INSTITUT NEEL Grenoble

PhD grant

Theory of spin photon interfaces

Context : The PhD project is part of the ITN "QUDOT-TECH" (www.qudot-tech.eu), that aims to construct a platform for fully integrated on-chip quantum information (QI) processing including Quantum Dots (QD)-based single-photon sources, waveguides, nonlinearities and detectors implemented on a planar chip. QUDOT-TECH gathers leading European academic and industrial partners to show that in a combined effort the current technological bottlenecks can be overcome, paving the way for quantum enabling technology for research and industry. While the long-term applications of this on-chip QI platform include machine learning, efficient code-breaking and database sorting, full demonstration of these applications is beyond the scope of the QUDOT-TECH project. Instead, our overall research objective is to build an integrated on-chip technology platform, which will represent a major contribution to the subsequent realization of these applications.

Objectives and means available: The PhD work consists in building a complete theoretical framework to model protocols for the generation of spin-photon entanglement and deterministic photonic quantum gates. The system to model is a spin resident in a QD embedded in a directional cavity like a Photonic Crystal waveguide or a micropillar, and will be implemented in the various physical platforms studied in the consortium. Such optical media are known to provide giant non-linearities, allowing to implement photonic gates. The PhD candidate will address the following objectives: **(i)** Develop a complete analytical and numerical framework to describe the experiments conducted in the consortium. To do so a dedicated input-output formalism will be set up, that will include experimental imperfections like solid state induced decoherence, finite cooperativity and realistic detection schemes (detection efficiency, choice of polarisation basis). **(ii)** Focus on two-photon entanglement mediated by the resident spin. Assess the fidelity of the modeled gate expected in real devices and optimize the experimental parameters. **(iii)** Setting up bounds to the number of photons that can possibly be entangled for realistic spin coherence times.
The PhD candidate will provide the theoretical support useful to the development of the spin-mediated photon-photon gates developed in the consortium. In-depth theoretical studies will be conducted to understand the potential limitations in real devices and strategies will be proposed to improve the gates performances.

Possible collaboration and networking : The candidate will be hosted in the theory group of A. Auffèves (CNRS, Néel) and will benefit of the vibrant environment of Grenoble for quantum engineering. She/he will work in close collaboration with the experimental groups of the consortium to which she/he will provide theoretical support. Short term visits in the nodes of the consortium working on spin photon entanglement are scheduled to improve the candidate's skills on the following topics: phonon-induced decoherence, technology of photonic crystals, experimental realization of multi-photon entanglement, commercialization of quantum devices. Finally, the candidate will benefit from the training actions organized within the ITN.

Required profile : Candidates should have advanced skills in quantum mechanics, theoretical quantum optics and numerical tools. Former experiences in the solid-state will be appreciated.
The candidate can be of any nationality. **Candidates must not have resided or carried out their activities - work, studies, etc.- in the country of their host organization for more than 12 months in the 3 years immediately before starting the PhD.** Candidates shall at the date of recruitment be in the first four years of their research career.

Start for the grant : 06/2020
Amount : 2800€ per month brutto (2300€ netto) + family allowance (+250€ netto if applicable).
Duration : 36 months

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