



**POLITECNICO**  
MILANO 1863

PhD School - Politecnico di Milano  
Regulations of the PhD Programme in:

PHYSICS

Cycle XXXVII

# 1. General Information

PhD School - Politecnico di Milano

PhD Programme: Physics

Course start: November 2021

Location of the PhD Programme: Milano Leonardo

Promoter Department: Physics

Scientific Disciplinary Sectors:

- FIS/01 - Experimental physics
- FIS/03 - Physics of matter

PhD School Website: <http://www.polimi.it/phd>

PhD Programme Website: [http://www.fisi.polimi.it/en/teaching/teaching\\_offer/phd](http://www.fisi.polimi.it/en/teaching/teaching_offer/phd)

## 2. General presentation

Translating scientific knowledge into new technology and transferring innovation to the production system represent necessary steps for many companies, also dictated by an increasingly global market. For that purpose, a professional profile with a broad cultural background is needed. In particular, many advanced sectors of industry and research require a good knowledge in topics such as condensed matter physics, optics, laser technology and instrumentation, and nanostructured materials.

The aim of the PhD in Physics at Politecnico di Milano is the training of personnel with strong research capacity, able to operate in basic and applied research and development facilities, and to manage and design high-tech and innovative products and processes in various industrial sectors. This application-oriented character clearly distinguishes the PhD Programme in Physics at Politecnico from those offered by the Schools of Science.

The education contents are strictly related to the research activities carried out in the research laboratories at the Department of Physics. Although a clear distinction is not possible, they can be divided into two main research tracks:

1) Laser physics, photonic devices and applications

(optics and quantum electronics, including biomedical applications of lasers, laser applications in optical communications; diagnostics for Works of Art; time-resolved optical spectroscopy; ultrashort light pulse generation and applications; UV and X optical harmonic generation)

2) Solid state physics: Advanced spectroscopy, scanning probe microscopy, nanostructure fabrication

(photoemission; spin-resolved electronic spectroscopy; magneto-optics; X ray diffraction; magnetic nanostructures for spintronics; synchrotron radiation spectroscopy, positron spectroscopy, semiconductor nanostructures)

These research activities make use of advanced experimental laboratories located at Politecnico di Milano (Milano-Leonardo Campus and Como Campus), including:

- Coherent vibrational spectroscopy
- Spectroscopy with femtosecond time resolution

- Attosecond pulse generation and spectroscopy
- Coherent Raman spectroscopy and microscopy
- Applications of lasers in telecommunications
- Photonic and optofluidic devices
- Ultrashort laser pulse micromachining
- Solid state lasers
- Biomedical applications of lasers
- Time-domain diffuse optical spectroscopy
- Imaging and spectroscopy for Cultural Heritage
- Advanced optical microscopy and optical projection tomography
- Electron spectroscopy with spin resolution
- Growth and characterization of magnetic nanostructures for spintronics
- Scanning Auger Microscopy (SAM), Scanning Near-field Optical Microscopy (SNOM), Scanning Tunnelling Microscopy (STM)
- Spectroscopy with synchrotron radiation
- Spectroscopy with positrons
- Epitaxial semiconductor nanostructures for electronics and optoelectronics
- Optical and electron beam lithography

Moreover, many collaborations are on-going with high-level international institutions (please see Section 8 for a list of collaborations).

Students in our PhD Programme will therefore have a real opportunity to gain experience also in prestigious laboratories abroad.

The PhD course is run by a Coordinator and a Faculty Board.

The Coordinator chairs the Faculty Board, coordinates the preparation of the annual Educational Programme and organises the general educational activities of the PhD course (see Attachment A1).

The Faculty Board is responsible for the Educational programme and for teaching and administrative activities related to the PhD course (see Attachment A2).

### 3. Objectives

The PhD in Physics at Politecnico di Milano aims at training professionals with high research skills, capable of designing products and managing processes with high technological and innovative content in various industrial sectors. This general objective involves the development of the typical mentality of the experimental scientist through the extensive use and deep knowledge of experimental methods, and with the achievement of a high degree of qualification in specific methodologies.

