Curriculum C: Physics of Matter

Solid State Physics/Quantum Technologies path

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Solid State Physics/Quantum Technologies path

Focused on the **physical properties of materials** for applications in photonics, energy, microelectronics and quantum technologies (sensing, communication, computing).

This path in Curriculum C focuses on the study of **quantum materials for different applications** while quantum paths in Curriculum B mostly focuses on quantum sensing devices for particle physics/astrophysics; or quantum hardware.

Solid State Physics/Quantum Technologies path

Curriculum C: PHYSICS OF MATTER

16 ECTS to be chosen from the following pairs of courses:

Type of Educational Activity / Area	ECTS Area	Codes	Courses	ECTS	SSD	Semester
Core – Experimental and Applied	16	F1703Q014	(*) LABORATORIO DI ELETTRONICA I	10	FIS/01	I
		F1703Q015	(*) LABORATORIO DI ELETTRONICA II	6	FIS/01	II
		F1703Q020	LABORATORY OF PLASMA PHYSICS I	10	FIS/01	I
		F1703Q021	LABORATORY OF PLASMA PHYSICS II	6	FIS/01	II
		F1703Q022	LABORATORY OF QUANTUM TECHNOLOGIES, MATERIALS AND SENSORS I	10	FIS/01	I
		F1703Q023	LABORATORY OF QUANTUM TECHNOLOGIES, MATERIALS AND SENSORS II	6	FIS/01	II

6 ECTS to be chosen from:

Type of Educational Activity / Area	ECTS Area	Codes	Courses	ECTS	SSD	Semester
Core - Theoretical and Foundations of Physics	6	F1703Q052	STATISTICAL MECHANICS	6	FIS/02	I
		F1703Q053	THEORETICAL PHYSICS I	6	FIS/02	I
		F1703Q056	THEORY OF CONDENSED MATTER	6	FIS/02	I

Three core courses (18 ECTS) to be chosen from the following:

Type of Educational Activity / Area	ECTS Area	Codes	Courses	ECTS	SSD	Semester
Core - Microphysics of Matter and Fundamental Interactions	18	F1703Q004	APPLIED QUANTUM TECHNOLOGIES	6	FIS/04	I
		F1703Q007	ENERGY PHYSICS	6	FIS/03	II
		F1703Q031	OPTICAL SPECTROSCOPY OF SOLIDS	6	FIS/03	II
		F1703Q035	PHYSICS OF SEMICONDUCTORS	6	FIS/03	II
		F1703Q036	PLASMA PHYSICS I	6	FIS/03	I
		F1703Q037	PLASMA PHYSICS II	6	FIS/03	II
		F1703Q049	SOLID STATE PHYSICS	6	FIS/03	I

Three related/supplementary courses (18 ECTS) to be chosen from the following:

Type of Educational Activity / Area	ECTS Area	Codes	Courses	ECTS	SSD	Semester
Related / Supplementary Educational Activities	18	F1703Q001	APPLICATION OF NEUTRON PHYSICS	6	FIS/07	I
		F1703Q003	APPLIED ELECTRONICS	6	ING-INF/01	I
		F1703Q006	COMPUTATIONAL MATERIALS SCIENCE	6	FIS/03	I
		F1703Q008	EXPERIMENTAL METHODS IN HIGH ENERGY PHYSICS	6	FIS/04	II
		F1703Q009	FABRICATION AND CHARACTERIZATION OF NANO AND QUANTUM MATERIALS	6	FIS/03	II
		F1703Q012	(*) INFORMATICA INDUSTRIALE	6	ING-INF/05	II
		F1703Q025	MACHINE LEARNING AND STATISTICAL PHYSICS OF MACRO-MOLECULAR SYSTEMS	6	FIS/07	II
		F1703Q026	MACHINE LEARNING APPLICATIONS	6	FIS/07	II
		F1703Q027	MATHEMATICAL METHODS FOR PHYSICS	6	FIS/02	I
		F1703Q028	MONTE CARLO SIMULATION OF RADIATION DETECTORS	6	FIS/04	II
		F1703Q039	QUANTUM ELECTRONICS	6	ING-IND/22	I
		F1703Q043	QUANTUM INFORMATION AND QUANTUM COMPUTING	6	FIS/02	I
		F1703Q044	QUANTUM MATERIALS	6	FIS/03	II
		F1703Q045	QUANTUM PHOTONICS	6	FIS/03	I
		F1703Q046	(*) RADIAZIONI ELETTROMAGNETICHE NON IONIZZANTI	6	FIS/01	II
		F1703Q060	(*) RIVELATORI DI RADIAZIONI	6	FIS/04	I
		F1703Q061	(*) SOSTENIBILITA' ENERGETICA	6	FIS/07	II
		F1703Q051	STATISTICS AND DATA ANALYSIS	6	FIS/01	II

