PhD subject proposal – 2020

Title: Control and characterization of systems for quantum technologies

Supervisor: H.R. Jauslin

Scientific department: ICQ – Quantum Interactions and Control
Research group: DQNL - Quantum and Nonlinear Dynamics
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General scientific context:

The paradigm of new quantum technologies is based on the exploitation of purely quantum phenomena, which have no analogy in classical physics, to lead to more efficient components and processes than the conventional systems currently available. There are many possible applications, ranging from new types of sensors to quantum computers. The scientific and technical challenges that must be overcome are very complex, but the advances that these technologies can provide are so important that they justify the risk taking and the investments required.
One of the aspects that must be developed in this context are theoretical tools that allow a precise and efficient description of quantum dynamics, including their control through external fields, and their stability with respect to the interaction with external uncontrolled environments.
Key concepts for the applications in quantum information are the production and characterization of entanglement and contextuality, as well as their robustness with respect to perturbations and experimental uncertainties.
Our team has a well-established experience in the domains of quantum control, field quantization, construction of effective models, analysis of resources and strategies for quantum information.

Objectives:

Our project is focused on the construction of quantum models for systems comprising different types elements, like emitters and detectors, antennas, beam splitters, interferometers, nanostructured metallic and dielectric elements, or more generally systems used in quantum technologies. Several phenomena extending from dispersion and dissipation of energy, to the influence of noise and external perturbations will be accounted for in the description of quantum dynamics.

A possible aspect will be to study the main phenomena involved in quantum circuits: controlled emission of photons, their guided propagation and their interaction with optical devices and with plasmonic excitations, production and characterization of entanglement, control of systems interacting with an environment.

Required knowledge:

The execution of the project will require a combination of mathematical tools and numerical calculation. A technical difficulty that must be overcome is the very high dimension of the spaces in which the quantum dynamics of the system are described. The development of suitable effective models is an essential element to obtain a description of the dynamics allowing reliable predictions.

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