Part of the basic research training aims to complete the student's preparation, taking into account his/her previous studies. Courses are also envisaged to familiarize the student with various experimental and theoretical methods of general use in the research activity. Some teaching activities aim at generating deep knowledge of more specific themes, at the basis of the thesis research work. Finally, courses aimed at ensuring the development of "soft skills" complete the training.

To teach the students how to conduct an independent research activity at all levels (including experimental, theoretical and organizational aspects), they will join one of the research groups at the Department of Physics, taking advantage of several experimental laboratories with advanced instrumentation both in Milano-Leonardo and in Como.

## 4. Professional opportunities and job market

Transforming scientific knowledge into new technologies and transferring innovation to the productive system now represent key steps for many companies, also dictated by an increasingly global market. To meet those needs, a professional profile with a wide and open background is required. Many advanced industry and research sectors specifically require up-to-date knowledge in physics of matter, optics and photonics, technologies and instrumentation, which the PhD in Physics at Politecnico di Milano provides.

The development of experimental capacities through the use of advanced instrumentation allows the PhD in Physics to form extremely versatile professionals, suited to high-level industrial job.

The excellent physical-engineering preparation also provides great competitiveness at European level, where technological-innovative elements are even more relevant.

The high level of theoretical and experimental training provided also promotes the access to the Academic environment both in Italy and in other Countries.

## 5. Enrolment

### 5.1 Admission requirements

Italian and International citizens can apply. They are requested to have graduated in accordance with the pre-existing laws D.M. 3.11.1999 n. 509, or to have a Master of Science degree in accordance with D.M. 3.11.1999 n. 509, or a Master of Science in accordance with D.M. 22.10.2004 n. 270, or a similar academic title obtained abroad, equivalent for duration and content to the Italian title, with an overall duration of university studies of at least five years.

The certified knowledge of the English language is a requirement for admission. Please refer to the PhD School website for details.

The admission to the Programmes will be established according to the evaluation of the candidates' curricula, motivation letters, and an illustrative report about the development of a possible PhD research, which candidates will send contextually with their application to the admission announcement.

### 5.2 Admission deadlines and number of vacancies

The number of positions is reported in the call for admission to the 35<sup>th</sup> PhD cycle Programmes: <http://www.dottorato.polimi.it/en/looking-for-a-phd/call-for-positions-and-scholarships/>.

Scholarships both on general and on specific themes are available, in accordance with what is specified in the call for admission.

## 6. Contents

### 6.1 Requirements for the PhD title achievement

The achievement of the PhD title in Physics requires a study and research activity of at least three years equivalent of full time study, research and development of PhD thesis.

PhD candidates in Physics must earn a minimum of **20 course credits** (see paragraph 6.3 below), and continuously conduct studies and research. Moreover, the PhD students are requested to attend at least 12 scientific seminars.

At the beginning of the course, the Faculty Board assigns a tutor to each PhD candidate to supervise and assist him/her in the overall training programme. The tutor shall be a professor belonging to the Faculty Board. The tutors assist the candidates in the choice of courses to be included in the study plan, which is eventually submitted for approval to the Coordinator of the PhD Programme (see also section 6.4 below).

The Faculty Board may assign extra course credits to one or more candidates, in case they need to complete their preparation in specific topics, relevant for their research projects.

## 6.2 Research development

The main aim of the PhD Programme in Physics and, more generally, of all PhD Programmes at Politecnico di Milano is the development in the candidates of a research-oriented mind-set, with expertise and skills in a specific research topic. To this end, candidates develop a problem-solving capability in complex contexts, including the capacity of performing deep problem analysis, identifying original solutions, and evaluating their applicability in practical contexts.

These skills provide the PhD candidates with major opportunities of development in their research both in the academic field, and in public and private organizations.

PhD candidates are requested to develop an original research contribution. The PhD thesis must thus contribute to increase the knowledge in the candidate's research field. Besides, it has to be coherent with the research topics developed at the Department of Physics, where the PhD Programme is carried out.

The original research results are collected in the PhD thesis, where the candidate's contribution is put in perspective with respect to the research state of the art in the specific research field.

The PhD research is developed under the guidance of a supervisor, who supports the candidate in the setting-out and in the everyday activities related to the thesis development. The supervisor is not necessarily a member of the Faculty Board and may also belong to an institution different from Politecnico di Milano. The supervisor can be supported by one or more co-supervisors.

