

INTERNATIONAL RELATIONS



INTERNSHIP SUBJECT

2874 - Minimal embeddings of unitary algebras for controllability of quantum systems

Together with our colleagues from Dijon, we began studying the control of NV centers. Roughly speaking, these are defects in diamonds with unique quantum mechanical properties that can be observed at room temperature. This makes them a very promising platform for quantum technology, notably quantum metrology. Our collaborators posed several questions, one of which concerned the controllability of such systems—namely, which quantum states or unitary operators can be achieved by shining a laser on the defects?

As we began working on this, we realized that the controllability problem can be solved quite efficiently for spin-1/2 networks. The key observation is that spin-1/2 matrices either commute or anti-commute, giving their tensor products unique algebraic properties. Unfortunately, the defects and nitrogen nuclei in NV centers are spin-1, even though the carbon nuclei are spin-1/2.

The goal of this internship will be to find embeddings of products of special unitary Lie algebras, $su(m)$, into $su(2^N)$. This will allow us to reduce the problem for any spin value to spin-1/2 networks, for which we have efficient algorithms. We will look for embeddings that respect the algebraic structure of $su(2^N)$, leading us essentially to a sparse optimization problem.

Starting date is flexible and can be discussed.

Required Skills

Necessary skills:

- Programming skills: knowledge of at least python, but Julia is preferable
- Solid mathematical background
- Not being scared of both pure and applied mathematics at the same time

Helpful but not necessary:

- Knowledge of Lie theory
- Knowledge of finite-dimensional quantum mechanics

General Information

- **Research Theme :** Optimization and control of dynamic systems
- **Locality :** Sophia Antipolis
- **Level :** Master
- **Period :** 5th January 2026 -> 5th April 2026 (3 months)

 *These are approximative dates. Please contact the training supervisor to know the precise period.*

- **Deadline to apply :** 1st July 2025 (midnight)

Contacts

- **Training Supervisor :** Ivan Beschastnyi / ivan.beschastnyi@inria.fr
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More information

- **Inria Team :** MCTAO
- **Inria Center :** Centre Inria d'Université Côte d'Azur