INSTITUT JEAN LAMOUR

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Salle Patrick Alnot (4-A014)

Coherent Magnonics for Quantum Information Science

The current revolution in quantum technologies relies on coherently linking quantum objects like quantum bits (“qubits”). Coherent magnonic excitations of low-loss magnetic materials can wire together these qubits for sensing, memory, and computing. Coherent magnonics may reduce the size of superconducting qubits (which otherwise struggle with the large scale of microwave excitations) and may increase the size of spin-based qubit networks (which otherwise contend with the very short distances of dipolar or exchange interactions). Compared to photonic devices, these magnonic devices require minimal energy and space. However, efforts to exploit coherent magnonic systems for quantum information science will require a new understanding of the linewidths of low-loss magnonic materials shaped into novel structures and operating at dilution-refrigerator temperatures.

This lecture will introduce the fundamental requirements for practically linking quantum objects into large-scale coherent quantum systems as well as the advantages of coherent magnonics for next-generation quantum coherent systems (i.e., spin-entangling quantum gates [1]). Other critical challenges for quantum information science then will motivate the development of coherent magnonics for quantum transduction from “stationary” spin systems to “flying” magnons and for quantum memory [2]–[4]. Finally, the advantages of all-magnon quantum information technologies that rely on manipulating and encoding quantum information in superpositions of fixed magnon number states will highlight the potential of new magnetic materials, devices, and systems.

[1]M. Fukami, D. R. Candido, D. D. Awschalom, and M. E. Flatté, “Opportunities for long-range magnon-mediated entanglement of spin qubits via on and off-resonant coupling,” *PRX Quantum*, vol. 2, Oct. 2021, Art. no. 040314. [2]D. R. Candido, G. D. Fuchs, E. Johnston-Halperin, and M. E. Flatté, “Predicted strong coupling of solid-state spins via a single magnon mode,” *Mater. Quantum Technol.*, vol. 1, Dec. 2021, Art. no. 011001. [3]Ö. O. Soykal and M. E. Flatté, “Strong field interactions between a nanomagnet and a photonic cavity,” *Phys. Rev. Lett.*, vol. 104, Feb. 2010, Art. no. 077202. [4]T. Liu, X. Zhang, H. X. Tang, and M. E. Flatté, “Optomagnonics in magnetic solids,” *Phys. Rev. B, Condens. Matter*, vol. 94, Aug. 2016, Art. no. 060405(R).

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