Further activities intended to develop the candidate's personal skills and research expertise are encouraged during the PhD path.

Candidates must acquire the capability to present and discuss their work in their research community. Consequently, both the participation to international conferences and the publication of the research results in peer-reviewed journals are encouraged.

The PhD Programme favors the candidates' research interactions with other groups in their research field, preferably abroad. Research visits of at least three months are strongly encouraged, as through them the candidates may acquire further skills to develop their research work and thesis.

The duration of the Programme is normally three years.

## 6.3 Objectives and general framework of the teaching activities

The PhD Programmes and the PhD School activate teaching forms of different kind and credit value, including courses, seminars, project workshops, laboratories. Teaching activities cover both the basic research issues (problems, theories, methods), which represent the founding element of the PhD Programme and clearly identify its cultural position, and the investigation of specific research issues connected with the problems developed in the thesis.

Lessons are usually held in English, except when indicated otherwise. More generally, the entire path of the PhD in Physics is in English language.

Structured teaching activities allow to earn ECTS credits. Other activities, typically specialized and for which it is difficult to evaluate the learning level and its quantification, fall within the scientific activities that the Faculty Board takes into account in the overall evaluation, but they do not allow to earn ECTS.

The tables below summarize the candidate's path (as regards coursework activities). At the same time, the Programme foresees that the candidates are devoted to research activity in a continuous way, following the lead of their supervisors, and of the Faculty Board.

### *First/Second Year*

Within the first two years, the candidate is expected to acquire 20 ECTS following the rules summarized here below and described in the following:

Course type	Number of ECTS (minimum)	Notes
Courses characterising the PhD Programme	10	See Table A here below
PhD School Courses	10	See Table B here below

### **Third year**

The third year should be devoted entirely to the research and to the development of the PhD thesis.

### **PhD Course List**

**A)** The PhD Programme in Physics organizes **Characterizing Courses**. The characterizing courses for the **2021-2022** Academic Year are listed in table A. Courses from other PhD programmes might be added to the list upon resolution of the Scientific Board.

For admission to the thesis defense, the acquisition of at least **10 credits** from characterizing courses is **mandatory**.

**Table A: PhD COURSES CHARACTERISING THE PhD PROGRAMME FOR THE 2021-2022 ACADEMIC YEAR**

<b>TEACHER</b>	<b>COURSE TITLE</b>
Paola Folegati	Interaction of Radiation with matter: Phenomenological aspects and biological effects
Giovanni Isella	Optical and optoelectronics properties of semiconductor nanostructures
Cristian Manzoni	Optical techniques to probe matter / Tecniche ottiche per la caratterizzazione dei materiali
Ezio Puppin	Relativity and its implications / Teoria della relatività e sue implicazioni
Dario Natali	Organic Electronics

Characterizing courses to be offered in 2022-23 will be selected in the first semester of 2022.

**B)** The PhD School of Politecnico di Milano proposes a set of courses aiming to training the PhD candidates in soft and transferable skills. The skills and abilities provided by these courses are expected to help candidates across different areas of their careers in responding to the rapidly evolving needs of the global economy and society at large.

**10 out of the 20 course credits** that each candidate is required to earn shall be obtained through soft and transferable skills courses organized by the PhD School.

The following table reports PhD School courses that will be available for the **2021-2022** Academic Year. A complete and updated list for can be found at:

[https://www11.ceda.polimi.it/manifestidott/manifestidott/controller/MainPublic.do?check\\_params=1&kcorso\\_la=1300&lang=EN&\\_pj0=0&\\_pj1=af2af78ed4bc3da23ce04f3ee67b5333](https://www11.ceda.polimi.it/manifestidott/manifestidott/controller/MainPublic.do?check_params=1&kcorso_la=1300&lang=EN&_pj0=0&_pj1=af2af78ed4bc3da23ce04f3ee67b5333).

