PHYSICS

PNRR/NQSTI - Theory and simulation of solid state spin qubits

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Dipartimento DISAT
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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
Objectives	The project aims to formulate and investigate models of electronic quantum devices based of novel materials, in order to design new implementations of spin qubits, to manipulate the qubit quantum states, and to minimize the decoherence effects from the environment. Thus, it involves a balance between fundamental questions in quantum physics and their applications to quantum technologies. Specifically, we shall investigate whether and how the non-trivial spin-texture emerging in some novel materials, such as topological materials, can be exploited to design a spin qubit. Indeed electron spin is expected to be more robust to decoherence effects than the charge degree of freedom. The coupling of the spin qubit with the electromagnetic radiation will be investigated to control and manipulate the quantum state of the spin qubit, while the theory of open quantum systems will be exploited to determine the decoherence effects from the spin environment. The research topic has a significant overlap with various other fields of the quantum world, such as the

	use of spin qubits as quantum thermal machines, and the realization of spin entangled states by interfacing the spin-textured topological materials with superconductors. 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.