**2nd Transnational Round Table on Magnonics, High-Frequency Spintronics, and Ultrafast Magnetism**

# Phonon-Driven Spin Dynamics in Rare-Earth Orthoferrites across Spin-Reorientation Temperatures

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The pursuit of energy efficient alternatives to conventional electronic devices has become a central focus of scientific research. One promising approach employs spin waves (magnons) as a means of information transfer to avoid Joule-heating. Additionally, all-optical magnetisation switching holds the potential to enhance magnetic data-storage technology, offering high speed operation and improved efficiency.

Spin dynamics in rare-earth orthoferrites have been extensively studied due to their canted antiferromagnetic structure, strong spin-lattice coupling and very high magneto-optics. Also of interest is a phase transition during which the antiferromagnetic vector undergoes a spin reorientation. For thulium and erbium orthoferrites, $TmFeO_3$ and $ErFeO_3$, this occurs from about 80K to 90K. Recently, a phononic pathway to excite spin dynamics has been discovered in rare-earth orthoferrites [1][2], while phonon-driven switching was observed in an iron garnet [3].

To study phonon-driven responses in a single crystal, 60 µm-thick sample of $TmFeO_3$ we performed a time-resolved pump-probe spectroscopy experiment, shown in Fig.1a. Mid-infrared pump pulses were tuned at resonance with optical phonons, distorting the crystal lattice which induced a torque on the spins, thereby driving them into precessional motion. The spin dynamics were measured by polarisation rotation of an 800 nm probe as a function of time-delay with respect to the pump pulse.

Polarisation rotation signals reveal the quasi-ferromagnetic magnon mode over the spin reorientation temperature region, shown in Fig.1b. A complementary experiment performed on the $ErFeO_3$ sample provided similar evidence for phonon-driven excitation by an observed increase in the magnitude of magnon oscillations approaching resonant excitation of infrared phonons. While the frequency dependence in $TmFeO_3$ (Fig.1c) agrees with prior experimental results which used another non-thermal excitation [4], the pump polarisation dependence differs from expectation. Further investigation into the interesting behaviour of phonon-driven spin dynamics will yield a better understanding of how the mechanism differs between rare-earth orthoferrites.

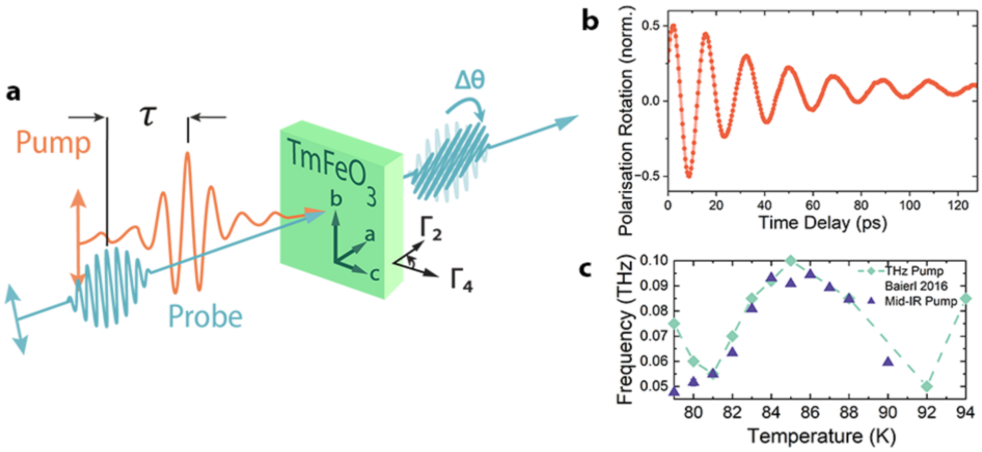


**Fig.1 a** Schematic of the pump-probe experimental setup. The antiferromagnetic vector reorients itself from the *c* to *a* crystallographic axis as the temperature is increased. **b** The normalised polarisation rotation signal measured at 82K with exponential offset removed. **c** Frequency dependence calculated from Fourier transforms of the rotation data across the spin reorientation region. Good agreement is observed between our experimental data and previous resonant THz excitation measurements [4].

**References**


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