**Table B: PhD SCHOOL COURSES ON SOFT AND TRANSFERABLE SKILLS FOR THE 2021-2022 ACADEMIC YEAR**

<b>TEACHER</b>	<b>COURSE TITLE</b>
Aliverti Andrea	Ethics in Research
Armondi Simonetta	Strengthening Critical Spatial Thinking
Arnaboldi Michela	Advanced Interaction Skills for Academic Professionals
Balducci Alessandro	Approaches to Resilience: Social, Economic, Environmental and Technological Challenges of Contemporary Human Settlements
Biscari Paolo	English for Academic Communication
Cardilli Lorenzo	European Culture
Chiodo Simona	Epistemology of Scientific and Technological Research (Technologies Reshaping Humans)
Di Blas Nicoletta	Professional Communication
Gianinetto Marco	The Copernicus Green Revolution for Sustainable Development
Iarossi Maria Pompeiana	Power of Images and Visual Communication for Research Dissemination
Jacchetti Emanuela	Communication Strategies that Score in Worldwide Academia
Lavagna Monica	Sustainability Metrics, Life Cycle Assessment and Environmental Footprint
Mancini Mauro	Project Management (in Action)
Masarati Pierangelo	Ethical Aspects of Research on Dual-Use Technologies
Ossi Paolo Maria	Sulla responsabilità della Tecnica
Paganoni Anna Maria	La comunicazione nella Scienza
Pizzocaro Silvia Luisa	Practicing Research Collaboration / La pratica della collaborazione nella ricerca
Raos Guido	Science, Technology, Society and Wikipedia
Sancassani Susanna	Teaching Methodologies, Strategies and Styles
Valente Giovanni	Scientific Reasoning: Philosophy, Logic and Applications
Volonte' Paolo Gaetano	Introduction to Academic Research
Zani Maurizio	Laboratorio di insegnamento a classi numerose

Courses on soft and transferable skills to be offered in 2022-23 will be selected in the first semester of 2022.

## **PREPARATORY COURSES**

If the supervisor and the tutor find it useful or necessary for the candidate to attend preparatory courses (chosen among the activated courses at the Politecnico di Milano) the Faculty Board of the PhD Programme may assign some extra-credits to be acquired to complete the training path. Such credits may be of PhD or master level, and will be considered as additional, in relation to the mandatory credits to be acquired with the PhD courses.

## **SPECIALISTIC COURSES, LONG-TRAINING SEMINARS**

The attendance of Specialist Courses, Workshops, Schools, Seminar cycles is strongly encouraged and (if these seminars and workshops are certified and evaluated) may permit to acquire credits according to the modalities established by the Faculty Board and upon approval of the study plan submitted by the candidate. These courses and workshops can be inserted in the study plan, even if they are not evaluated (and therefore not qualified as credits), as optional “additional teaching”.

## **SCIENTIFIC SEMINARS**

During the PhD Programme, each PhD candidate is required to attend at least 12 scientific seminars. Each seminar can be organized either by the Physics Department or by other scientific institutions.

## **6.4 Presentation of the study plan**

PhD candidates must submit a study plan, which may be revised periodically (approximately every three months), to adapt them to possible changes in the course list, or to needs motivated by the development of their PhD career. The study plans must be approved by the PhD Programme Coordinator, according to the modalities established by the Faculty Board of the PhD Programme itself.

## **6.5 Yearly evaluations**

The candidates present their work to the Faculty Board at least once a year. In particular, they must pass an annual evaluation in order to be admitted to the following PhD year. The third-year evaluation establishes the candidate's admission to the final PhD defense.

As the result of each annual evaluation, the candidates who pass the exam receive an evaluation (A/B/C/D) and may proceed with the enrolment at the following year. Candidates who do not pass the exam are qualified either as “Repeating candidate” (Er) or “not able to carry on with the PhD (Ei)”. In the former case (Er), the candidates are allowed to repeat the PhD year at most once. The PhD scholarships – if any – are suspended during the repetition year. In the latter case (Ei) the candidates are excluded from the PhD programme and lose their scholarships – if any.

In case the Faculty Board holds appropriate to assign directly an exclusion evaluation (Ei) without a previous repetition year, the request must be properly motivated, and validated by the PhD School.

After the final year, candidates who have achieved enough results but need more time to conclude their research work and write their theses, may obtain admission to a further year.

## **6.6 PhD thesis preparation**

The main objective of the PhD career is the development of an original research contribution. The PhD thesis is expected to contribute to the advance of knowledge in the candidate's research field.

