



The PhD school in Physics, Astrophysics, and Applied Physics University of Milan

Short description of the doctoral program

The PhD in Physics, Astrophysics and Applied Physics is established as a unifying element of the third-level University education in physics and related areas. Besides their main commitment to the research activity, students are asked to attend specialist and soft skills courses, seminars, and advanced schools. Students are strongly encouraged to spend part of their time abroad in order to participate in scientific collaborations in their fields of interest; collaborative research with industrial partners is also supported. The scientific research is expected to lead to the publication of results in international, peer-reviewed journals. The goal of the PhD in Physics, Astrophysics, and Applied Physics is a highly specialized scientific training that opens professional carriers in academic institutions and research laboratories, either public or private.

PhD in Physics is awarded to students who have demonstrated:

1. The creation and interpretation of new knowledge, through original research and/or other advanced training activities aiming at extending the forefront of the discipline, and leading to high-quality publications.
2. A systematic acquisition and understanding of a substantial body of cutting-edge knowledge of academic research or area of professional practice, as well as a detailed understanding of applicable techniques for research and advanced academic or industrial enquiry.
3. The general ability to conceptualize, design, and implement a project for the generation of new knowledge, applications or understanding at the state-of-the-art of research, and to adjust the project design in the light of unforeseen problems.

Subject areas

The PhD school in Physics, Astrophysics, and Applied Physics at the University of Milan offers high-level research training in nearly all areas of Physics, including:

Astrophysics | Cosmology | Astroparticle Physics | Condensed Matter | Classical and Quantum Optics
| Nuclear Physics | Particle Physics | Plasma Physics | Theoretical Physics | Nanotechnology
| Quantum Information & Technology | Accelerator Physics | Biophysics | Electronics |
Environmental Physics | Medical Physics |.



Our PhD program includes graduate-level courses delivered in English and requires a PhD Thesis based on original research. The PhD school has been active at the University of Milan since 1983. It currently involves about 80 students and about 90 faculty members and researchers as supervisors/co-supervisors/mentors and/or teachers. Each student can select a supervisor and a co-supervisor for having a guidance in his/her PhD training. Moreover, at the beginning of the PhD he/she chooses a Mentor (see a list at <http://phd.fisica.unimi.it/organization/boards/>), who shares his/her personal experience and technical expertise, ensures the support and the resources needed to develop the PhD projects, gives advice for your future career. The Mentor promotes the welfare of the PhD students and can help the students in solving conflict/inconvenience situations.

The PhD degree gives graduates the competence for an international research career and challenging specialist assignments in society. The doctoral education is based on research, which is carried out in internationally recognized groups. Besides acquiring in-depth knowledge of a field of study, students are encouraged to cultivate their critical and analytical thinking.

Main skills to be developed

First of all, during their PhD our students are learning how to do research and to produce new knowledge. At the same time, they are gaining a solid expertise in a specific field of physics. In addition, they learn core skills that apply to jobs both in and out of academia. These include written communication, public speaking, project management, leadership, critical thinking and collaboration.

Typically, holders of PhD in Physics, Astrophysics and Applied Physics

1. will be able to make informed judgements on complex issues in specialist fields and be able to communicate their ideas and conclusions clearly and effectively to specialist and non-specialist audiences;
2. will be able to continue to undertake pure and/or applied research and development at an advanced level, contributing substantially to the development of new techniques, ideas, or approaches;
3. will have the qualities and transferable skills necessary for employment requiring the exercise of personal responsibility and largely autonomous initiative in complex and unpredictable situations, in professional or equivalent environments.

Our PhD students also receive training in teaching and are often offered the position of teaching assistant/tutor for courses in the BSc and MSc programs. Teaching is not mandatory, but a large fraction of students is taking this opportunity to acquire additional skills.



Main training activities

Our PhD program provides specialist graduate-level courses (all delivered in English) and many other courses are available from the University Catalogue lists (<https://www.unimi.it/en/education/postgraduate-and-continuing-education-programmes/doctoral-programmes-phd/phd-courses-list>) Soft-skills courses are common to all doctoral programmes (<https://www.unimi.it/en/study/postgraduate-study/doctoral-research-phd-programmes/following-your-plan-study/soft-skills-phd-students>) and aim at building a basic expertise on e.g., exploitation of research results, intellectual property protection process, ethical implications of research, research funding systems, communication skills, etc.

PhD students in Physics, Astrophysics, and Applied Physics are trained in research groups working at the forefront of research, in collaboration with several institutions in Europe and overseas. They are expected to attend one advanced school focusing on their research field topics and to actively participate to conferences and workshops, as well as meetings of international collaborations.

Since 2009 the PhD school organizes a series of Physics Colloquia, hosting distinguished guest speakers who highlight the forefront of ongoing research in Physics and in related fields. The Colloquia series provides an excellent opportunity for students to get a feeling of different research areas, to catch the various research opportunities for future jobs, and to talk directly with leading scientists. Attendance to the Colloquia is mandatory for our students.

