UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

SCHOOL OF GRADUATE STUDIES
PHYSICS AND NANO SCIENCES

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PhD Program in Physics and NanoSciences at University of Modena and Reggio Emilia.

The objective of the PhD Program is to train researchers on cutting-edge sectors of Physics and NanoSciences and who possess transversal knowledge useful for interacting with international operators and with different approaches in multi-disciplinary sectors. The proposed training path is indeed highly interdisciplinary and it is open to students with different backgrounds (Physics, Chemistry, Biology, Engineering, etc.).
The Program is focused on the development/application of experimental techniques and advanced theoretical/computational methods for the study of matter and systems at the nano-scale. Some other aspects of fundamental and applied physics are also subjects of the Program, research foci include:

- **Materials systems for sustainability and health**
  - Energy harvesting and energy storage
  - Bio- and Flexible electronics
  - Tribology at the nanoscale
  - Biosystems for health
- **Quantum science and nanotechnology**
  - Quantum technologies
  - Quantum information science
  - Low dimensional and quantum materials: growth, characterization and modeling
  - Micro- and nano-fabrication
  - Microscopy and spectroscopy
- **Condensed matter theory and computation**
  - First principles and multiscale simulations
  - Quantum theory of many-body systems
  - Advanced simulations of materials and molecules: properties, excitations and spectroscopies
  - Theory and method development for computational condensed matter physics
  - High performance computing for materials
  - Data-driven design and discovery of materials: machine learning and automated workflows
  - Applications of quantum computing in quantum chemistry and materials science

- **Fundamental interactions and astrophysics**
  - Quantum field theory
  - String theory
  - High energy and astroparticle physics
  - Theory and computational methods for black holes and galaxies simulations

The training project for each PhD student includes: the design and implementation of an original research project; the registered attendance of courses, seminars and schools; the preparation/assignment/grading of exercises and problems; experience in scientific communication and (limited) teaching activity.
To carry out research projects, doctoral students have access to both local (material deposition, lithographs, microscopies, spectroscopies, low temperature physics, biophysics, scientific computing) and international (synchrotrons, super-computing, high magnetic fields, microscopy) infrastructures. They have the opportunity to participate at conferences, schools and national/international research networks with stays abroad. Applied projects also include training periods in companies or in collaboration with other bodies (e.g. research institutions, secondary schools) for scientific communication. The training load is quantified by *credits* whose overall amount counts 180 credits distributed over three years.
The training Program involves the acquisition and practice of advanced experimental techniques -including surface science, microscopies, low temperature physics, synthetic chemistry, material preparation and characterization-, methods for theoretical physics and computational techniques for high-performance scientific computing, in particular for the study of matter or for astrophysics. The transversal training objectives include the critical review of scientific results, group work, writing scientific articles, presentation and management of a scientific project, educational and scientific communication activities. The progress of doctoral students in education and research are monitored and validated annually by the Steering Board.
As such, the PhD Program aims -and it has a long standing tradition- to an interdisciplinary training of researchers in a broad field including the physics of matter and materials, the physical chemistry of functional molecules, nanosciences and enabling technologies such as nano-, digital and quantum ones. More recently the Program has expanded its offerings by including advanced training paths on fundamental interactions and astrophysics as well as dedicated paths of applied physics in collaboration with industries. These training paths focus on both basic science and applications and respond to the demand for training in the information sectors (Quantum Technologies, High Performance Computing, Big Data and Machine Learning, Nano(Spin) Electronics etc.), science of life (biotechnology, diagnostics and drug design) and technologies for the optimization of energy resources. The skills achieved are those necessary to access to an academic career as researcher or technologist in universities and research institutions (in Italy or abroad) as well as careers as managers or company executives in the industrial and service sectors. It is worth stressing that the tracking of employment opportunities for our doctors in recent years shows excellent placement of some of our doctoral students in research centers and foreign universities.

The PhD Program in Physics and NanoSciences offers a robust career development program with a high degree of internationalization**:** all lectures and research are carried out in English. Students have a travel budget to attend conferences and workshops and are guided in connecting to national and international research networks. The program offers the possibility to spend time abroad for advanced training opportunities. Research projects may involve the active participation of industries, or third parties such as hospitals and high schools, as appropriate.

As planned by the Italian Ministry, the PhD program is run in editions that usually start in November with yearly cadence. The PhD program lasts three years. A "Laurea specialistica" (second class honours degree) or equivalent degree (4-5 years university) is required, in physics, chemistry, biotechnology, engineering or other science subjects. Admission is granted on a competitive basis. A

commission examines the curricula of the candidates and evaluates their abilities to carry out research. The aim of the selection is to determine the preparation and aptitude of the candidate to perform the research activity in relation to the topics of the PhD. The PhD Program awards scholarships on a merit basis. Other scholarships supported by National, Regional or projects awarded by Agencies or Enterprises are available on specific themes. The annual amount of a study scholarship is about 16K€ gross (barring subsequent regulatory amendments). The grant is increased by 50% for periods spent abroad. The School also provides a small budget for supporting missions of PhD students. Guest housing is accessible upon request for non-resident PhD students.

The PhD Program in Physics and NanoSciences is run by a Steering Board whose Members are Professors of UNIMORE, Researchers of CNR and other distinguished experts from international Universities. The Coordinator manages all activities and is the reference contact. At the beginning each PhD student choose a project withing those proposed by the PhD Program. Each PhD student is supervised by one Tutor who supports the research project and guide PhD student to everyday activities that are normally run within a group and one or two co-tutors may well contribute to the guidance.

The yearly progresses of each is assessed by hearings in which PhD students report on their research achievements and on attendance to courses and seminars. At the end of the three years, PhD students present an original written work (Thesis) that will be defended in front of a Jury. The original work should comprise one or more publications in international Journals and in which the candidate's contribution should be discernable. Other products of research, such as the realization of instrumentation, definition and test of scientific protocol or the realization of computer code also contribute to the final assessment of the Thesis's work.