

**COURSE OF STUDY** *Physics (LM-17)*
**ACADEMIC YEAR** 2023-2024

**ACADEMIC SUBJECT** *Advanced Quantum Field Theory*

General information	
Year of the course	2nd
Academic calendar (starting and ending date)	1st semester: September - December 2023
Credits (CFU/ECTS):	3
SSD	FIS/02
Language	English
Mode of attendance	Compulsory

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
75	16	15	44
CFU/ECTS			
3	2	1	

<b>Learning Objectives</b>	Knowledge of the most advanced methods of quantum field theory
<b>Course prerequisites</b>	Basics of quantum field theory

<b>Teaching strategie</b>	Lectures/exercise classes in the classroom
<b>Expected learning outcomes in terms of</b>	
<b>Knowledge and understanding on:</b>	<ul style="list-style-type: none"> <li>o Consolidation of the knowledge in Quantum Field Theory and of the applications in particle physics and in condensed matter.</li> </ul>
<b>Applying knowledge and understanding on:</b>	<ul style="list-style-type: none"> <li>o Ability in modelling phenomena in particle physics and in condensed matter through techniques of advanced quantum field theory.</li> </ul>
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>• <i>Making informed judgments and choices</i> <ul style="list-style-type: none"> <li>o Development of a critical spirit to distinguish the relevant aspects from the marginal ones in the problems studied. Verify assumptions and approximations</li> </ul> </li> <li>• <i>Communicating knowledge and understanding</i> <ul style="list-style-type: none"> <li>o Development of adequate skill in communicating scientific topics</li> </ul> </li> <li>• <i>Capacities to continue learning</i></li> </ul>

	Ability is searching bibliographical references, in using (online) databases, and online material
<b>Syllabus</b>	
<b>Content knowledge</b>	<ol style="list-style-type: none"> <li>1. <i>Quantum field theory in condensed matter</i>. Many body theory. Superfluidity. Quasi-particles. Superfluid Lagrangian. Superconductivity. BCS Theory.</li> <li>2. <i>Symmetries and Symmetry Breaking</i>. Spontaneous symmetry breaking. Goldstone theorem. Higgs mechanism in condensed matter and particle physics.</li> <li>3. <i>Topological objects in quantum field theory</i>. Solitons. Monopoles. Instantones.</li> <li>4. <i>Phonons and their interactions</i>. Quantization of free phonon field. Interactions and interaction scheme. Phonon propagator. Perturbation theory. Feynman diagrams.</li> <li>5. <i>Fractional statistics</i>. Topology. Anyons. Chern-Simons action. Integer and fractional quantum Hall effect. Elements of dual theories.</li> <li>6. <i>Renormalization</i>. Introduction to renormalization and renormalization group.</li> </ol>
<b>Texts and readings</b>	<ol style="list-style-type: none"> <li>1. A. Zee, <i>“Quantum Field Theory in a Nutshell,”</i> Princeton University Press.</li> <li>2. Chetan Nayak, Dispense su <i>“Quantum Condensed Matter Physics”</i>.</li> <li>3. Gerard't Hooft <i>“Monopoles, Instantons and Confinement”</i>, arXiv:hep-th/0010225.</li> </ol>
<b>Notes, additional materials</b>	
<b>Repository</b>	

<b>Assessment</b>	
Assessment methods	Oral exams on topic treated during the lectures
Assessment criteria	<ul style="list-style-type: none"> <li>• <i>Knowledge and understanding</i> <ul style="list-style-type: none"> <li>o Knowledge of advanced theoretical foundation of quantum field theory</li> </ul> </li> <li>• <i>Applying knowledge and understanding</i> <ul style="list-style-type: none"> <li>o Use the acquired knowledge to solve problems of advanced quantum field theory</li> </ul> </li> <li>• <i>Autonomy of judgment</i> <ul style="list-style-type: none"> <li>o Developing physical and mathematical tools to properly model physical problems relative to complex quantum systems</li> </ul> </li> <li>• <i>Communicating knowledge and understanding</i> <ul style="list-style-type: none"> <li>o Express in a proper way physical and mathematical concepts characterizing advanced quantum field theory</li> </ul> </li> <li>• <i>Communication skills</i> <ul style="list-style-type: none"> <li>o Acquire an appropriate rigorous language to communicate science</li> </ul> </li> <li>• <i>Capacities to continue learning</i> <ul style="list-style-type: none"> <li>o Develop mathematical and physical tool to model physical problems</li> </ul> </li> </ul>
Final exam and grading criteria	Clarity in the oral exposition of the physical concepts.
<b>Further information</b>	