Corso di dottorato in Fisica / PhD in Physics
Ciclo 38 / Cycle 38 – Second Call
A.Y. 2022-2023

Borse a tematica vincolata / Reserved scholarships

A - Molecular astrophysics: challenging reactivity beyond the second period elements via ion-molecule reactions
B - MIMOSA 1 - Incorporamento di materiali biologici in matrici di silice mediante simulazioni di dinamica molecolare classica / Embedding of biological materials in silica matrices by classical Molecular Dynamics simulations
C - MIMOSA 2 - Microscopia 4D di materiali biologici mediante sorgenti terahertz a impulsi brevi / 4D Microscopy of biological materials by short pulse terahertz sources
D - Quantum Algorithms with Tensor Networks (QATN)
E - QUANtum optics around Exceptional Points (QUANEP)
F - Verification of the QUantum theory of MAgnetoREception in a new animal model, a biological magnetic sensor (QUMARE)

Scholarship A

PhD Scholarship Title	Molecular astrophysics: challenging reactivity beyond the second period elements via ion-molecule reactions
Research group link	
Contacts.:	Daniela Ascenzi, lab. FAM, Ines Mancini, lab. Chimica Bioorganica Paolo Tosi
Synthetic description of the activity and expected research outcome	The number of molecules detected in space is increasing at a fast pace thanks to the improved sensitivities of telescopes. The presence of complex molecules in regions with extreme temperature and pressure conditions is a great challenge to the comprehension of chemical reactivity. By using an interdisciplinary approach (physics/chemistry/astronomical observations) the project aims at unveiling the formation routes of molecules containing atoms beyond the second period of the Periodic Table (e.g. S, P, Si and Cl). The research will focus on the reactivity of charges species with neutrals using guided ion beam mass spectrometry (also carried out at SOLEIL synchrotron radiation facility). Contact: Daniela Ascenzi (daniela.ascenzi@unitn.it)
Ideal candidate (skills and competencies):	

Scholarship B

Topic:	MIMOSA 1 - Embedding of biological materials in silica matrices by classical Molecular Dynamics simulations
Research group link	- Statistical and Biological Physics (SBP) group (UniTN) - ECT* (FBK)
Contacts.:	Gianluca Lattanzi, Simone Taioli
Synthetic description of the activity and expected research outcome	The studentship is fully funded by the MIMOSA project in the frame of the HORIZON EIC 2021 PATHFINDER OPEN Europe Programme. The ultimate goal of MIMOSA is to provide an alternative to tomography at the nanoscale with a high chemical resolution for biological and medical systems, based on Tomographic Atom Probe. The specific task of this studentship is to develop numerical methods to study the embedding of model proteins in the silica matrix, by extensive classical molecular dynamics simulations, to give inputs to the experimental procedure in terms of pH, concentration, and temperature. The embedding methods will then be applied to relevant medical sample such as several kinds of liposomes. The unique property of silica, being an amorphous material, is its ability to replace water without significantly influencing the role of the replaced water. The balance of electrostatic interactions, Van der Waals forces, hydrogen bonding and hydrophobic interactions are retained during the sol-gel process resulting in preserved protein structures.
Ideal candidate (skills and competencies):	- MSc. in Chemistry, Physics, Materials Science or a related subject with a strong background in computational and/or theoretical methods. Experience of the use of molecular dynamics codes is preferred. - The candidate is expected to have a strong commitment to research, good programming skills (e.g., Fortran, C, Python), and the ability to translate physics/chemistry/math concepts to computer programs effectively. - The candidate must be able to work independently and as part of a team. - Self-motivation and an excellent work ethic are also essential for this post. - Good interpersonal, organizational, and communication skills are desirable to ensure efficient working within the wider team.

Scholarship C

Topic:	MIMOSA2 - 4D Microscopy of biological materials by short pulse terahertz sources
Research group link	- ECT* (FBK) - Statistical and Biological Physics (SBP) group (UniTN)
Contacts.:	Gianluca Lattanzi, Simone Taioli
Synthetic description of the activity and	The studentship is fully funded by the MIMOSA project in the frame of the HORIZON EIC 2021 PATHFINDER OPEN Europe Programme.

expected research outcome	The ultimate goal of MIMOSA is to provide an alternative to tomography at the nanoscale with a high chemical resolution for biological and medical systems, based on Tomographic Atom Probe. The specific task of this studentship is to provide theory and modeling expertise to the experimental partners of MIMOSA, in particular: i) to understand the physics underlying THz radiation/biological matter interactions in the strong-field regime; ii) to investigate the electronic structure and optical properties of model proteins, also embedded in a silica matrix, under intense static and THz dynamic electromagnetic fields using ab-initio and concurrent approaches.
Ideal candidate (skills and competencies):	- MSc. in Chemistry, Physics, Materials Science, or a related subject with a strong background in many-body computational and theoretical methods. Experience of the use of molecular dynamics and electronic structure codes is preferred. - The candidate is expected to have a strong commitment to research, good programming skills (e.g., Fortran, C, Python), and the ability to translate physics/chemistry/math concepts to computer programs effectively. - The candidate must be able to work independently and as part of a team. - Self-motivation and an excellent work ethic are also essential for this post. - Good interpersonal, organizational, and communication skills are desirable to ensure efficient working within the wider team.

