UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# SYLLABUS DEL CORSO

# Laboratory of Quantum Technologies, Materials and Sensors I

**2526-1-F1703Q022**

## Aims

Development of experimental skills in quantum materials, devices and technologies through advanced laboratory techniques based mainly on optical spectroscopy and the analysis of superconducting quantum devices. This course contributes in a coherent way to the master's degree programme through the following learning objectives:

*Knowledge, understanding and application of the skills*: students will acquire knowledge of the research methodology pertaining to experimental physics and will learn advanced topics in the area of physical sciences that are needed to solve complex problems.

*Making judgment*: students will be directed to deepen advanced topics in an independent way and to make critical judgments using the scientific method.

*Communication skills*: students will develop the ability to communicate synergistically in teamwork and present effectively their achievements.

*Learning skills*: ability to consult teaching material and the pertinent scientific literature, integrating the sources autonomously whenever necessary.

## Contents

Implementation of an experiment based on the application of quantum physics. The student will be able to investigate a specific area choosing between quantum materials and cryogenic devices for quantum computation and metrology.

## Detailed program

The course consists of an experiment performed by students divided into groups of three or four people.

The lab activities will follow introductory lessons on the correlation between physical properties of the solids, quantization effects and the associated experimental techniques. Besides the design of the experiment, students will conduct the characterization of the system under examination, complementing the activities with data analysis and a written report.

Examples of experiences:

Solid State group:

- Quantum optics experiments using single photons and quantum key distribution;
- Optical spin orientation and effects of quantum confinament on optical transitions;
- Design and characterization of quantum dot emitters for applications in quantum information;
- Fabrication and characterization of photonic nanoantennas for quantum communication applications.

Cryogenic lab group:

- Characterization, control and readout of a superconducting qubit;
- Single photon detection by means of a cryogenic detector;
- Characterization of a parametric amplifier with quantum limited readout noise.

## Prerequisites

Bachelor in physics or equivalent.

## Teaching form

Teaching makes use of interactive teaching (laboratory). The practical sessions will be conducted in the laboratories located in the buildings U2 and U5.

## Textbook and teaching resource

References (available also as e-book through the University’s library):

Lecture notes provided by the instructor

J. H. Davies "The Physics of Low-dimensional Semiconductors", Cambridge University Press

F. Fox "Optical Properties of Solids", Oxford University Press

I. Pelant and J. Valenta " Luminescence Spectroscopy of Semiconductors", Oxford University Press

A.M. Zagoskin "Quantum Engineering - Theory and Design of Quantum Coherent Structures", Cambridge

University Press

G. Ventura, L. Risegari - The Art Of Cryogenics

F. Pobell - Matter and Methods at Low Temperatures

David M. Pozar - Microwave Engineering

Serge Haroche, Jean-Michel Raimond - Exploring the Quantum: Atoms, Cavities, and Photons

Riccardo Manenti and Mario Motta - Quantum Information Science

Michael A. Nielsen, Isaac L. Chuang - Quantum Computation and Quantum Information

## Semester

First semester

## Assessment method

The assessment method consists of a project work written by the group and its discussion in a final oral exam (with a presentation) to evaluate the knowledge and the communication skills in the disciplinary field.

Tests will not be conducted in itinere.

The final mark is also based on the skill showed in the development of the lab experiment.

## Office hours

A help desk will be provided to the students upon direct request via email to the instructor. All the information related to the contacts and office address can be found at the university website.

## Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE