European XFEL

THEORY GROUP MEETING

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15:00

AER 19 Seminar Room 4.14

Modelling Ultrafast Spin Dynamics

by

Thomas Ostler

L'Université de Liège

Controlling the excitation of magnetic materials on ultrashort time-scales promises to pave the way for the next generation of magnetic based technologies. Interpreting the dynamics of highly complex materials after very strong and short stimuli is a key challenge for the theoretical/modelling community. The time-scales involved often mean that traditional models of magnetization dynamics fail to capture the highly complex physical processes involved. In this talk I will outline one approach for modelling ultrafast spin dynamics known as atomistic spin dynamics and discuss it in context of other models. The formalism is a so-called second principles method based on the many body Landau-Lifshitz phenomenology. This intrinsically real-space method allows one to simulate real-time dynamics of highly complex magnetic materials. Based on a Heisenberg-like Hamiltonian formalism that can be parameterised from both first-principles and experimental measurements I will present a number of examples of how atomistic spin dynamics can be used to both; gain insight into experimental measurements in a comparative way; and also make predictions of new phenomena or trends.

Using this model in comparison with XMCD measurements we have shown that the intrinsic demagnetisation times of multi-component magnetic materials is most strongly affected by the exchange, not only within each sublattice, but between the sublattices, demonstrating decoupled magnetisation dynamics. Such decoupled dynamics has important consequences for all-optical switching. Finally, I will show model calculations of FeRh, a magnetic material that shows a metamagnetic phase transition from an antiferromagnetic to ferromagnetic phase which has been posed for a number of technological applications. By investigating the real space spin-spin correlation function we show that the formation of ferromagnetism occurs on the picosecond time-scale completely suppressing the antiferromagnetic state.