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May 10, 2023 at 10:30 AM

IJL – 4-014

A spin-wave imaging platform based on nitrogen vacancy spins in diamond

Magnetometry based on nitrogen-vacancy(NV) spins in diamond has recently emergedas a powerful tool for probing spin waves1 –the elementary excitations of coupled spinsin magnetically ordered materials. In this talkI will focus on how we utilize scanning NVmagnetometry – in which we use a NVsensor spin(s) that are shallowly embeddedin the tip of a diamond scanning probe – toimage spin waves in a thin film magneticinsulator. I will focus on two studies:(1) I will show how microwave excitation oflow-wavenumber spin waves leads to a highdensity and, most surprising, a unidirectionalgas of incoherent magnons2. We find that theenhanced magnon density extendsunidirectionally over hundreds of micrometres from the excitation stripline. Furthermore, wedemonstrate how the spatial decay of the stray fields reveals the wavenumber content of bothcoherently excited spin waves with a well-defined wavenumber as that of the incoherent magnongas.(2) I will show how we can use our single-NV sensor as a wavelength filter to characterize frequencydegenerate spin wave modes3. With the NV probe in contact with the magnet we observe a mixtureof thermal and coherently driven spin waves and when we retract our tip we suppressed the smallwavelength modes, leaving only the coherently driven mode visible. We also show that our in-contactscans at low microwave drive power surprisingly show occupation of the entire isofrequency contourof the two-dimensional spin-wave dispersion despite our one-dimensional microstrip geometry.These results reveal the power of scanning NV-magnetometry as a tool for spin-wave probing. Whilstshowcasing that (1) coherently driven, low-wavenumber spin waves are efficient generators of anon-equilibrium magnon gas in target directions and that (2) nanoscale control over the NV-sampledistance enables wavenumber-selective imaging of magnetization oscillations. Our results open newavenues for local control of spin transport and for imaging other coherent spin-wave modes.

References:

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Séminaire organisé dans le cadre du projet de programme interdisciplinaire MAT-PULSE