Internship subject: Feedback stabilization of open quantum systems

Quantum control is a multidisciplinary field which has an immense ability to be applied in different fields such as chemistry, biology, mathematics, engineering, physics, etc. Controlling quantum systems is an important step to advance further quantum technologies including quantum computer, cryptography, quantum memory, etc. This branch of research addresses many key open questions which have no counterparts in classical control theory.

Open quantum systems are quantum systems in interaction with an environment. This interaction perturbs the system states and causes loss of information from the system to the environment. However by applying quantum feedback control, the system can fight against this loss of information. This is a major task in developing further quantum technology devices.

This internship is multidisciplinary between quantum physics, control and probability theory. In this internship, we consider Markov models to express the quantum system and we will study quantum measurement-based feedback which is a strategy of feedback which naturally generalizes classical feedback.

The evolution of the system is described by Stochastic Master Equations (SMEs). We will study feedback strategies which stabilize the quantum system towards a predetermined state by using especially Lyapunov functions. For this, we will use the stochastic control theory [3].

The first period of the internship will be devoted to the study of the literature around stochastic stability [3], stabilization of quantum systems using non-linear control tools (see e.g., [11, 2, 3, 6, 13, 12, 4]).

In the second part of the internship, we will focus on the strategies proposed in [4], where we showed exponential stabilization of N-level quantum angular momentum systems towards a predetermined eigenstate of the measurement operator. For such a system, we aim to study robustness with respect to delays, measurement imperfections, etc. In addition, our strategies of feedback proposed in [4] are not optimal. Hence, it is important to study the role of different parameters appeared in the feedback form in [4].

The internship can be extended to a PhD thesis where we aim to obtain systematic strategies to stabilize general open quantum systems in presence of measurement imperfections and study their applications in different contexts (see e.g., [8, 10, 9, 1, 5, 7]).

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References


