Stroboscopic XMCD-PEEM Imaging of Standing and Propagating Spinwave Modes in Permalloy Thin-Film Structures

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Stroboscopic PEEM imaging is being used by an increasing number of groups for probing fast processes and transient states (for a recent review, see [1]). Exploiting the time structure of Synchrotron radiation in a special bunch-compression mode (low-α mode at BESSY), we have reached a time resolution in the 10 ps range, determined by the photon pulse width of < 5 ps and an electronic jitter of the set-up. Snapshot images are obtained by varying the delay time between the onset of the pump pulse (in our case the magnetic field) and the photon pulse (probe). For intensity reasons, images have to be averaged over typically 10^8 cycles. Hence, periodic processes like spinwaves are an ideal testing ground for stroboscopic PEEM imaging. In this contribution, we present spinwave modes in structured thin permalloy ($Ni_{80}Fe_{20}$) films.

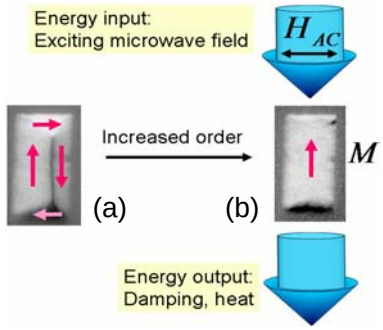

***Fig. 1**: Standing mode*

Standing modes have been studied in rectangular elements (16x32 microns^2, 30 nm thick). They were excited by an electromagnetic microwave field applied to the thin-film element via a coplanar waveguide [2]. Fig. 1 shows the surprising result: The particle is driven from the initial Landau flux-closure state (a) into a single-domain state (b) magnetized *perpendicular* to the applied field $\boldsymbol{H_{AC}}$. We discuss this behaviour as a result of the constant throughput of energy (open system) that allows for an increase of local order, contrary to the usual increase on entropy in closed systems.

A *propagating phase front of a spinwave* in the upper part of an elliptical particle (semi axes: 6x12 micron^2, 3 nm thick) is visible in the snapshot sequence Fig. 2 (50 ps increment), taken close to the field pulse maximum. Starting at 150ps, the phase front of a wave with large precessional angle (bright contrast) propagates from the left to the right. Its phase velocity is 14000 m/s, i.e. much larger than typical domain wall velocities in permalloy.

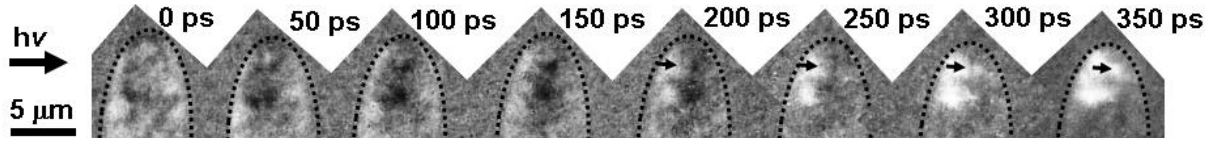

***Fig. 2:** Propagating phase front (arrow) of a spinwave in the upper part of an elliptical thin-film structure*

[1] G. Schönhense, H.J. Elmers, S.A. Nepijko, C.M. Schneider; Adv. in Imaging and El. Physics **142**, July 2006
[2] A. Krasyuk et al., Phys. Rev. Lett. **95** (2005) 207201