LNCMI

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NMR investigation of low-dimensional quantum spin systems

Master 2

Summary

Quantum spin systems are insulating crystals containing regular array of atoms carrying spin S = 1/2 or 1, described by simple spin Hamiltonians. In low-dimensional model compounds, we study by Nuclear Magnetic Resonance (NMR), which is a microscopic probe to magnetism, the magnetic-field-induced "exotic" phases, such as the Bose-Einstein condensate, magnetization plateaus or spin-nematic phase.

Detailed subject

Based on the microscopic information obtained from NMR measurements, coupled to advanced theoretical numerical analysis, we aim at understanding of topical, magnetic-field-induced phenomena in antiferromagnetic quantum spin systems.

Having covered in great detail quasi-one-dimensional materials such as spin ladders [1,2] and chains [1,3], we are now focused on two-dimensional (2D) systems such as $Ba_2CuSi_2O_6Cl_2$ and $Ba_2CoSi_2O_6Cl_2$ spin-dimer compounds, the two new archetypal 2D systems that have, respectively, their Bose-Einstein condensate (BEC) phase and the magnetization-plateau phase accessible to high-field NMR experiments. We will also investigate $BaCdVO(PO_4)_2$ for its putative spin-nematic phase.

The internship provides an introduction to the NMR technique and its application to study one such quantum spin system. It involves all aspects of the work: preparation of experiments, NMR measurements, cryogenics, analysis of the results, numerical simulations, and will be performed in an internationally recognized research group. The investigation of quantum spin compounds by NMR can also be recommended as an excellent subject for an experimental thesis, strongly coupled with theory.

Publications linked to the theme

[1] M. Horvatić, M. Klanjšek, and E. Orignac, *Direct determination of the Tomonaga-Luttinger parameter K in quasi-one-dimensional spin systems*, Phys. Rev. B **101**, 220406(R) (2020), arXiv:2003.05904.
[2] M. Jeong *et al.*, *Dichotomy between Attractive and Repulsive Tomonaga-Luttinger Liquids in Spin Ladders*, Phys. Rev. Lett. **117**, 106402 (2016), arXiv:1604.05252.
[3] A. Orlova, *et al.*, *Detection of a Disorder-Induced Bose-Einstein Condensate in a Quantum Spin Material at High Magnetic Fields*, Phys. Rev. Lett. **121**, 177202 (2018), arXiv:1801.01445.

Background and skills expected :

The candidate should be motivated for topical research in a high-level international laboratory and is expected to have a solid knowledge of solid state physics and quantum mechanics. Experimental skills and some knowledge of electronics and/or NMR technique will be an advantage.

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