Open PhD position

Quantum-classical hybrid simulations of nanometric systems

Description

Quantum mechanics is the fundamental theory that rules the way nature works at the microscopic scale. However, a fully quantum description is often a fierce challenge, both for analytical developments and numerical calculations, especially for objects containing hundreds or thousands of particles. In those cases, it may be convenient to separate the system into several subsystems, some of which are treated classically and some quantum mechanically.

In this project, we will address this problem from the perspective of the Koopman-von Neumann theory, a representation of classical mechanics that uses a mathematical formalism analogous to that of quantum mechanics (operators in Hilbert spaces, etc.). By casting classical mechanics in a quantum formalism, this approach appears to be an ideal candidate to describe hybrid systems through a total wave function in which some variables are classical and others are quantum.

Two practical applications are envisaged: (i) The entanglement of two distant quantum spin qubits coupled via magnetic dipole interactions mediated by a classical system, such as a macroscopic ferromagnet, magnonic excitations, or magnetic domain walls; (ii) The effect of strong spin-orbit coupling on the electronic and spin transport in one-dimensional semiconductor quantum wires. For both cases, we will address several effects that are crucial for any quantum computing scenario, such as the loss of spin coherence through coupling to a classical system, or the efficiency of classically-mediated qubit entanglement.

Hosting institution: Institute of Physics and Chemistry of Materials of Strasbourg (IPCMS). Website: https://www.ipcms.fr/en/home/. This project is funded by the graduate school "Quantum Science and Nanomaterials" (QMat), https://qmat.unistra.fr/. The duration is **3 years**.

Supervisor: Dr. Giovanni Manfredi. E-mail address: manfredi@unistra.fr. Web page: https://www.ipcms.fr/en/giovanni-manfredi-2/

Research group: Quantum dynamics of nano-objects, https://tinyurl.com/QDyno-ipcms/

Requirements: We are looking for a highly motivated candidate with a Master degree in theoretical/computational physics or applied mathematics. A strong background in quantum mechanics and computer simulations is required (e.g., Python, Mathematica, Matlab). Some knowledge of nonequilibrium statistical mechanics (Boltzmann and Vlasov equations) and magnetism (spin dynamics, Landau-Lifshitz-Gilbert equation) is desirable. Proficiency in English is also required.

Collaborations: This is a joint project with the University of Surrey, UK. Short secondments to the School of Mathematics and Physics are envisaged during the PhD duration.

How to apply: Applicants should send a detailed CV (with names and email addresses of Bachelor and Master supervisors, and possibly other references), official Master grade transcripts (M1 and M2 grades for applicants studying in French universities), and a letter of motivation to Dr. Giovanni Manfredi: manfredi@unistra.fr.