Soutenance de thèse

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14h30, Amphithéâtre - C2N

SPIN NOISE SPECTROSCOPY
OF SINGLE SPINS USING SINGLE DETECTED PHOTONS

Manuel Gundín

Supervisor
Loïc Lanco (C2N)

Jury Members
Thierry Amand (rapporteur), Directeur de recherche émérite, LPCNO, INSA Toulouse
Denis Scalbert (rapporteur), Directeur de recherche, L2C, Université de Montpellier
Valia Voliotis (examinatrice), Professeure, INSP, Sorbonne Université
Carole Diederichs (examinatrice), Maîtresse de conférences, LPENS, Sorbonne Université
Lucien Besombes (examinateur), Directeur de recherche, Institut Néel

Abstract
Quantum emitters capable of high-fidelity and high-rate operation are the cornerstone of photonic quantum technologies, which require increasing precision in the manipulation of single qubits. Emitters that can host a spin are particularly interesting for quantum communication networks and quantum computation, as they exploit the key resource of spin-photon entanglement. In this context, self-assembled semiconductor quantum dots (QDs) have become promising candidates for spin-photon interfaces due to their exceptional optical properties. Nevertheless, short spin coherence times strongly limit the potential of this platform. Better strategies to mitigate the environmental fluctuations and decouple the spin from them are required to improve its performance.

In this regard, Spin Noise Spectroscopy (SNS) has become a key technique to obtain information from spin environments in atomic and solid-state systems via the measurement of polarimetric signals such as Faraday polarization rotation. However, the low signal imprinted by a single spin has limited most SNS implementations to spin ensembles. In this manuscript, we introduce a novel SNS technique based on the measurement of single spins via the detection of single photons. We demonstrate spin noise measurements in the ultrafast regime above the 10 GHz level, breaching traditional bandwidth limitations with unprecedented sensitivity.

Our approach relies on the cavity-enhanced spin-photon interaction, increasing several orders of magnitude polarimetric signals from a single spin. Spin-dependent polarization rotations of the photons reflected from the interface of up to π are observed, allowing for the mapping of spin fluctuations into polarization fluctuations and the efficient optical detection of spin noise mechanisms. Crucially, the SNS signal is mapped into single photons. As a result, correlations can be directly calculated between single photon detection events, dramatically improving the detection bandwidth. Ultimately, the temporal resolution is only limited by the temporal jitter of single-photon detectors.