Scholarship D

PhD Scholarship Title	Quantum Algorithms with Tensor Networks (QATN)
Research group link	https://webapps.unitn.it/du/it/Persona/PER0016084/Pubblicazioni
Contacts.:	Alessandro Roggero a.roggero@unitn.it
Synthetic description of the activity and expected research outcome	Propelled by the amazing experimental advances in the construction of quantum computing devices containing tens to hundred qubits and fully controllable operations, the theoretical research in the design of advanced quantum algorithms for many-body simulations has seen a tremendous growth in recent years. Yet, a full-scale implementation of the most advanced techniques is still not feasible on today's quantum technology. The main goal of this project is to implement a number of advanced techniques designed to be executed on scalable quantum architectures using tensor network methods and test their efficacy on realistic many-body problems. This will open the possibility of exploring the practical advantages of asymptotically optimal algorithms on real problems but has also the potential of leading to more efficient tensor network schemes on their own. The role of entanglement and it's time-dependence will play a pivotal role in these explorations.
Ideal candidate (skills and competencies):	Passion for computational approaches to many-body physics, some expertise in tensor network techniques and/or quantum algorithms for many-body simulations and willingness to learn new methods. Some knowledge of nuclear physics/astrophysics will also be helpful.

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Scholarship E

PhD Scholarship Title	Quantum optics around Exceptional points (QUANEP)
Research group link	http://nanolab.physics.unitn.it/
Contacts.:	Stefano Biasi (stefano.biasi@unitn.it) Lorenzo Pavesi (lorenzo.pavesi@unitn.it) Iacopo Carusotto (iacopo.carusotto@unitn.it)
Synthetic description of the activity and expected research outcome	Non-Hermitian physics has found a fertile ground in optics. Indeed, modeling natural phenomena often requires description in terms of open systems. As a result, the energy can be exchanged with the environment and a purely Hermitian description is no longer valid. A radical difference between Hermitian and non-Hermitian systems arises in the presence of the degeneracies. In the first case, the degeneracies are called diabolic points while in the second one, they are called exceptional points. Precisely close to these exceptional points counterintuitive phenomena occur. From the quantum point of view, the description of systems through non-Hermitian Hamiltonians is complex because energy and probability are not conserved. However, there is a special case of non-Hermitian Hamiltonians that satisfy PT-symmetry where the energy exchange is strictly balanced. Consequently, the energy is conserved, and the eigenvalues are real quantities. The breaking of this symmetry is generally associated with the presence of exceptional points. However, from the quantum point of view, the breaking of PT-symmetry is still an open problem. In this project, we want to leverage our knowledge on non-Hermitian optical structures in the classical domain to study them in the quantum domain. The student will develop both theoretical and experimental skills on non-Hermitian physics. Thus, they will be involved in both theoretical and laboratory activities. The project will run through three main steps: i) demonstrating that high-sensitivity sensors can be obtained by exploiting non-Hermitian systems working on an exceptional point; ii) engineering a two-dimensional array to experimentally demonstrate a quantum spin-Hall topological laser insulator; iii) designing a topology of coupled microresonators with gain and loss to study the PT-symmetry breaking at the microscopic level. The project will not only attempt to answer fundamental physics questions but also to determine the performance of systems in particular applications such as sensing or lasing. Thus, the knowhow following from this study will provide the basis for an implementation of integrated circuits capable of exploiting the counterintuitive properties of exceptional points on quantum devices.
Ideal candidate (skills and competencies):	The ideal candidate should have a good understanding of quantum mechanics. Furthermore, they should not only have an excellent theoretical background but also a very good attitude toward experimental activities in the laboratory.

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Scholarship F

PhD Scholarship Title	Experimental testing of the quantum theory of magnetoreception in an insect model, a biological magnetic sensor (QUMARE)
Research group link	https://r.unitn.it/en/cimec/nphys
Contacts.:	Albrecht Haase albrecht.haase@unitn.it
Synthetic description of the activity and expected research outcome	The project aims to test one of the most prominent models in quantum biology, animal magnetoreception through the mechanism of entangled radical pairs. Experimental setups will be constructed to test honey bees, known to be sensitive to the geomagnetic field, in behavioural experiments and for the first time via in vivo brain imaging while exposed to magnetic stimuli. Neuronal responses will be linked to quantitative predictions from recent theoretical models. The project is a collaboration between the Neurophysics group at the University of Trento, the CNR Institute of Materials for Electronics and Magnetism (IMEM), and the Quantum Biology and Computational Physics research group at the University of Oldenburg.
Ideal candidate (skills and competencies):	The ideal candidate should have a degree in physics, engineering, biotechnology, biology, neuroscience, or similar fields. He/she should be highly motivated and interested in working on neurophysics, microscopy techniques, optical data analysis, and quantum biology.