Department of Physics
Condensed Matter Physics
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UNIVERSITY OF OXFORD

CONDENSED MATTER PHYSICS SEMINAR

Thursday 18 June at 14:30
Simpkins Lee Seminar Room, Department of Physics
(https://maps.app.goo.gl/WjG71uLF2D48n85B6)

Optical renormalization of collective magnetic excitations in quantum materials

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The optical manipulation of the macroscopic properties of solids is one of the main research directions in contemporary condensed matter physics. The ability to control the magnetic and ferroelectric order parameter via laser pulses has been demonstrated. Moving beyond order-parameter control, an emerging frontier is the tailoring of collective excitations, and ultimately their dispersion relations, as a means to achieve a deeper and more versatile control of material functionality.

In this talk, I will focus on collective magnetic excitations and begin by introducing their dispersion relations in antiferromagnets, the most abundant class of magnetic materials. I will briefly discuss how these excitations can be coupled to charge degrees of freedom - a key concept underlying spintronics - highlighting recent progress involving processes at terahertz frequencies [1-2].

The main part of the talk will address the optical manipulation and renormalization of magnon spectra. I will show how resonant excitation of specific magnetic and electronic transitions drives the system into non-equilibrium states in which magnon modes that are not directly excited become activated and substantially renormalized. Two distinct physical scenarios will be discussed. In the first, optical excitation of electronic transitions modifies the magnetic anisotropy in a 20-nm-thick magnetic film, leading not only to the generation of coherent magnons but also to an on-demand frequency renormalization [3]. By tuning the pump fluence and the external magnetic field, both redshifts and blueshifts of the magnon frequency are achieved, reaching up to 40% of its equilibrium value at room temperature.

In the second scenario, I will present an approach based on high-momentum magnons with wave vectors near the edges of the Brillouin zone, which can be resonantly driven using mid-infrared laser pulses. This excitation pathway activates distinct zone-center modes whose amplitudes and frequencies are strongly renormalized compared to their equilibrium values [4]. I will conclude by outlining future perspectives of this research direction, with the longterm goal of achieving arbitrary optical control over magnon dispersion relations in quantum materials.

[1] T. Mezger et al. Physical Review Letter **135**, 076702 (2025) - Cover and Editor's suggestion DOI: https://doi.org/10.1103/76xj-j9qr
[2] M. Cimander et al. Nature Communications - Accepted
[3] V. Wiechert et al. Nature Communications **17**, 145 (2026) https://doi.org/10.1038/ s41467-025-66707-7
[4] C. Schoenfeld et al. Science Advances **11**, 25 (2025) DOI: 10.1126/sciadv.adv4207

Host: Dr Hariom Jani