The PhD study and research work is carried out, full time, during the three years of the PhD course. Stages or study periods in (Italian or International) companies or external Institutions may complete the candidate's preparation.

The resulting thesis needs to be coherent with the research activities developed at the Department of Physics, where the PhD Programme is developed.

The candidate must present an original thesis and discuss its contribution to the state of the art in the research field.

The PhD research is developed under the guidance of a supervisor, who supports the candidate in the setting out and in the everyday activities regarding the thesis development.



At the conclusion of the PhD studies, the Faculty Board evaluates the candidates. Candidates who receive a positive evaluation submit their theses to two external reviewers for refereeing. If the evaluation provided by the reviewers is positive (or after the revisions required by the external reviewers), the candidates defend their thesis in a final exam, in front of a Committee composed of three members (at least two of which must be external experts).

## 7. Laboratories, PhD Secretary Services

### 7.1 Laboratories

The PhD students will join advanced research laboratories of the Department of Physics, learn about experimental techniques, contribute to research activity, and attend meetings and internal seminars aimed at providing more in-depth knowledge on specific research topics. A non-comprehensive list of the experimental laboratories is provided here below:

1. Ultrashort light pulse generation and applications to the study of ultrafast phenomena in the matter
  - Attosecond Reaction Microscope
  - Femtosecond laser laboratory
  - High-energy attosecond pulse laboratory
  - Laboratory for coherent Raman spectroscopy and microscopy
  - Laboratory for IR-VIS ultrafast spectroscopy
  - Laboratory for XUV ultrafast spectroscopy
  - Mid-IR Laser Laboratory for Strong-Field Physics
  - Ultrafast Molecular Imaging
2. Solid state lasers and photonic devices for integrated systems
  - Characterization of photonic and optofluidic devices
  - Frequency comb laboratory - Campus Point (Lecco)
  - High-resolution and high-precision laser spectroscopy
  - Virtual Lab of Computational Electromagnetics Laboratory of coherent vibrational spectroscopy
  - Solid state lasers
  - Two-photon polymerization by femtosecond lasers
  - Ultrashort laser pulse micromachining
  - Wet etching in hydrofluoric acid for microfluidic circuits
3. Photonics for health, food and cultural heritage
  - Diffuse Optical Spectroscopy
  - Diffusive Optical Phantoms
  - Fast Fluorescence Molecular Tomography
  - Fluorescence Spectroscopy
  - Functional Near Infrared Spectroscopy
  - Gated Photon Counting
  - Imaging Spectroscopy for Cultural Heritage
  - Near Infrared Spectroscopy for Food
  - Diffuse Optics for Clinical Diagnostics
  - Optical Projection Tomography

4. Epitaxial growth and nanostructure fabrication
  - Electron Beam Lithography
  - Materials and devices for Spin Electronics
  - Nanobiology
  - Scanning Tunnelling Microscopy
  - Semiconductor growth
  - Versatile Electron Spectroscopy Instrumentation
  
5. Electronic, optical and magnetic properties of low-dimensional systems
  - Magneto-Optical Kerr effect
  - Nonlinear nano-optics
  - Scanning Auger Microscopy
  - Scanning probe microscopy
  - Scanning near-field optical microscopy
  - Synchrotron radiation facilities
  - Ultrafast Photoemission and Optical Spectroscopy
  - Variable energy positron annihilation spectroscopy
  - Vibrational infrared spectroscopy

## 7.2 PhD Secretary Services

Ms. Daniela Rossi

Department of Physics

Tel.: 02 23996169

Fax: 02 23996126

e-mail: [daniela.rossi@polimi.it](mailto:daniela.rossi@polimi.it)

## 8. Internationalisation and inter-sectoriality

Carrying out study and research activities at external laboratories is strongly recommended. As mentioned in Section 2, the students can take advantage of scientific collaborations that are on-going between the Department of Physics and several high-level International Institutions, including universities and research centres.

Politecnico di Milano supports joint PhD paths with International Institutions, as well as Joint and Double PhD Programmes. Further information is available on the PhD School website and on the PhD Programme website.

