UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Fisica e Chimica - Emilio Segrè		
ACADEMIC YEAR	2022/2023		
MASTER'S DEGREE (MSC)	PHYSICS		
INTEGRATED COURSE	LAB OF PHYSICS OF MATTER		
CODE	22660		
MODULES	Yes		
NUMBER OF MODULES	2		
SCIENTIFIC SECTOR(S)	FIS/01		
HEAD PROFESSOR(S)	AGNELLO SIMONPIETRO	Professore Ordinario	Univ. di PALERMO
OTHER PROFESSOR(S)	MESSINA FABRIZIO AGNELLO SIMONPIETRO	Professore Associato Professore Ordinario	Univ. di PALERMO Univ. di PALERMO
CREDITS	6		
PROPAEDEUTICAL SUBJECTS			
MUTUALIZATION			
YEAR	2		
TERM (SEMESTER)	1° semester		
ATTENDANCE	Not mandatory		
EVALUATION	Out of 30		
TEACHER OFFICE HOURS	**AGNELLO SIMONPIETRO** Monday 12:30 13:30 Dip.to Fisica e Chimica Via Archirafi 36 Studio Docente Wednesday 12:30 13:30 Dip.to Fisica e Chimica Via Archirafi 36 Studio Docente **MESSINA FABRIZIO** Tuesday 16:00 17:00 DiFC - Emilio Segre. Via Archirafi 36, Studio del docente. Gli studenti sono pregati di concordare in anticipo l'orario preciso dell'incontro via email (fabrizio.messina@unipa.it). Friday 16:00 17:00 DiFC - Emilio Segre. Via Archirafi 36, Studio del docente. Gli studenti sono pregati di concordare in anticipo l'orario preciso dell'incontro via email (fabrizio.messina@unipa.it).		

DOCENTE: Prof. SIMONPIETRO AGNELLO

PREREQUISITES	Solid knowledge of the basics of classical physics and quantum mechanics. In particular: classical methods of optics and electromagnetism, fundamentals of spectroscopy, knowledge of Hamiltonians and energy levels of an atomic and molecular system, basic knowledge of the structure of matter, fundamentals of radiation-matter interaction processes, standard methodologies for the analysis and processing of data laboratory and associated errors.
LEARNING OUTCOMES	Knowledge and understanding: Learning of specific spectroscopic methodologies widely used in matter physics: Raman spectroscopy, electron paramagnetic resonance spectroscopy, time resolved photoluminescence spectroscopy, femtosecond optical spectroscopy. Applications to the study of simple physical systems. Development of the ability to perform spectroscopic measurements independently, to analyze the data obtained, to interpret and comment on the results basing on the theoretical knowledge and the ability to produce laboratory reports. Ability to apply knowledge and understanding: The laboratory experiences allow students to achieve a level of autonomy sufficient for the conscious use of laboratory equipment on a variety of physical systems. Autonomy of judgment: Critical ability to independently choose the best experimental conditions for acquiring the measurements. Ability to autonomously interpret the experimental results obtained. Communication skills: Ability to illustrate the methods of measurement, to explain the result of the laboratory activity, and to comment on the experiments carried out on a physical basis using written reports and oral description. Learning skills: Being able, on the basis of the skills acquired during the course, to plan, prepare, analyze and interpret experiments and to analyze the experimental results obtained in order to obtain relevant information for understanding the microscopic properties of the investigated materials.
ASSESSMENT METHODS	The final test consists in the preparation of reports concerning the experiments carried out by the student in the laboratory and in an oral test. The laboratory report typically contains a description of the experimental setups used, a description of the experiments performed, the analysis of the data collected and finally a discussion on the data obtained and their interpretation. The experiments and related reports are typically carried out in groups of three students, in order to exercise the critical discussion of the results obtained. The oral test consists of an interview in which the candidate is asked to present and discuss the laboratory reports, demonstrate knowledge of the theoretical contents covered during the course, also relating them to the experimental activity carried out. This test allows to evaluate, in addition to the candidate's knowledge and ability to apply them, also the possession of scientific language properties and clear and direct exposure skills. The final evaluation, suitably graded, will be formulated as follows: a) Basic knowledge of the theoretical foundations of the experimental techniques being taught, a sufficient degree of awareness and autonomy in illustrating the activities carried out in the laboratory and described in the reports (18-22); b) Good knowledge of the theoretical foundations of the experimental techniques being taught, a fair degree of awareness and autonomy in the illustration of the activities carried out in the laboratory and described in the reports (23-26); c) In-depth knowledge of the theoretical foundations of the experimental techniques being taught, a good degree of awareness and autonomy in the illustration of the activities carried out in the laboratory and described in the reports (27-30 cum laude);
TEACHING METHODS	The course is in a semester and is divided into two distinct modules. It includes lectures (2 CFU) and laboratory experiences (4 CFU). The first are intended to give basic theoretical and technical knowledge aimed at understanding the experiences that follow. The laboratory activities, on the other hand, have the purpose of introducing students to the use of advanced spectroscopic techniques and making them aware of the potential of these techniques, through the execution of experiments in prototype samples. The first module (MODULE: Time-resolved spectroscopy laboratory; Prof. Fabrizio Messina) is dedicated to optical spectroscopy techniques, such as time-resolved fluorescence and femtosecond pump/probe spectroscopy, while the

	second module (MODULE: Laboratory of Raman and Electronic Paramagnetic Resonance spectroscopy; Prof. Simonpietro Agnello) focuses on vibrational spectroscopy with Raman technique and electronic paramagnetic resonance spectroscopy.

