POLITECNICO DI MILANO

PhD in FISICA / PHYSICS - 41st cycle

ACN - CYBER Research Field: DESIGN AND DEVELOPMENT OF ULTRACOMPACT QUBIT SOURCES ON CHIP FOR QUANTUM CRYPTOGRAPHY BASED ON NOVEL VAN DER WAALS MATERIALS

Monthly net income of PhDscholarship (max 36 months)
1600.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Quantum Key Distribution (QKD) enables ultra-secure communication by exchanging cryptographic keys through quantum states of light, primarily using single photons or entangled photons. While theoretically secure, practical implementations face challenges such as photon loss, limited entanglement efficiency, and macroscopic footprint. The project aims to overcome these limitations by developing microscopic qubit sources integrated on photonic chips based on Transition Metal Dichalcogenides (TMDs), which are ultrathin van der Waals layered crystals with exceptionally high nonlinearity and the ability to generate highly pure entangled photons via spontaneous parametric down-conversion. A major goal is to interface these materials with integrated photonic circuits to create fast, energy-efficient, and scalable QKD systems. Such integration could enable robust, chip-based quantum cryptography.Quantum Key Distribution (QKD) enables ultra-secure communication by exchanging cryptographic keys through quantum states of light, primarily using single photons or entangled photons. While theoretically secure, practical implementations face challenges such as photon loss, limited entanglement efficiency, and macroscopic footprint. The project aims to overcome these limitations by developing microscopic qubit sources integrated on photonic chips based on Transition Metal Dichalcogenides (TMDs), which are ultrathin van der Waals layered crystals with exceptionally high nonlinearity and the ability to generate highly pure entangled photons via spontaneous parametric down-

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Methods and techniques that will be developed and used to carry out the research	The scholar will work on the application of nonlinear and quantum microscopy tools for the characterization of integrated photonic devices based on low-dimensional materials, as well as transient absorption microscopy techniques for the study of cutting-edge problems in functionalized 2D semiconductors. Particular focus will be on the generation of entangled photon pairs from integrated 2D material platforms via the second-order nonlinear process of spontaneous parametric down-conversion.
Educational objectives	The scholar will receive a multidisciplinary training in topics including but not limited to nonlinear optics, integrated optics, quantum optics and spectroscopy, as well as material science, with special focus on 2D materials. Additionally, he/she/they will have the opportunity to visit partner laboratories and companies in Italy and abroad.
Job opportunities	Due to the multidisciplinary training in cutting edge techniques of nonlinear optics, integrated photonics and as well as quantum optics, the scholar will have excellent job opportunities in high-tech industries. In addition, he/she/they will be well positioned for an academic career.
Composition of the research group	1 Full Professors 3 Associated Professors 3 Assistant Professors 10 PhD Students
Name of the research directors	Prof. Dr. Chiara Trovatello

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	800.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activitiesEducational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences). Financial aid per PhD student per 3 years: max 6.522,50 euros per student. ***Teaching assistantship***:There are various forms of financial aid for activities of support to the teaching practice.The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations. **Computer and desk availability**: individual or shared use computer and desk