More specifically, the PhD Programme in Physics collaborates on a variety of research topics in the areas of laser physics, photonic devices and applications, and of solid state physics (see Section 2) with several International Academic Institutions, including: Massachusetts Institute of Technology, Harvard University - Harvard-Smithsonian Center for Astrophysics, University College London, University of Cambridge, Polytechnic University of Zurich (ETH), Polytechnic University of Lausanne (EPFL), Ecole Polytechnique - Palaiseau (Paris), Technical University of Denmark, Royal Institute of Technology (KTH, Stockholm).

Interaction with and exposure to non-academic sectors provides significant benefits to doctoral candidates as well as to research and innovation intensive employment sectors. Direct exposure to the challenges and opportunities in non-academic sectors of the economy and society at large is fostered by networking, connectivity, inter-sectoral mobility and wide access to knowledge.

In particular, the PhD Programme in Physics has strong and long-lasting links with Consiglio Nazionale delle Ricerche (CNR) and Istituto Italiano di Tecnologia (IIT): the headquarters of the CNR Institute for Photonics and Nanotechnology are at the Department of Physics, and the IIT Center for Nano Science and Technology

is located at Politecnico di Milano. Furthermore, the PhD Programme in Physics collaborates with:

- International Research Agencies, like Commissariat à l'énergie atomique et aux énergies alternatives - Laboratoire d'électronique des technologies de l'information (CEA-Leti), Grenoble (optical tomography and reconstruction techniques; nanofabrication; spintronics); Centre National de la Recherche Scientifique (CNRS), Grenoble (nanofabrication); European Synchrotron Radiation Facility (ESRF), Grenoble; Max Planck Institute, Stuttgart; Paul Scherrer Institut (PSI), Villigen; The Institute of Photonic Sciences (ICFO), Barcelona (optical techniques for medical diagnostics); Institut Català d'Investigació Química (ICIQ), Tarragona (new materials for photonics); Consejo Superior de Investigaciones Científicas (CSIC), Barcelona (nanofabrication); CIC nanoGUNE Cooperative Research Centre, San Sebastian (nanoscience); ELI Attosecond Light Pulse Source (ELI-ALPS), Szeged (attosecond science); Interuniversitair Micro-Elektronica Centrum (IMEC), Leuven, Elettra Sincrotrone Trieste (advanced spectroscopy).
- Large companies, like Toshiba Research Europe Limited (microfluidic devices) and Quanta System- EEn (laser development).
- SMEs, like Hemophotonics SL (development of innovative instruments for optical diagnostics), Combustion and Energy s.r.l., Xnext s.r.l. (x-ray inspection), Elvsys sas (microfluidic devices), Suspersonic Imagine (ultrasound medical imaging), Photek Limited (high sensitivity photon detectors), Roentdek - Handels GmbH (innovative detectors), Artinis Medical Systems (standardization of medical devices), Optec SpA (instrumentation for Raman spectroscopy).

# Attachment A1 – PhD Programme Coordinator

The PhD Programme in Physics is coordinated by Marco Finazzi  
born in Palazzolo sull'Oglio (BS), Italy, August 14, 1965  
Web site: <http://www.fisi.polimi.it/it/personale/finazzi>

## **CURSUS STUDIORUM**

1994 PhD in Physics, Politecnico di Milano, Italy.  
1989 Laurea Degree in Electronic Engineering, Politecnico di Milano, Italy.

## **PROFESSIONAL ACTIVITY**

2015 – to date Full professor – Physics Department, Politecnico di Milano, Italy.  
2005 – 2015 Associate professor – Physics Department, Politecnico di Milano, Italy.  
2012 National Scientific Qualification for 1st level professorship in Experimental Physics of Matter (SC 02/B1).  
2002 – 2005 Assistant Professor – Physics Department, Politecnico di Milano, Milano, Italy.  
2000 – 2002 Adjunct Professor, Università Sacro Cuore, Brescia, Italy.  
1998 – 2002 Scientist of the Istituto Nazionale di Fisica della Materia (INFN) – ELETTRA Synchrotron Radiation Facility, Trieste, Italy.  
1996 – 1998 Post doc – European Synchrotron Radiation Facility, Grenoble, France.  
1994 – 1996 “Marie Curie” fellow, “Human Capital and Mobility” – Laboratoire pour l’Utilisation du Rayonnement Electromagnétique (LURE), Orsay, France.  
1993 – 1994 Post doc – Centre National pour la Recherche Scientifique (CNRS), Orsay, France  
1993 Grant – Laboratoire pour l’Utilisation du Rayonnement Electromagnétique (LURE), Orsay, France.

