Politecnico di Torino

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

PHYSICS

MUR DM 118 - Light-Matter Interaction in Topological Semimetals

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Dipartimento DISAT

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Context of the research activity	Topological materials are special classes of superconductors, insulators or semimetals, identified by their band structure and their protected surface states. The recently-discovered topological Weyl and Dirac semimetals, in particular, are object of huge interest in the scientific community because of the high carrier mobility and the characteristic responses to electric and magnetic fields, which follow from their band structure. The latter is believed to generate the colossal photovoltaic effect observed in this class of materials [1,2,3], as well as a number of photoinduced effects [4,5,6], with technological applications ranging from energy and frequency conversion to sensing and production of clean energy. [1] Lv et al., "Observation of Weyl nodes in TaAs", Nat. Phys. 11, 724 (2015). [2] de Juan et al., "Quantized circular photogalvanic effect in Weyl semimetals", Nature Communications 8, 1 (2017). Chan et al. "Photocurrents in Weyl semimetals", Phys. Rev. B 95, 041104 (2017). [3] Osterhoudt et al. "Colossal mid-infrared bulk photovoltaic effect in a type-I Weyl semimetal", Nature Materials 18, 471 (2019). [4] Takasan et al. "Current-induced second harmonic generation in inversion-symmetric Dirac and Weyl semimetals", Physical Review B 104, 16 (2021). [5] Wu et al., "Giant anisotropic nonlinear optical response in transition metal monopnictide Weyl semimetals", Nat. Phys. 13, 350 (2017). [6] Nathan et al., "Topological frequency conversion in Weyl semimetals" Phys. Rev. Research 4, 043060 (2022) Progetto finanziato nell'ambito del PNRR - DM 118/2023 - CUP E14D23001640006

Objectives	The research will focus on transport phenomena in innovative topological materials, with attention to light-induced phenomena in Weyl and Dirac Semimetals. Using the analytical tools of Quantum Mechanics and Quantum Field Theory, complemented by numerical calculations, the student will investigate effective low-energy Hamiltonian describing generation and manipulation of currents in this class of materials. The fellowship is in collaboration with the Institute of Theoretical Physics of the Heinrich-Heine University of Düsseldorf, Germany (https://www.physik.hhu.de/en/institutes-and-research-groups/translate-to-english-quantenphysik) and the Research Centre in Mathematics of City, University of London, UK (https://researchcentres.city.ac.uk/research-centre-in-mathematics/mathematical-physics). Within the Department of Applied Science and Technology (DISAT for friends), the student will attend graduate courses and perform research in contact with a broad variety of specializations - including analytical, numerical and experimental techniques - and backgrounds - including Condensed Matter Theory, Statistical Physics, Material Science and Chemical Physics. In addition, (s)he will spend an extended period in the two partner institutions (with increased salary), perform research in contact with established international scientific networks and learn the techniques of scientific communication. The formation of an individual with specialized knowledge of innovative materials will introduce on the job market a figure of clear interest for the research and development sections of commercial enterprises in the field of sensor technology, laser devices and clean energy production. Progetto finanziato nell'ambito del PNRR, Intelligence Research (FAIR) - CUP E13C22001800001 PNRR M4C2, Investimento 1.3 - Avviso n. 341 del 15/03/2022 - PE0000021 Network 4 Energy Sustainable Transition (NEST) - CUP E13C22001890001

Skills and competencies for the development of the activity	M.Sc. (Laurea Magistrale) in Physics, previous knowledge of Quantum Mechanics, Quantum Field Theory, Solid State Physics, Mathematical Methods in Physics.