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

UNIVERSITY OF OXFORD

CONDENSED MATTER SEMINAR

Thursday 23rd of November at 2.15pm

"Room Temperature chiral skyrmions and skyrmion bubble dynamics in nanostructures "

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Magnetic skyrmions are particle-like magnetic spin textures with a topology characterised by their Skyrmion number. They can arise due to the exchange, anisotropy and dipolar energy in the case of skyrmion bubbles and an additional Dzyaloshinskii-Moriya interaction (DMi) in the case of chiral skyrmions [1,2]. Skyrmionic structures can exhibit rich dynamical behaviour governed by their topology [1-3]. At the same time the ultra small size of the chiral skyrmions and their robustness makes them ideal candidates for a new generation of magnetoelectronic devices [1,2]. The recent demonstrations of room temperature chiral skyrmions are the first necessary step in order to control their dynamical behaviour and introduce them in devices. In previous work, nanoscale sub-nanosecond X-ray pump-probe imaging was used to demonstrate, for the first time, the gyrotropic mode of a single skyrmion bubble in the gigahertz regime and ii) the breathing-like behaviour of a pair of skyrmionic configurations. The observed dynamics confirmed the skyrmion topology and showed the existence of an unexpectedly large inertia that is key for describing skyrmion dynamics [4]. We have recently also demonstrated by high resolution scanning transmission X-ray microscopy imaging the observation of room temperature nanoscale (sub-100nm) individual chiral skyrmions in a technologically relevant material [5]. We tailor-design cobalt-based multilayer thin films where the cobalt layer is sandwiched between two heavy metals in order to engineer additive interfacial Dzyaloshinskii– Moriya interactions (DMIs) and thereby achieve a high value of |D|=~2 mJ m–2. The recent observations of R.T. chiral skyrmions can serve as a basis for the development of skyrmion-based memory and logic devices and enable further fundamental studies on the very rich physics of skyrmions [6]. We will also be presenting recent numerical results on skyrmion Hall angle tuning in confined synthetic skyrmions and skyrmion lattice melting in interfacial systems.

[1] N. Nagaosa and Y. Tokura, Topological properties and dynamics of magnetic skyrmions, Nature Nanotechnology 8, 899 (2013).
[2] A. Fert, V. Cros, J. Sampaio, Skyrmions on the track, Nature Nanotechnology 8, 152 (2013).
[3] C. Moutafis, S. Komineas, J.A.C. Bland J.A.C, Dynamics and switching processes for magnetic bubbles in nanoelements, Physical Review B 79, 224429 (2009).
[4] F. Büttner, C. Moutafis, et al., Dynamics and inertia of skyrmionic spin structures, Nature Physics 11,225 (2015).
[5] C. Moreau-Luchaire, C. Moutafis , et al., Additive interfacial chiral interaction in multilayers for stabilization of small individual skyrmions at room temperature , Nature Nanotechnology 11, 444–448 (2016).
[6] W. Legrand, …, C. Moutafis, et al., Room-temperature current-induced generation and motion of sub-100 nm skyrmions, Nano Letters, 17 (4), pp 2703–2712 (2017).

Host: Prof Thorsten Hesjedal

Audrey Wood Seminar Room, Clarendon Laboratory