PHYSICS

PNRR/NQSTI - Theory of quantum devices based on topological materials

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014]
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Context of the research activity	The research area is Theoretical Physics of Matter, with a focus on Quantum Physics, and it involves various aspects of Condensed Matter Physics, Statistical Physics, Quantum Information, Field Theory. The Ph.D. fellowship is partly financed by the project “Topological Material platform for the implementation of Andreev spin qubits”, CUP E13C24001560001, funded by the Bando a Cascata call issued by Scuola Normale Superiore di Pisa as the Spoke 5 of the National Quantum Science and Technology Institute (NQSTI), PE0000023 of the "Piano Nazionale di Ripresa e Resilienza" (PNRR), Mission 4 “Istruzione e Ricerca” – Component 2 “Dalla ricerca all’impresa” – Investment 1.3 "Partenariati estesi a Università, centri di ricerca, imprese e finanziamento progetti di ricerca", financed by the European Union – NextGenerationEU - Avviso n. 341 del 15.03.2022 Partenariati Estesi - emanato con Decreto Direttoriale 15 marzo 2022
	The objective of the project is to provide a theoretical description of the electronic states of topological materials, such as topological insulators and Weyl semimetals, in order to understand whether and how their topological protection against perturbations can be exploited to design novel and high performance quantum devices. Specifically, we shall investigate the elementary quantum phenomena emerging when topological materials and superconductors are contacted, and determine how the topological features affect the resulting Andreev reflection and Josephson effect. Further fundamental aspects, such as the interaction of the electronic states with electromagnetic fields and/or with the environment shall be considered, in order to design novel and realistic quantum devices that are tunable and robust to decoherence. The theoretical work will be developed taking also into account the advances of the related experimental groups working in the field. The research topic has a

Objectives	significant overlap with various other fields of the quantum world, such as the realization of robust qubits to encode and manipulate quantum information, or the reduction of energy waste in nanodevices by harnessing quantum thermoelectric effects. For these reasons, the project represents a unique opportunity for a Ph.D. student to broaden the spectrum of her/his knowledge by addressing challenging questions. The Ph.D. student is expected to actively contribute to the realization of the project with ideas and proposals, combining analytical and numerical methods, and to be involved in the activities of the Nanophysics and Quantum Systems group at DISAT. The fellowship involves also funds for collaborations with the NQSTI centers and with other research institutions abroad.

Skills and competencies for the development of the activity	The candidates should have a solid background in Quantum Mechanics, Statistical Physics and Condensed Matter Physics. A strong interest in both analytical calculations and programming is necessary.