PhD Project
Numerical simulations of SU(N) spins

PhD Supervisors: Pierre Nataf and Loïc Herviou
Laboratory: Laboratoire de Physique et Modélisation des Milieux Condensés (UMR 5493)
Address: 25 rue des Martyrs, Grenoble
Emails: pierre.nataf@lpmmc.cnrs.fr and loic.herviou@lpmmc.cnrs.fr
Phone number: 04 76 88 79 84
Web pages: lpmmc.cnrs.fr/nataf and lherviou.github.io

Scientific scope:

Large-spin models have recently gained significant attention due to experimental breakthroughs in cold atom systems. These setups enable highly controlled experiments that simulate complex theoretical models. However, large-spin models present considerable challenges for numerical modeling. The large spin dimensions and intricate symmetries of these systems make simulations extremely difficult, and standard methods often fall short, failing to access certain experimental regimes of interest.

In this context, an alternative approach was recently proposed by one of the PhD supervisors. This method bypasses the calculation of Clebsch-Gordan coefficients, thereby overcoming the limitations of traditional approaches. Given its demonstrated potential, there are now several promising avenues for further development.

Project:

The proposed PhD thesis will explore these avenues in multiple stages. Initially, the student will study group theory, with a particular focus on SU(N) group representations, which are crucial for modeling large-spin systems. A solid grasp of these concepts is essential for the later stages of the project. Subsequently, the student will implement a numerical method (exact diagonalization) to model quantum systems with high accuracy. Several theoretical models are under consideration, including variants of Heisenberg chains and ladders, where analytical approaches fail to provide clear predictions.

Once the different mathematical tools necessary to the understanding of SU(N) physics have been acquired, the student will explore tensor network methods. These have become one of the most powerful and efficient tools for modeling low-dimensional quantum systems. Tensor networks are particularly well-suited to simulating one-dimensional systems like spin chains, offering unmatched precision in capturing their fundamental properties. Our goal is to adapt existing algorithms to integrate this new computational approach, which should significantly advance the field.

Through potential collaborations, the student will also learn non-Abelian bosonization and the general field-theoretical approaches to the study of SU(N) chains and ladders.

Keywords:

SU(N) symmetry, exact diagonalization, tensor networks