UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Quantum Photonics

2324-1-FSM01Q023

Aims

This course will guide students through the field of quantum optics, with a special focus on how to implement quantum technologies like quantum communication and sensing using optical techniques and photonic circuits. Students will have the possibility to get acquainted with materials and methods needed to create, manipulate, and read out quantum states of light. Major achievements and future challenges in the field will be discussed, including photonic quantum computation and topological systems.
The main goal of this course is therefore to provide a basic knowledge of the quantum description of light. In addition, the course will provide an experimental perspective on phenomena based on light-matter interaction. The discussions of relevant applications will expand the student's background in optics and will aim at providing technological insights into materials for quantum photonics.

Contents

• Photon statistics and materials for quantum emitters
• Light-matter interaction
• Quantum cryptography
• Interferometry, entangled states, teleportation
• Quantum internet and photonic computing

Detailed program

Photon statistics: classification of light by statistics, coherent sources, shot noise and quantum theory of photodetection.

Interferometry: materials platforms for single photon sources, Hanbury Brown-Twiss experiment, Hong-Ou-Mandel interference, quantum eraser, photon bunching and anti-bunching.

Light-matter interaction: weak coupling, Purcell effect, strong coupling, cavity quantum electrodynamics.

Quantum cryptography: Principles of classic and quantum cryptography, quantum key distribution using single photons, BB84 protocol.

Entangled states: entangled photon pairs, experimental tests of Bell’s theorem, CHSH inequality, and teleportation.

Spin-photon interfaces: Optical spin orientation, quantum internet.

Advanced applications: materials and principles for photonic quantum computing, basic concepts of topological photonics.

Prerequisites

Students should have knowledge of electromagnetic waves, quantum mechanics and structure of matter at the level of undergrad introductory courses. Knowledge of atomic physics and optical properties of solids is advantageous.

Teaching form

The instructor explains and formally derives the new concepts using a blackboard or a tablet. Formal derivations are always followed by applications. At the beginning of each lesson, the instructor briefly recalls the content of the previous lecture.

Textbook and teaching resource

Lecture notes and papers made available to students through this e-learning platform.
Adopted Text (also available in e-book format through the university library): Mark Fox, Quantum Optics, Oxford University Press.

Semester

Second semester

Assessment method

The assessment relies on a final oral test. During the examination, the instructor evaluates the student's learning level and the communication capabilities pertaining to the specific field. There will be no intermediate tests.

Office hours

From Monday to Friday at any working hour, provided that students ask for an appointment with the instructor by email.

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE | SUSTAINABLE CITIES AND COMMUNITIES