Politecnico di Torino

Finanziato dall'Unione europea NextGenerationEU

PHYSICS

Advanced Experimental Physics of Matter

Funded By	Ministero dell'Università e della Ricerca - MUR [P.iva/CF:96446770586]
Supervisor	GLIOZZI ANTONIO - antonio.gliozzi@polito.it
Contact	DESCROVI EMILIANO - emiliano.descrovi@polito.it DI FABRIZIO ENZO MARIO - enzo.difabrizio@polito.it GIORGIS FABRIZIO - fabrizio.giorgis@polito.it GONNELLI RENATO - renato.gonnelli@polito.it
Context of the research activity	The applicants have the possibility to choose one of the following topics: T1: Single-Photon sources based on 2D materials for quantum nano-optics applications T2: Impact of heavy metals intercalating on DNA (in humans, soils and plants) on the life and food cycle. T3: Lab-on-chip platforms with active plasmonic nanostructures for qualitative and quantitative ultrasensitive analyses of contaminants in agri-food matrices T4: Development of new 2D superconductors for advanced quantum technologies via ionic gating and intercalation.
	The research activities foreseen by the four topics listed above involve an experimental approach, together with data analysis and modelling of the involved physical phenomena. They all fit into the M4C2 component of the National Recovery and Resilience Plan (NRRP) of the Italian Government, and concern the topics “Quantum science and Technologies” and “Precision Agriculture technologies devoted to Food Security” mentioned in NRRP. T1: This project involves the exploration of new concepts for the design, fabrication and characterization of active nanophotonic devices emitting structured light in single-photon regime. Among the big family of structured light fields, Vortex Beams represent an important instance of optical radiation carrying Orbital Angular Momentum (OAM), i.e. a vorticity, during propagation. In this framework, monolithic nanophotonic devices for Structured Light emission in free-space, operating in single-photon regime under optical pumping are highly desired for optical (quantum) communication applications. The activity is focused on the precise integration of Single-Photon (SP) sources such as colloidal quantum dots and point-defects in hexagonal Boron Nitride flakes on dielectric nanophotonic platform able to outcouple SP OAM emission in free-space at room temperature. The

Objectives	expected work will be computational, technological (clean room fabrication) and experimental, in the lab. T2: This topic aims to study, with physical methods, the direct (bond) and indirect (structural variation) effects of intercalating molecules on DNA, in order to understand, at the molecular level, the mechanisms of interaction or a wide category of molecules and metal complexes with DNA, and their binding energy. The student will be involved in an experimental activity that combines: i) micro and nanoRaman spectroscopy based on Atomic Force Microscopy with nanometric spatial resolution, ii) single beam resonant vibrometry of DNA bundle (consisting of a few double helices) and iii) TEM imaging of DNA-intercalant construct. The suspended DNA bundle is a vibrating nanostructure and can be considered the smallest mechanical resonator entirely composed of DNA. A correlative analysis between mechanical and structural properties can highlight the intrinsic changes of the double strand of DNA as a function of the different intercalant molecules. The study also aims at seeking a quantitative assessment of the presence of heavy metals in soils with low, medium and high levels of pollution, and their effect on food chain. T3: The objective of the research concerns the study and development of microfluidic chips integrating Raman-active metal-dielectric nanostructures aimed to perform quantitative analyses of contaminants (aflatoxins and several kinds of antibiotics) in agri-food matrices (such as milk, eggs, honey…). The micro/optofluidic chips will be optimized to achieve extremely low Limits of Detection and high dynamic measurement ranges, and adapted for use on portable spectrometers to allow in-field analyses. The student will be involved in all the following experimental activities: i) synthesis of plasmonic nanomaterials, ii) fabrication of the microfluidic modules (Lab-on-chip, LOC), iii) LOC application in Surface Enhanced Raman Spectroscopy (SERS), iv) spectroscopic data analysis for the ultrasensitive characterization of the molecular complexes. The experimental findings will be corroborated by optical modeling. He or she will share the activities with other researchers belonging to an interdisciplinary team, will author the papers, will participate in international conferences. T4: The family of new 2D and layered materials, which display a variety of easily tunable properties, offers an unprecedented possibility to predict and realize new superconductors, easily integrable into existing platforms and with the desired properties for real technological applications (from quantum computing to energy transport and storage). The research of this topic will be focused on the modulation of the electrical properties of 2D and layered systems by means of ionic gating and permanent field-effect-driven intercalation with hydrogen or other ions (i.e. alkaline metals, organic molecules). Guided by a computational ab-initio approach, this study will aim at the discovery and characterization of new 2D/layered superconducting materials that could ensure a leap forward in technological applications of superconductors. The research involves different disciplines like solid-state physics, material science and electrochemistry. The student will be in charge of the gating experiments, of the characterization of the materials, of the data analysis. ab-initio Density Functional Theory calculations on solid-state materials can be foreseen as an optional part of the work.

	All the topics require experimental skills, fundamental knowledge of Physics and Condensed Matter Physics, capabilities of analytical and critical

Skills and competencies for the development of the activity	reasoning, team working and problem solving. Specific competencies preferentially required for each topic are: T1: condensed matter physics, optics, nanotechnology T2: optics, spectroscopy, basic biology T3: optical spectroscopy, electronic and probe microscopy, nanofabrication technologies T4: condensed matter physics, cryogenics, superconductivity (optional: DFT calculations)