UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO INTERUNIVERSITARIO DI FISICA

General information		
Academic subject	Laboratory of Quantum Optics	
Degree course	Laurea Magistrale Physics	
Academic Year	2022/23	
European Credit Transfer and Accumulation System (ECTS)	6	
Language	English	
Academic calendar (starting and ending date)	Sept. 28-Dec. 19, 2022	
Attendance	No	

Professor/ Lecturer	
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Department and address	Physics Dept.
Virtual headquarters (Microsoft Teams code)	vamqudt
Tutoring (time and day)	Mon & Wed from 3 to 4 pm, office and online

Syllabus	
Learning Objectives	Knowledge and understanding of the limits of validity of classical optics, evolution of concepts in the transition from classical to quantum optics (quantum states of radiation, entangled states, counting of photons, interference and coherence, ..), measurement of correlations, interferometry and quantum imaging.
Course prerequisites	Background knowledge on classical e.m. theory, classical optics, statistical physics and quantum mechanics.
Contents	***Basics of quantum optics:*** Quantum theory of e.m. radiation: Field quantization and Fock states Other states of e.m. radiation: thermal light, choerent states Photon statistics and photon counting ***Theory of coherence:*** Review of classical theory of interference and coherence Mutual coherence function and degree of coherence: - Temporal coherence and spectrum; - Spatial coherence Coherence and stellar interferometers: - Michelson stellar interferometer - Hanbury-Brown and Twiss interferometer Quantum theory of coherence: - Correlation functions and their measurement ***Quantum entanglment in optics*** Pure states and mixed states, factorizable and entangled states SPDC: a source of entangled photons EPR paradox Some historical experiments on multi-photon interference Quantum imaging with entangled photons and thermal light ***Esperienze di laboratorio (30 ore)*** - Photon statistics - HBT interferometer Ghost imaging with pseudo-thermal light
Books and bibliography	Scully & Zubairy, *Quantum Optics* Gerry & Knight, *Introductory Quantum Optics* *Scientific papers*
Additional materials	*Slides available in dropbox folder shared with students*

Work schedule	

Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
	32	30	
ECTS			
	4	2	

Teaching strategy	
	Frontal teaching using slides: experimental and historical approach, discussion of crucial experiments. Laboratory activities: group work for the preparation for laboratory activities, the conduct of experiments, and the discussion and critical analysis of the results. Report of lab experiences in different formats: internal note, conference presentation, scientific article.

Expected learning outcomes	
Knowledge and understanding on:	○ limit of validity of classical optics ○ evolution of the optical concepts going from classical to quantum optics ○ theoretical model for describing quantum states of radiation, ○ peculiarities of quantum optics with special attention to entangled states, ○ practical consequences and technological applications of quantum optics.
Applying knowledge and understanding on:	○ solve complex practical problems in the framework of quantum optics ○ designing and implementing an optical setup for measuring the typical characteristics of a non-classical light source (spectrum, intensity, coherence, etc.)
Soft skills	• **Making informed judgments and choices** ○ Students are encouraged to choose optical instruments and experimental devices for implementing typical quantum optics experiments, as well as to grasp delicate aspects of contemporary research such as innovative technologies, fundamental interest of basic research,..). • **Communicating knowledge and understanding** ○ Know- how to properly expose and master the presentation of topics and problems of quantum optics ○ write a technical report on quantum optics experiments performed in the lab ○ present a topic in the form of a short seminar with slides and practical examples. • **Capacities to continue learning** ○ Know-how on typical experimental techniques in quantum optics ○ Ability to updating knowledge with particular regard to research on entangled states.

Assessment and feedback	
Methods of assessment	Lab report and oral exam
Evaluation criteria	• Knowledge and understanding of the salient elements of quantum optics covered • Knowledge and understanding applied to the creation of experimental apparatus for the study of typical phenomena of quantum optics and their use • Independent judgment in the analysis and interpretation of experimental data • Written and oral communication skills, assessed through the various forms of proposed reports (internal notes, conference presentation, scientific article)
Criteria for assessment and attribution of the final mark	20% lab reports, 80% oral exam (20% for each of the above criteria)

Additional information	