Lab project M1 PPN & QuanTEEM

04/05/2026 – 19/06/2026

Title of the project: Driven open quantum systems

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Laboratory / Department / Team : Lab. Interdisciplinaire Carnot de Bourgogne (ICB)/ ICQ / DITeQ

Collaborations: Dominique Sugny (ICB), Bruno Bellomo (Université de Franche-Comté, Besançon)

Summary:

General context: Quantum technologies hold great potential to outperform current technologies based on classical physics and classical systems in areas such as computation, secure communications, simulation, metrology and sensing. The main challenges delaying such applications is the extreme vulnerability of quantum systems and the quantum information they carry to external noise and experimental uncertainties. One promising solution is quantum optimal control which can produce a high level of precision to perform quantum operations for quantum information processing and quantum sensing. However, to overcome the theory-reality gap, quantum control needs to take into account external noise perturbing the dynamics of the target quantum system as well as experimental uncertainties on the systems' parameters.

Research Project: The project will focus on taking into account external noise. Using a recently derived master equation for driven quantum systems [1], the aim will be to simulate the resulting dynamics for simple systems, starting with a qubit. For the simulation, a possible option is to use the Python package QuTiP (Quantum Toolbox in Python) [2] with its built-in functions for master equations. A second possibility, tractable for small systems, will be to use a Dyson series in the Liouville space. Then, we will compare the results with other methods like pseudo-mode [3] or Hierarchy Equation of Motion (HEOM) [4,5] (from collaborators or papers in the literature). Finally, depending on the advancement of the project, we will consider doing quantum control in open dynamics in simple situations.

[1] C. L. Latune, M. Boubakour, Simplified Master Equation for Driven Open Quantum System, to be published.

[2] See QuTiP website here

[3] G. Pleasance, B. M. Garraway, F. Petruccione: Generalized theory of pseudomodes for exact descriptions of non-Markovian quantum processes. Phys. Rev. Res. 2, 043058 (2020).

[4] Y. Tanimura, Numerically exact approach to open quantum dynamics: The hierarchical equations of motion (HEOM), J. Chem. Phys. 153, 020901 (2020).

Type of project (theory/experiment): theory

Required skills: Interest in and good understanding of open quantum systems with good programming skills.