Course unit English denomination	Structured light: from principles to modern applications
Teacher in charge (if defined)	Dr. Gianluca Ruffato, Prof. Filippo Romanato
Teaching Hours	24
Number of ECTS credits allocated	3
Course period	February - June 2025
Course delivery method	☒ In presence ☐ Remotely ☐ Blended
Language of instruction	English
Mandatory attendance	☒ Yes (50% minimum of presence) ☐ No
Course unit contents	The course aims to provide an overview on the state of the art in the physics and applications of structured light in various fields, from life sciences to information and communication technologies, in both classical and single-photon regimes. Specifically, the program is structured into two main blocks, each 12 hours long: the first module focuses on the theory and models to describe the generation and propagation of structured light beams and their control via optical elements; the second module is dedicated to the nanofabrication of optical elements and their integration into innovative devices, with case studies at the state of the art. The course covers the following topics: - Recap of wave optics and electromagnetism. - Fourier optics: description of the propagation of a light beam in the paraxial regime. - Orbital angular momentum of light: families of optical vortices and their properties. - Polarization and combination with spatially structured light: vector beams. - Refractive, diffractive optical elements, and metasurfaces: physical principles, design methods, and realization. - Spatial modes in multimode optical fibers and their applications in classical and quantum regimes. - Methods for generating, measuring, and controlling the orbital angular momentum of a light beam. - Design and fabrication of optics for the generation of structured light. - Nanostructuring of matter to achieve nano-optical effects. - Basics of nanofabrication for nanostructured optical devices. - Design and fabrication of metalenses and diffractive optics. - Optical characterization and applications of metalenses and diffractive optics. - Applications of light with innovative devices, such as quantum computers

	and trapping, optical computers, metaguides, and quantum optics.
Learning goals	At the end of the course, the student will be able to: - describe the propagation of an optical beam in free space or in an optical fiber - describe the effect of an optical element on the propagation of a light beam - design standard optical elements (refractive or diffractive) and metasurfaces to perform specific optical operations - understand the physical mechanisms underlying optical devices used in the field of information and communication technologies, particularly for encoding and transmitting information on the spatial modes of light, both in the classical and quantum regimes - apply concepts of modeling, simulation, and computation to the design of nanostructured optical devices - understand and describe the correlations between the nanostructuring of matter and the effects on nanostructured light - understand and describe processes and protocols for nanofabrication.
Teaching methods	Lessons in presence and analysis of case studies
Course on transversal, interdisciplinary, transdisciplinary skills	☒ Yes ☐ No
Available for PhD students from other courses	☒ Yes ☐ No
Prerequisites (not mandatory)	None
Examination methods (in applicable)	Final seminar on a topic agreed upon with the teachers
Suggested readings	Slides of the lessons, books and articles suggested by the teachers
Additional information	