Curriculum C: Solid State Physics/Quantum Technologies path

Type of Educational Activity / Area	ECTS Area	Codes	Courses	ECTS	SSD	Semester
Core – Experimental and Applied	16	F1703Q022	LABORATORY OF QUANTUM TECHNOLOGIES, MATERIALS AND SENSORS I	10	FIS/01	I
		F1703Q023	LABORATORY OF QUANTUM TECHNOLOGIES, MATERIALS AND SENSORS II	6	FIS/01	II
Core - Theoretical and Foundations of Physics	6	**One course to be chosen from:**				
		F1703Q052	STATISTICAL MECHANICS	6	FIS/02	I
		F1703Q056	THEORY OF CONDENSED MATTER	6	FIS/02	I
Core - Microphysics of Matter and Fundamental Interactions	18	**Choose three courses from the list:**				
		F1703Q004	APPLIED QUANTUM TECHNOLOGIES	6	FIS/04	I
		F1703Q031	OPTICAL SPECTROSCOPY OF SOLIDS	6	FIS/03	II
		F1703Q035	PHYSICS OF SEMICONDUCTORS	6	FIS/03	II
		F1703Q049	SOLID STATE PHYSICS	6	FIS/03	I
Related / Supplementary Educational Activities	18	**Three courses to be chosen from:**				
		F1703Q006	COMPUTATIONAL MATERIALS SCIENCE	6	FIS/03	I
		F1703Q009	FABRICATION AND CHARACTERIZATION OF NANO AND QUANTUM MATERIALS	6	FIS/03	II
		F1703Q039	QUANTUM ELECTRONICS	6	ING-IND/22	I
		F1703Q044	QUANTUM MATERIALS	6	FIS/03	II
		F1703Q045	QUANTUM PHOTONICS	6	FIS/03	I
		F1703Q043	QUANTUM INFORMATION AND QUANTUM COMPUTING	6	FIS/02	I
Elective course (chosen by the student)	12	*** **Two Courses to be chosen from:**				
		FSM02Q011	** APPLICATIONS OF MATERIALS FOR IONIZING RADIATION DETECTION	6	FIS/07	II
		FSM01Q026	** ENGINEERED NANOMATERIALS	6	ING-IND/22	I
		F1703Q026	MACHINE LEARNING APPLICATIONS	6	FIS/07	II
		FSM02Q009	** METALS SCIENCE AND SUSTAINABILITY	6	FIS/03	II
		FSM02Q013	** MOLECULAR ELECTRONICS AND PHOTONICS	6	FIS/01	II
		FSM02Q016	** NANOTECHNOLOGY & INNOVATION	6	FIS/01	I
		FSM01Q029	** PHYSICS AND TECHNOLOGY OF ELECTRONIC DEVICES	6	ING-IND/22	I
		FSM02Q015	** PHYSICS OF SOFT MATTER NANOSTRUCTURES	6	FIS/01	I

Several **Master Thesis for the Solid State Physics/Quantum Technologies** path are offered by researchers belonging to the **Materials Science Department**

https://www.mater.unimib.it/en/research/research-areas

Thesis topics can be found on the Master in Physics website under the Physics Department "Giuseppe Occhialini" site. In particular, the list can be found at:
https://www.fisica.unimib.it/it/didattica/corsi-studio/corso-laurea-magistrale-fisica/argomenti-prova-finale-della-laurea-magistrale/argomenti-prova-finale-della-laurea-magistrale-fisica-dello-stato-solido
Still in Italian! Better to contact directly research PIs or Prof. Bernasconi/Prof. Montalenti for further information

Thesis are all based on three main approaches

- Fabrication of materials with atomic level control (e.g. Molecular Beam Epitaxy)
- Experimental characterization of the functional physical properties – advanced spectroscopy and microscopy techniques also time-resolved
- Design and simulations of materials at different length scale: quantum-mechanical calculations, atomistic molecular dynamics simulations, mesoscopic simulations also with the aid of machine learning techniques



Materials for

- Microelectronics
- Photonics
- Energy (e.g. photovoltaics/batteries)
- Detector devices
- Cultural heritage
- Quantum technologies (sensing, communication, computing)

- Different classes of materials:
  Semiconductors, magnetic materials, topological insulators, amorphous materials and glasses, and many others