Open post-doctoral position

Quantum-classical hybrid simulations of nanometric systems

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.

Here, we will address this problem from two complementary perspectives. On the one hand the Wigner representation casts quantum mechanics in the classical formalism of probability distributions evolving in the phase space. On the other, the Koopman-von Neumann theory is a representation of classical mechanics that uses a mathematical formalism identical to that of quantum mechanics (operators in Hilbert spaces). These two approaches appear to be ideal candidates to describe hybrid systems 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/.

Duration: 20 months, starting October 1st, 2025.

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

Requirements: We are looking for a highly motivated candidate with a PhD in theoretical/computational physics or applied mathematics. A strong background in quantum mechanics and numerical 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 Master and PhD supervisors, and possibly other references), official Master grade transcripts, list of publications, and a letter of motivation to Dr. Giovanni Manfredi: manfredi@unistra.fr.