## **SCIENTIFIC ACTIVITY**

Marco Finazzi’s research activity spans a time lapse of about 25 years and can be classified within the field of Nano-Science and Technology. Many research fields have been investigated, from magnetism of thin films and interfaces to spintronics, and from scanning probe microscopy to nano-optics. Although most of the activity has been experimental, several theoretical works, either numerical or analytical, have also been published.

The experimental activity has been conducted either on campus at the Physics Department of Politecnico di Milano, or at large scale synchrotron radiation facilities (LURE - Orsay, France, Elettra - Trieste, ESRF - Grenoble, ALS - Berkeley, BESSY - Berlin). Both types of activities have often required the realization of ad hoc advanced scientific instrumentation. In this context, it should be reminded that Marco Finazzi was hired (1996-1998) at the European Synchrotron Radiation Facility (ESRF), Grenoble, France, to develop the instrumentation of the experimental station of the soft X-ray beamline ID12B and to give assistance to users: in two years, about 50 experiments have been performed by groups from all Europe.

The recent scientific activity can be roughly divided along the following principal lines:

### *Scanning tunneling microscopy and spectroscopy of low-dimensional systems*

Electronic and magnetic properties of matter stem from the local organization of the elemental constituents. This has led in 2006 to opening a new research line at the Physics Department of Politecnico di Milano dedicated to Scanning Tunneling Microscopy.

- Study of the contrast mechanisms for scanning tunneling microscopy on thin oxide films.
- Stable alignment of tautomers at room temperature in porphyrin two-dimensional layers.
- Morphologic and electronic properties of ultrathin oxide films (CrO, FeO, CoO, NiO).
- Surfactant action of oxygen in the growth of transition metal films.

### *Nano-optics and plasmonics*

In 2003, Marco Finazzi contributed to funding the nano-optics/scanning probe microscopy laboratory at the Physics Department at Politecnico di Milano, dedicated to studies of the optical properties of nano-systems and super-resolution microscopy. In this frame, particular emphasis has been dedicated to nonlinear nano-

optics and to the study of polarization in the near field of nanostructures.

- Study of planar waveguides as quantum mechanical analogs (Zeno effect, wave packet collapses and revivals in a quantum bouncing ball).
- Macroscopic movement of azo-polymer chains by near-field probes.
- Near-field polarization and chirality.
- Self-organization in polymeric thin films.
- Kerr and Faraday microscopy on magnetic materials.
- Semiconductor-based nano-optics and plasmonics.
- Nonlinear nano-optics.

### *Spintronics*

Spintronics is the new branch of Physics aiming at exploiting the spin of the carriers to transport and manipulate information. In 2013, Marco Finazzi contributed to funding the SemiSpin laboratory at the Physics Department at Politecnico di Milano, dedicated to the study of the generation and transport of spin-polarized electrons in semiconductors.

- Excitation of spin-polarized electron with circularly polarized light in GaAs, Ge and Si.
- Study of spin-charge conversion through the Inverse Spin-Hall Effect in Pt films coupled to GaAs, Ge and Si.
- Demonstration of a spin cell generating a spin photovoltage by exploiting metal nanostructures on Ge and GaAs.

### **INSTITUTIONAL RESPONSIBILITIES**

2019 – today Coordinator of the PhD School in Physics. Politecnico di Milano, Italy.

2013 – 2018 Vice-coordinator of the PhD School in Physics. Politecnico di Milano, Italy.

2016 – 2018 Member of the commission for the assignment of Abilitazione Scientifica Nazionale, sett. conc. 02/B2 – Theoretical Physics of Matter.

2013 – to date Responsible for the spin-in-semiconductors (SEMISPIN) laboratory at the Physics Department, Politecnico di Milano.

2003 – to date Responsible for the nano-optics and scanning optical microscopy (SNOM) laboratory at the Physics Department, Politecnico di Milano.

