CFEL SCIENCE

Max Planck Research Department for

Structural Dynamics

SEMINAR

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Magnetism on the timescale of the exchange interaction: explanations and predictions

Ferromagnetic or antiferromagnetic spin ordering is governed by the exchange interaction, the strongest force in magnetism. Understanding spin dynamics in magnetic materials is an issue of crucial importance for progress in information processing and recording technology. However, rather little is known about the behaviour of spins in a magnetic material directly after being excited on a timescale equivalent to or faster than that corresponding to the exchange interaction (10–100 fs), that is, in a non-adiabatic way. After the first demonstration of ultrafast laser-induced demagnetization in ferromagnetic nickel [1], many intriguing observations have been reported on magnets with multiple magnetic sublattices, including ultrafast changes of the anisotropy [2] and magnetization reversal [3]. Nevertheless, the theoretical understanding of ultrafast laser-induced spin dynamics is still a challenge. In particular, so far the role of the exchange coupling between different magnetic sublattices has largely been ignored. In this contribution we present a general theoretical framework for the analysis of ultrafast longitudinal spin dynamics in multi-sublattice magnets [4]. We distinguish relaxation of relativistic and exchange origin and show that when the former dominates, non-equivalent sublattices have distinct dynamics despite their strong exchange coupling. Even more interesting, in the exchange dominated regime sublattices can show highly counter-intuitive transitions between parallel and antiparallel alignment. Moreover, our theory predicts that exchange relaxation enhances the demagnetization speed of both sublattices only when they are antiferromagnetically coupled.

[1] E. Beaurepaire et al., Phys. Rev. Lett. 76, 4250 (1996).
[2] A. V. Kimel et al., Nature 429, 850 (2004).
[3] C.D. Stanciu et al., Phys. Rev. Lett. 99, 047601 (2007).
[4] J.H. Mentink et al., Phys. Rev. Lett. 108, 057202 (2012).

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Host: Martin Eckstein, MPSD-THEO, CFEL