Optically Driven Collective Magnetic Cycloid and Néel-type Skyrmion Lattice Excitations in GaV_4S_8

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The manipulation and control of Skyrmion dynamics has received a great deal of interest in recent years, fueled by the importance of these magnetic topological defects in technological applications and emergent phenomena [1]. Here, we report on time-resolved magneto-optical Kerr effect (TR-MOKE) measurements that demonstrate the coherent collective excitation of magnetic cycloid (Cyc) and Néel-type Skyrmion lattice (SkL) states in the lacunar spinel GaV_4S_8. These GHz oscillations of the magnetic texture, as seen in Figure 1, are driven by an optically induced thermal modulation of the host material's uniaxial magnetic anisotropy. This conclusion is supported by micromagnetic simulations of the SkL dynamics under the Landau-Lifshitz-Gilbrt equation, as shown in Figure 2. In addition, we observe a transient enhancement of the magnetization, as seen in Figure 3, due to the optically-induced switching between the Cyc and SkL states. Our results establish an alternative route towards the optical manipulation of novel spin textures through the intimate coupling between the lattice and spin degrees of freedom.

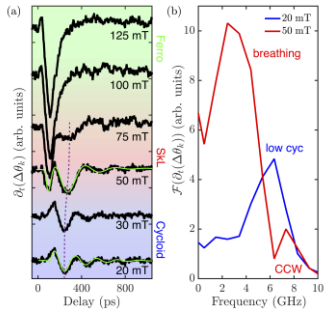

Figure 1: (a) Time-derivative of TR-MOKE traces showing collective Cyc and SkL oscillations and **(b)** Fourier transforms of the 20 mT and 50 mT traces in **(a)** showing the dominant modes [2].

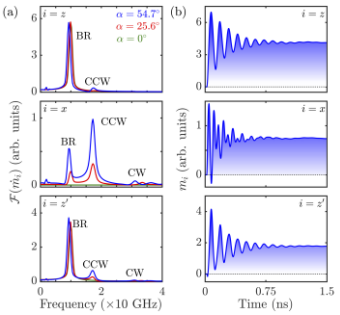

Figure 2: (a) Fourier transforms of the simulated SkL $\partial_t m_z(t)$, $\partial_t m_x(t)$, and $\partial_t m_{z'}(t)$ for different angles α between the external magnetic field and the rhombohedral axis and **(b)** simulated $m_z(t)$, $m_x(t)$, and $m_{z'}(t)$ for $\alpha = 54.7^\circ$ [2].

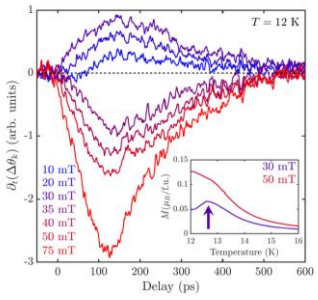

Figure (3): Derivative of TR-MOKE signals taken at 12 K at various external magnetic fields. The inset shows the temperature dependence of the magnetization at 30 mT (purple) and 50 mT (red). The arrow marks the peak at the Cyc/SkL interface [2].

References:

[1] A. Rosch, "Electric control of skyrmions," Nat. Nanotechnol. 12, 103 (2016).

[2] P. Padmanabhan, F. Sekiguchi, R. B. Versteeg, E. Slivina, V. Tsurkan, S. Bordács, I. Kézsmárki, and P. H. M. van Loosdrecht, "Optically Driven Collective Spin Excitations and Magnetization Dynamics in the Néel-type Skyrmion Host GaV_4S_8, "Phys. Rev. Lett. 122, 107203 (2019).