### **COMMISSIONS OF TRUST**

2012 – 2013 Review panel member for the National Interest Research Project call, Ministry of University and Scientific Research, Italy

2012 – 2013 Review panel member for the Italian Fund for Fundamental Research call, Ministry of University and Scientific Research, Italy

2013 Scientific Evaluation, Swiss National Science Foundation, Switzerland.

2015 Scientific Evaluation, German Research Foundation, Germany.

### **PUBLICATIONS**

**245** publications on international peer-reviewed journals

**2** research monographs.

**+4500** citations (Scopus)

**H index:** 36 (Scopus).

## Attachment A2 – PhD Faculty Board

The Board of Professors is composed of 13 full professors, 8 associate professors, and a retired full professor of Politecnico di Milano. The director of the CNR Institute of Photonics and Nanotechnology is also part of the Board, as strong long-lasting collaboration and integrated research are on-going between the CNR Institute and the Department of Physics. The director of the Centre for Nano Science and Technology of the Italian Institute of Technology – who is also affiliated to Politecnico di Milano – is also part of the Board.

<b>Name</b>	<b>Affiliation</b>	<b>Scientific Disciplinary Sector</b>
Marco FINAZZI (coordinator)	Politecnico di Milano	FIS/01 Experimental Physics
Riccardo BERTACCO	Politecnico di Milano	FIS/01 Experimental Physics
Alberto BRAMBILLA	Politecnico di Milano	FIS/01 Experimental Physics
Mario CAIRONI	IIT - Centre for Nano science and Technology	FIS/01 Experimental Physics
Giulio CERULLO	Politecnico di Milano	FIS/01 Experimental Physics
Franco CICCACCI	Politecnico di Milano	FIS/01 Experimental Physics
Rinaldo CUBEDDU	Politecnico di Milano*	FIS/01 Experimental Physics
Cosimo D'ANDREA	Politecnico di Milano	FIS/01 Experimental Physics
Claudia DALLERA	Politecnico di Milano	FIS/01 Experimental Physics
Giuseppe DELLA VALLE	Politecnico di Milano	FIS/01 Experimental Physics
Lamberto DUO'	Politecnico di Milano	FIS/01 Experimental Physics
Giacomo GHIRINGHELLI	Politecnico di Milano	FIS/01 Experimental Physics
Giovanni ISELLA	Politecnico di Milano	FIS/01 Experimental Physics
Guglielmo LANZANI	Politecnico di Milano IIT - Centre for Nano science and Technology	FIS/01 Experimental Physics
Paolo LAPORTA	Politecnico di Milano	FIS/01 Experimental Physics
Marco MARANGONI	Politecnico di Milano	FIS/01 Experimental Physics
Mauro NISOLI	Politecnico di Milano	FIS/03 Physics of Matter
Dario POLLI	Politecnico di Milano	FIS/01 Experimental Physics
Roberta RAMPONI	Consiglio Nazionale delle Ricerche	FIS/01 Experimental Physics
Salvatore STAGIRA	Politecnico di Milano	FIS/01 Experimental Physics
Paola TARONI	Politecnico di Milano	FIS/01 Experimental Physics
Alessandro TORRICELLI	Politecnico di Milano	FIS/01 Experimental Physics
Maurizio ZANI	Politecnico di Milano	FIS/01 Experimental Physics

## Attachment A3 – PhD Advisory Board

The composition of the Advisory Board has been recently changed. It is now composed of six distinguished researchers/managers representative of different applied research environments: two of them belong to international universities ([Center for Quantum Nanoscience at Ewha Womans University](#) and [University of Würzburg](#)), three to leading hi-tech companies in the fields of optics, microelectronics, and vacuum technology, and one is the TTO Director a of the Italian Institute of technology, as specified in the following table:

<b>Name</b>	<b>Affiliation</b>
Davide BLANDINO	Optec SpA - Optical and Opto-Electronic Systems
Fabio DONATI	Center for Quantum Nanoscience at Ewha Womans University
Bert HECHT	University of Würzburg
Sebastiano LURIDIANA	Tecno Vacuum s.r.l.
Salvatore MAJORANA	Istituto Italiano di Tecnologia, TTO
Agostino PIROVANO	Micron Semiconductor Italia s.r.l.

Periodic meetings of the Advisory Board with the PhD Faculty, open to all PhD students and other researchers of the Department, are foreseen, typically on a yearly basis, to discuss the PhD Programme organization and possible professional opportunities.