Ultrafast spin-lattice dynamics in magnetic materials

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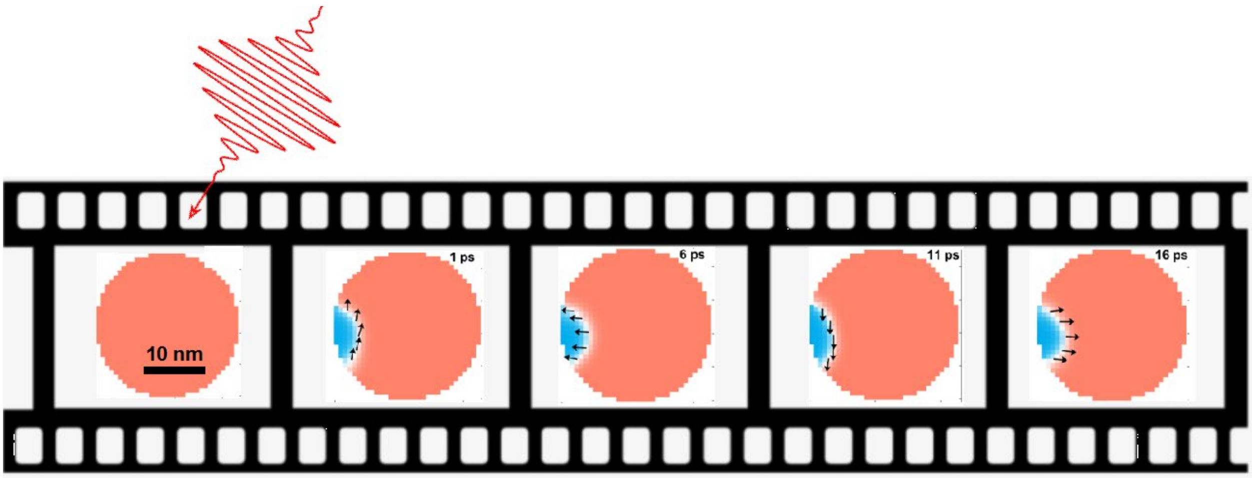
The dynamics of spins in magnetic materials initiated by a sub-picosecond laser pulse is an emerging and rapidly developing field in fundamental magnetism. The goal of this research is to understand and ultimately control the energy and angular momentum transfer processes in the laser-excited non-equilibrium state. The magneto-elastic coupling of phonon and magnon modes offers novel functionality for spintronics applications in information technology. Magnon polarons can form via magnetoelastic coupling [1], circularly polarized phonons can form and transport angular momentum [2] or phonons can be used to generate spin currents in metallic contacts [3]. However, many of these phenomena are currently only demonstrated at GHz frequencies and micrometer dimensions. I will give an overview how x-ray free electron lasers will enable us to explore the potential of moving towards THz frequencies and nanometer dimensions [4] that are far more attractive for applications.



The figure illustrates snapshots of soliton-like spin motion in an FePt nanoparticle of 10nm size following laser excitation [4].

References

[1] J. Li et al.: Observation of Magnon Polarons in a Uniaxial Antiferromagnetic Insulator", Phys. Rev. Lett. **125**, 217201 (2020).

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[3] M. Weiler et al.: "Spin Pumping with Coherent Elastic Waves" Phys. Rev. Lett. **108**, 176601 (2012).

[4] D. Turenne, et al., "Non-equilibrium sub-10 nm spin-wave soliton formation in FePt nanoparticles", Sci. Adv. **8**, eabn0523 (2022).