UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

DIPARTIMENTO INTERUNIVERSITARIO DI FISICA

General information		
Academic subject	Condensed Matter Physics	
Degree course	Physics	
Academic Year	1st	
European Credit Transfer and Accumulation System (ECTS)	6	
Language	English	
Academic calendar (starting and ending date)	1st semester, Last week of September – Third week of December	
Attendance	Attending the lectures is strongly recommended. Attending the laboratory sessions is compulsory.	

Professor/ Lecturer	
Name and Surname	Gaetano Scamarcio
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Telephone	080 544 3234
Department and address	Dipartimento Interateneo di Fisica, room 224
Virtual headquarters (Microsoft Teams code)	
Tutoring (time and day)	The students are invited to send an e-mail to arrange a meeting

Syllabus	
Learning Objectives	The main objective of the course is to provide the basis for understanding the main properties of condensed matter and its interaction with radiation in the spectral ranges of vibrational and electronic resonances. In addition to the characteristics of bulk solids, particular attention is paid to the properties of surfaces and interfaces both natural and obtained by epitaxial growth techniques. Special attention is placed in the description of quantization effects (e.g. phonons, plasmons, spin waves) and in the introduction to the physics of laser. A relevant objective is also the hands-on learning of advanced experimental techniques for the study of surface and dielectric properties of solids using research-grade instrumentation such as atomic force microscopy (AFM), scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR).
Course prerequisites	Solid state physics, quantum physics, statistical physics at the level of bachelor degree in physics.
Contents	Order and disorder in condensed matter. Bulk properties of crystals. Fourier analysis and reciprocal lattice. X-ray scattering. Collective effects in solids. The exchange interaction and magnetic order. Magnetic phase transitions. Ferromagnetic domains. Colossal magnetoresistance. Surface structure and crystal growth. Elastic properties of solids. Surface tension in solids. Roughening. Equilibrium crystal shapes. Non-equilibrium crystal growth: molecular beam epitaxy. Experimental methods to measure the structure, the mechanical and electrostatic properties of surfaces with atomic resolution: atomic force microscopy (AFM); scanning electron microscopy (SEM); Reflection high energy electron diffraction (RHEED). Laboratory activity: scanning probe microscopy (AFM). Laboratory activity: scanning electron microscopy (SEM). Classical and quantum waves in solids. Lattice vibrations, acoustic and optical modes in three dimensions. Phonons. Neutron diffraction. Dielectric function and its dispersion. Phonon-polaritons. Plasmons. Spin waves.

	Laboratory activity: Fourier transform infrared spectroscopy (FTIR); mid-infrared reflectivity spectra of relevant semiconductors at variable angle and polarizations; modelling using the complex Fresnel coefficients. The physics of lasers. Spontaneous and stimulated emission. Light-matter interaction. Population inversion. Four-level scheme. Rate equations. Properties of laser beams. Temporal and spatial coherence. Decoherence and dephasing. Homogeneous and inhomogeneous line broadening. Q-switching. Mode-locking. Relevant examples of classes of laser.
Books and bibliography	- L. Sander, “Advanced condensed matter physics”, Cambridge, 2009 - A. E. Siegman, “Lasers”, University Science books, 1986 Suggested readings: - Kittel, "Introduction to Solid State Physics", Wiley, 2005. - N. W. Ashcroft, N. D. Mermin, ”Solid state physics”, Thomson Brooks, 1976.
Additional materials	Lecture notes. Laboratory setups manuals

Work schedule			
Total	Lectures	Hands on (Laboratory, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
Hours			
150	40	15 (laboratory)	95
ECTS			
6	5	1	

Teaching strategy	
	Lectures in the teaching room with the aid of a laptop and a projector or a blackboard. Laboratory activities supervised in research grade setups.

Expected learning outcomes	
Knowledge and understanding on:	• basic and advanced aspects of condensed matter structure • surface structure and related experimental techniques • radiation-matter interaction in solids • physics of lasers
Applying knowledge and understanding on:	• the essential description and the assessment of physical limits of phenomena involving condensed matter or the interaction of light with matter in the condensed state
Soft skills	• **Making informed judgments and choices** ○ ability to describe and quantitatively model relevant structural, vibrational, optical and surface properties of condensed matter. ○ ability to choose suitable experimental methods to measure relevant structural, vibrational, optical and surface properties of condensed matter • **Communicating knowledge and understanding** ○ communication skills in English; ○ skills in the exposition of physical phenomena and experimental results using appropriate scientific language • **Capacities to continue learning** ○ ability to learn and to transfer experimental methods for the assessment of relevant physical properties of matter

Assessment and feedback	
Methods of assessment	
Evaluation criteria	• **Knowledge and understanding** ○ basic principle of condensed matter structure. ○ phenomena supporting present knowledge of condensed matter structure. ○ experimental methods to study the properties of solids and surfaces.

	○ successful models describing the condensed state of matter. • **Applying knowledge and understanding** ○ capability to discuss the interconnection between individual components of solids and related interaction phenomena • **Autonomy of judgment** ○ Identify and compare fundamental physical facts and supporting relevant phenomena • **Communicating knowledge and understanding** ○ Master physics and scientific communication • **Communication skills** ○ Capability of support statements with relevant examples, demonstrating understanding • **Capacities to continue learning** ○ Capability to exploit the achieved knowledge and concepts to further studying advanced physics and technological topics
Criteria for assessment and attribution of the final mark	Oral exam (75%). Laboratory report (25%).
Additional information	