PhD/Postdoct Offer

Unconventional spin-wave transport explored by NV magnetometry

Laboratory name: Laboratoire Albert Fert, CNRS, Thales, University Paris Saclay
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We have an open position at the Laboratoire Albert Fert in the field of "NV imaging of spin-wave dynamics in magnonics devices". Within the Laboratoire Albert Fert, we investigate the spin properties from various perspectives, ranging from fundamental to applied physics, and by connecting several scientific disciplines. In the recent period, we developed various research activities in developing novel ferro- and antiferro-magnetic oxides [1] for future ICT devices, with a strong focus on new magnonic functionalities [2] and unconventional [3] spin-dynamics and on developing new characterization techniques.

The position to be filled will deal with the imaging of unconventional spin-wave transport in ferromagnetic and antiferromagnetic materials [2,4,5] using NV centres. The electronic spin states of the NV center can be prepared, detected and manipulated by combining optical and microwave excitations, leading to a spin qubit that is now widely used for quantum technologies. In recent years, NV based imaging techniques have been demonstrated to enable spin-wave imaging with spatial resolution down to 50 nm with excellent signal to noise ratio. The PhD/postdoc will focus on investigating unexplored spin-wave transport regimes, with a focus on the exploration of inhouse developed materials, and on exploring nonlinear magnonic processes triggered by microwave and spin-orbit torque excitations. The recruited person will be in charge of mastering and further developing spin-wave imaging techniques using the inhouse confocal and scanning NV microscopes. The project will be integrated in a collaborative research project, focusing on investigating classical and quantum magnon spintronic phenomena.

Methods & Techniques

- Master the NV magnetometry techniques to observe magnonic transport, and implement microwave sequence pulses to investigate transient spin wave excitations,
- Study the specificity of spin-wave propagation in 2D and antiferromagnetic materials,
- Image spin-wave transport in both linear and nonlinear regimes, and explore the impact of spin-orbit torques on spin waves dynamics,

Profil & Skills required

- Diploma in Condensed Matter or Quantum physics (required),
- Magnetism and spintronics (required),
- Experience in NV imaging or quantum sensing (preferred),
- Experience in optical and electronic lithography (preferred),
- Experience in microwave measurements (desired),
- Programming skills in Python, Labview, Matlab, etc (required),
- Excellent organizational and scientific writing skills in English (required),
- Good communication skills (desired).

References

[1] L. Soumah, N. Beaulieu, L. Qassym, C. Carrétéro, E. Jacquet, R. Lebourgeois, J. B. Youssef, P. Bortolotti, V. Cros, and A. Anane, Ultra-low damping insulating magnetic thin films get perpendicular, Nat. Commun. **9**, 3355 (2018).
[2] H. Merbouche, B. Divinskiy, D. Gouéré, R. Lebrun, A. El Kanj, V. Cros, P. Bortolotti, A. Anane, S. O. Demokritov, and V. E. Demidov, True amplification of spin waves in magnonic nano-waveguides, Nat. Commun. **15**, 1560 (2024).
[3] B. Divinskiy et al., Evidence for spin current driven Bose-Einstein condensation of magnons, Nat. Commun. **12**, 6541 (2021).
[4] A. El Kanj, O. Gomonay, I. Boventer, P. Bortolotti, V. Cros, A. Anane, and R. Lebrun, Antiferromagnetic magnon spintronic based on nonreciprocal and nondegenerated ultra-fast spin-waves in the canted antiferromagnet α-Fe2O3, Sci. Adv. **9**, eadh1601 (2023).
[5] R. Lebrun, A. Ross, O. Gomonay, V. Baltz, U. Ebels, A.-L. Barra, A. Qaiumzadeh, A. Brataas, J. Sinova, and M. Kläui, Long-distance spin-transport across the Morin phase transition up to room temperature in ultra-low damping single crystals of the antiferromagnet α-Fe2O3, Nat. Commun. **11**, 1 (2020).