CEA – Saclay, 91191 Gif-sur-Yvette Cedex
Service de Physique de l'Etat Condensé - UMR 3680
Mercredi 05 Février 2025 à 11h15

SÉMINAIRE SPEC
Orme des Merisiers, en amphi Bloch Bât.774

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Quantum Micromagnetic Theory of Magnons in Finite Nanostructures

This talk presents a quantum field theoretical framework for studying magnons, quantized spin waves, in finite nanostructures with arbitrary shapes and spatially nonuniform ground states. Extending the classical micromagnetic formalism, this approach is derived from the continuum (long-wavelength) limit of the ferromagnetic Heisenberg model, resulting in a quantum micromagnetic Hamiltonian operator. The Hamiltonian accounts for key energy contributions, including exchange, Dzyaloshinsky-Moriya, anisotropy, magnetostatic, and Zeeman energies. The noncollinear nature of the ground state is handled by locally aligning the quantization axis of the magnetization field operator with the classical ground state. The Hamiltonian is expanded in the large spin-number limit and truncated to quadratic terms, enabling the derivation of the linear quantum Landau-Lifshitz equation. By solving this equation under appropriate boundary and normalization conditions, a discrete set of magnon creation and annihilation operators is obtained, providing a complete description of the magnon spectrum. Crucially, this formalism captures boundary effects, overcoming the limitations of plane-wave approximations.
In the final part of the talk, the formalism is applied to study low-temperature thermal equilibrium fluctuations in thin ferromagnetic nanodisks. The results reveal the critical role of edge effects in magnetization dynamics at the nanoscale. This work establishes a foundation for incorporating quantum effects into classical micromagnetic modeling, offering a pathway to extend classical computational techniques into the quantum domain. In this respect, it also provides valuable insights for applications in magnonics, spintronics, and quantum magnetism.

Coffee and pastries will be served

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