Our students are also expected to attend scientific seminars and to deliver talks in order to present their results to the local community. The overall activity of each student is recorded by the “e-booklet”, which helps students in self-assessing their progresses and, at the same time, allows the PhD Board to monitor the achievement of training credits (CFUs); moreover, it is a valuable tool for supervisors where validating the PhD student’s activities and writing their informed end-of-the-year judgement.

At the end of the first year, students are invited to give a talk in an open workshop, where each of them introduces the topic of the thesis and explains why he/she finds that topic interesting and worthwhile. The purpose is not to discuss technical details, but to give an overview of the research topic and to build an expertise in presenting their field and results to diverse audiences. This is an important moment of the PhD training and represents an opportunity to foster novel collaborations across the different sub-disciplines of physics. Second and third-year PhD students, give a talk on the progresses of their research at the end of each year (see a list in <http://phd.fisica.unimi.it/students/stud-seminars/>).

Finally, our PhD students are offered the position of teaching assistant for courses in the BSc and MSc programs. Teaching is not mandatory, but a large fraction of students is taking this opportunity to acquire additional skills.



Description of the main research environments in which the doctoral student is placed.

PhD students at our school mostly work in the Department of Physics (which includes the local branch of INFN-National Institute for Nuclear Physics) and in the Department of Medical Biotechnology and Translational Medicine. These are world-class university departments engaged in fundamental and applied research across a broad range of disciplines. Every year, approximately 20 new PhD candidates begin their research. Our school is a home to staff and students from several different countries, as already mentioned, English is the official language of the PhD school. Our students usually pursue their degree doing research in diverse research environments, including:

1. Top-level local groups working at the forefront of research in collaboration with the very best agencies and institutions, in Europe and overseas, engaged in promoting innovation at the highest level and contribute to advance the boundaries of human knowledge and find solution to fundamental problems in science and technology.
2. International light and particle facilities such as CERN, GSI, and several synchrotron facilities across Europe e.g., ESRF in Grenoble and Elettra in Trieste.
3. World renowned agencies and research centers doing cutting edge research in their respective disciplines, such as ESA, NASA, INFN, FermiLab, INRIM, etc... Those institutions often committed themselves by offering additional PhD positions for our program.
4. International collaborations (usually composed by 50-5000 researchers) originating from CERN/INFN or EU projects. In particular, it should be mentioned the presence of several consortia originating from ERC, RISE, ITN/ETN and Marie-Curie projects.

Description of the expected scientific production during the course of the doctoral program.

PhD students are expected to attend internal meeting and international conferences, present their results in form of posters or oral contributions and to publish them in international peer-reviewed scientific journals. Most of our students (about 95%) have papers published in international journals at the time of their defense. However, the number of publications expected within the three-year period of a PhD varies wildly (from 1-2 to 100/200 for equally successful PhD students) across the different branches of Physics, Astrophysics and Applied Physics, and should not be used to assess anything or anyone.

Description of the main expected employment possibilities

The training offered by the PhD program in Physics, Astrophysics, and Applied Physics provides hard and soft skills to undertake fundamental and applied research in the various sectors of physics, suitable for leading positions in high-tech industry (physics, computer science, materials, chemistry,



biomed) as well as in the world of academic research and teaching. More generally, a PhD degree in physics gives graduates the competence for an international research career or challenging specialist assignments in society.

Employers of physics PhD graduates usually include academic institutions, schools and colleges, public and private research institutes, the army, and industry. Industries employing physicists are varied and include: aerospace and defense, education, energy and renewable energy, engineering, environmental applications, health and medicine, instrumentation, manufacturing, meteorology and climate change, nanotechnology, oil and gas, science and telecommunications. Physicists with a PhD also move into careers outside of science and technology. Popular areas include banking and finance, as well as the software, computing and consultancy industries. Other areas include accountancy, law and transport. Several of our students also undertook entrepreneurial activities.

Description of the characteristics of the thesis and final discussion

The thesis must be presented in a satisfactory manner. The subject matter must be clearly and precisely expressed, its arguments logical and intelligible, and its language appropriate. It must show that the candidate not only has ideas, but also has the power of putting them into suitable words.

The thesis must be the result of the candidate's own work. This requirement does not preclude a candidate to obtain assistance/collaboration from/with the research group where he/she has done research, including the routine collection and/or processing of data. When such help is obtained it should be with the prior approval of the supervisor who must be satisfied that the spirit of the 'own work' requirement is not breached. Prior publications of papers arising from the research being undertaken will not adversely prejudice the assessment of the thesis.

The thesis is sent to two external Referees, who may recommend the acceptance of the thesis subject to minor corrections or recommend a major revision, postponing the "final defense" up to six months. The Referees can be part of the Board of Examiners; in any case, the reports are forwarded to the Board.

The Phd defense is an essential and important part of the examination of the candidate. It will normally include questions designed to ascertain that the thesis embodies the candidate's own research. It will test the candidate's general comprehension of the field of study within which the subject of the thesis falls. It will test the candidate's acquaintance with the general literature of the subject, knowledge of the relation of the work to the wider field of which it is a part, and the respects in which the work advances, modifies, or otherwise affects this wider field of scholarship. Finally, it will assess the ability of the candidate to communicate her/his ideas and conclusions clearly and effectively to specialist and non-specialist audiences.