COURSE OF STUDY PHYSICS

ACADEMIC YEAR 2023/24

ACADEMIC SUBJECT ADVANCED QUANTUM FIELD THEORY

General information	
Year of the course	II
Academic calendar (starting and ending date)	I Semester
Credits (CFU/ETCS):	3
SSD	FIS/02
Language	English
Mode of attendance	Free

Professor/ Lecturer	
Name and Surname	Alessandro Mirizzi
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Telephone	
Department and address	Dipartimento Interateneo di Fisica, Via Amendola 173
Virtual room	
Office Hours (and modalities: e.g., by appointment, on line, etc.)	On request. In presence or online

Work schedule			
Hours			
Total	Lectures	Hands-on (laboratory, workshops, working groups, seminars, field trips)	Out-of-class study hours/ Self-study hours
117	16	15	86
CFU/ETCS			
3	2	1	

Learning Objectives	Knowledge of the most advances methods of quantum field theory
Course prerequisites	Basics of quantum field theory

Teaching strategie	Lectures/exercise classes in the classroom
Expected learning outcomes in terms of	
Knowledge and understanding on:	○ Consolidation of the knowledge in Quantum Field Theory and of the applications in particle physics and in condensed matter.
Applying knowledge and understanding on:	○ Ability in modelling phenomena in particle physics and in condensed matter through techniques of advanced quantum field theory.
Soft skills	• *Making informed judgments and choices* ○ Development of a critical spirit to distinguish the relevant aspects from the marginal ones in the problems studied. Verify assumptions and approximations • *Communicating knowledge and understanding* ○ Development of adequate skill in communicating

	scientific topics • *Capacities to continue learning* Ability is searching bibliographical references, in using (online) databases, and online material
Syllabus	
Content knowledge	1. *Quantum field theory in condensed matter.* Many body theory. Superfluidity. Quasi-particles. Superfluid Lagrangian. Superconductivity. BCS Theory. 2. *Symmetries and Symmetry Breaking.* Spontaneous symmetry breaking. Goldstone theorem. Higgs mechanism in condensed matter and particle physics. 3. *Topological objects in quantum field theory.* Solitons. Monopoles. Instantones. 4. *Phonons and their interactions.* Quantization of free phonon field. Interactions and interaction scheme. Phonon propagator. Perturbation theory. Feynman diagrams. 5. *Fractional statistics.* Topology. Anyons. Chern-Simons action. Integer and fractional quantum Hall effect. Elements of dual theories. 6. *Renormalization.* Introduction to renormalization and renormalization group.
Texts and readings	1. A. Zee, *"Quantum Field Theory in a Nutshell,"* Princeton University Press. 2. Chetan Nayak, Dispense su *"Quantum Condensed Matter Physics".* 3. Gerard't Hooft *"Monopoles, Instantons and Confinement",* arXiv:hep-th/0010225.
Notes, additional materials	
Repository	

Assessment	
Assessment methods	Oral exams on topic treated during the lectures
Assessment criteria	• *Knowledge and understanding* ○ Knowledge of advanced theoretical foundation of quantum field theory • *Applying knowledge and understanding* ○ Use the acquired knowledge to solve problems of advanced quantum field theory • *Autonomy of judgment* ○ Developing physical and mathematical tools to properly model physical problems relative to complex quantum systems • *Communicating knowledge and understanding* ○ Express in a proper way physical and mathematical concepts characterizing

	advanced quantum field theory
	• *Communication skills*
	  ○ Acquire an appropriate rigorous language to communicate science
	• *Capacities to continue learning*
	  Develop mathematical and physical tool to model physical problems

Final exam and grading criteria	Clarity in the oral exposition of the physical concepts.
Further information	
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