Department of Physics
Condensed Matter Physics
Clarendon Laboratory, Parks Road, Oxford OX1 3PU

UNIVERSITY OF OXFORD

CONDENSED MATTER PHYSICS SEMINAR

Thursday 27 November at 14:30
Simpkins Lee Seminar Room, Department of Physics
(https://maps.app.goo.gl/WjG71uLF2D48n85B6)

Imaging Magnons and Fluxons using Nitrogen Vacancy Spins in Diamond

Dr. Samer Kurdi
Quantum Photonics Laboratory, Heriot-Watt University

Magnetometry based on nitrogen-vacancy (NV) spins in diamond has recently emerged as a powerful tool for probing spin waves1 –the elementary excitations of coupled spins in magnetically ordered materials. In this talk I will focus on how we utilize scanning NV magnetometry – in which we use a NV sensor spin(s) that are shallowly embedded in the tip of a diamond scanning probe – to image spin waves in a thin film magnetic insulator and discuss how NV enable the extraction of fundamental superconducting material properties.

Firstly, I will discuss imaging spin waves in a thin film magnetism insulator, where I will show how microwave excitation of low-wavenumber spin waves leads to a high-density and, most surprising, a unidirectional gas of incoherent magnons2. We find that the enhanced magnon density extends unidirectionally over hundreds of micrometres from the excitation stripline. I will also show how we can use our single-NV sensor as a wavelength filter to characterize frequency-degenerate spin wave modes3. We also show that when the diamond sensor is in contact with the magnetic film scans at low microwave drive power surprisingly show occupation of the entire isofrequency contour of the two-dimensional spin-wave dispersion despite our one-dimensional microstrip geometry.

Secondly, I will discuss current progress towards probing diamagnetism in a superconducting strip, with underlying motivation for understanding electronic transport in quantum devices. I will show that the degree of magnetic field shielding by the superconducting strip is dimension dependent, enabling the extraction of the London Penetration depth, as further supported by characterizing the magnetic field profile of Abrikosov vortices (fluxons).

These results reveal the power of scanning NV-magnetometry as a tool for magnetic field imaging over a wide detection range spanning DC to GHz. Whilst showcasing that (1) coherently driven, low-wavenumber spin waves are efficient generators of a non-equilibrium magnon gas in target directions, (2) nanoscale control over the NV-sample distance enables wavenumber-selective imaging of magnetization oscillations and (3) magnetic imaging of diamagnetism and fluxons enable the extraction of key superconducting material properties. Our results open new avenues for fabrication of magnonic crystals based on fluxon lattices.

References:

[1] I. Bertelli et al. *Sci. Adv.* **6** eabd3556 (2020).
[2] B. G Simon*, S. Kurdi* et al. *Nano Lett*. **21** 8213 (2021).
[3] B. G Simon*, S. Kurdi* et al. *Nano Lett*. **22** 9198 (2022).

Host: Professor Thorsten Hesjedal