrial and academic research. How to present your result at a conference, or in a paper and get it published. How to keep your data and when you need to worry about intellectual property. How to construct a path that suites your aspirations, write your CV and apply for a high-tech job. All this is also put in context: the structure of research organization and funding in Italy and Europe, with its risks, challenges, and opportunities.

Research Integrity in Sciences

Year: II Term: I Hours: 18 CFUs: 3

A course starting from the study of recent cases of scientific misconduct, such as falsification, fabrication, plagiarism, to discuss actual aspects and concepts of research integrity, an increasingly essential aspect of research.

Suggested free choice courses

Numerical processing of signals and images

Year: - Term: II Hours: 36 CFUs: 6 SSD: MAT/08

This course introduces 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. (in Italian)

Medical Physics

Year: I Term: II Hours: 36 CFUs: 6 SSD: FIS/07

The course is intended to give to the participants a basic knowledge about some of the principal diagnostic techniques that makes use of ionizing and non-ionizing radiation in humans from a physical (technical) point of view.

Coordinator
Prof Andrea Alessandrini
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www.fim.unimore.it/site/en/home/teaching/physics-courses/msc-degree.html

For B.Sc. students
Students still atttending the B.Sc. (Laurea Triennale) in physics in Modena, who intend to follow this study plan, are suggested to attend some of the following optional courses during their B.Sc studies: Elettronica, Spettroscopia, Laboratorio di Fisica Computazionale

Notes
Amongst the free choice courses, the student may include specific courses from the Biology, Mathematics, or Engineering programs at Unimore. Ask the Study Plan coordinator for an available course list.