MODULE
LAB OF TIME-RESOLVED SPECTROSCOPY

Prof. FABRIZIO MESSINA

SUGGESTED BIBLIOGRAPHY

Testi base:
Agnello S., Ed., Spectroscopy for Materials Characterization, JohnWiley&Sons, Inc. (2021). ISBN: 978-1-119-69805-0

Testi di approfondimento:
“Femtosecond laser pulses: Principles and Experiments”, C. Rullière, Springer, 2005. ISBN: 978-0-387-26674-9

AMBIT	20901-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	35
COURSE ACTIVITY (Hrs)	40

EDUCATIONAL OBJECTIVES OF THE MODULE

Familiarizing with some of the most important spectroscopic methods used for the characterization of materials and nanomaterials, with particular reference to time-resolved spectroscopy on the nanosecond, picoscond and femtosecond time scales. Understanding of the main underlying physical principles, and of the theoretical background necessary to interpret experimental data.

SYLLABUS

Hrs	Frontal teaching
2	CW, pulsed and mode-locked lasers. Introduction to nonlinear optics. Propagation of ultrashort pulses.
2	Radiative and non-radiative decay of a photoexcited system. Time-resolved photoluminescence. Experimental methods for the analysis of excited-state depopulation.
4	Ultrafast spectroscopy: introduction and main techniques. Transient absorption measurements with a pump/probe approach. Techniques to measure fluorescence with picosecond and femtosecond time resolution.

Hrs	Workshops
16	Time-resolved fluorescence experiments on the nanosecond time scale. Separation of different photoluminescence bands based on their different excited-state depopulation kinetics. Experimental estimates of lifetimes and externally-induced changes in lifetime. Reduction, analysis and interpretation of the experimental data.
16	Transient absorption measurements by pump/probe measurements on the femtosecond time scale. Observation of ultrafast dynamics in photoexcited systems. Reduction, analysis, and interpretation of the data.

MODULE
LAB OF RAMAN SPECTROSCOPY AND PARAMAGNETIC RESONANCE

Prof. SIMONPIETRO AGNELLO

SUGGESTED BIBLIOGRAPHY

Testi base:
Agnello S., Ed., Spectroscopy for Materials Characterization, JohnWiley&Sons, Inc. (2021). ISBN:9781119697329

Testi di Approfondimento
- John R. Ferraro, Kazuo Nakamoto and Chris W. Brown, Introductory Raman Spectroscopy, Elsevier (2003). ISBN 0-12-254105-7
- J. A. Weil, J. R. Bolton and J. E. Wertz, Electron Paramagnetic Resonance, Wiley (1994). ISBN 978-0471-75496-1

AMBIT	20901-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	35
COURSE ACTIVITY (Hrs)	40

EDUCATIONAL OBJECTIVES OF THE MODULE

Possess a good knowledge of some of the main spectroscopic techniques used in the investigation of materials and nanomaterials, of the physical principles underlying these techniques, and of the theoretical references necessary for the interpretation of the data obtained. In addition to these specific objectives, the course aims to contribute to achievement of the more general educational objectives set out in the didactic regulations of the master's degree in Physics.

SYLLABUS

Hrs	Frontal teaching
2	ELECTRONIC PARAMAGNETIC RESONANCE: Description of the classical motion of the magnetic moment in resonance conditions. Introduction and solution of the Bloch equations. Dispersion and Absorption curves in resonance. Homogeneous and inhomogeneous broadening factors. Rate equations for a two-level system.
2	Anisotropic Zeeman interaction and hyperfine interaction. Effects of the symmetry of the paramagnetic center on the properties of the factor of spectroscopic splitting g. EPR linshape for solid systems (powder and amorphous). Description of the operating principle of the electronic magnetic resonance spectrometer and its components.
4	RAMAN SPECTROSCOPY: Elastic and inelastic scattering. Molecular vibrations and polarizability. Classic and semiclassical treatment of the Raman effect. Raman microscopy. Description and principle of operation of a Raman spectrometer

Hrs	Workshops
16	Acquisition and study of electronic magnetic resonance (EPR) spectra of materials of interest to the physics of matter through the use of a EPR spectrometer. Observation of the line shapes. Reduction, analysis and interpretation of the obtained data.
16	Acquisition of Raman spectra through a dispersion spectrometer of samples of interest for the physics of matter. Identification of vibrational characteristics and spatial resolution. Reduction, analysis and interpretation of the obtained data.