Role of coercivity in surface acoustic wave driven ferromagnetic resonance

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Paralleling the developments of surface acoustic wave driven ferromagnetic resonance (SAW-FMR) over the past decade, the magnetic field sensing community has developed devices that rely on the same physics but approach questions from an acoustic perspective. Whether using magnetoelasticity to manipulate magnetization or to perform on-chip field measurements via acoustic properties, magnetic hysteresis is at best avoided and at worst constitutes a real problem to deal with. Here we report how we could instead use it to our benefit.

We report the first observation of SAW-FMR on polycrystalline FeRh [1] in its ferromagnetic phase (Fig. 1(a, b)). We use this material as a test-bench to study the role of hysteresis on SAW FMR, exploiting the steep temperature variations of the coercivity upon its first-order transition between FM and AFM states. A strong hysteresis of the resonance fields is observed and found to correlate with the static coercivity of the sample, as confirmed by temperature-dependent. The angular dependence of SAW-FMR is furthermore measured and found to exhibit a wide variety of shapes that differ from commonly observed resonance curves (*e.g.* for a field perpendicular to k_{SAW} in Fig. 1(c)). By modeling the hysteresis of the sample using a simple macrospin approach, we show that the observed features result from the softening of the magnetic eigenfrequency and of the magnetoelastic field allowed by hysteresis [2]. This observation opens up the possibility of coupling resonantly SAWs to magnetization dynamics for both low magnetic fields/low frequencies, which is normally possible only for samples presenting magnetic anisotropy. Long considered a problem to be reckoned with, hysteresis may now instead offer an appealing alternative for on-chip integration of magnetic SAW sensors.

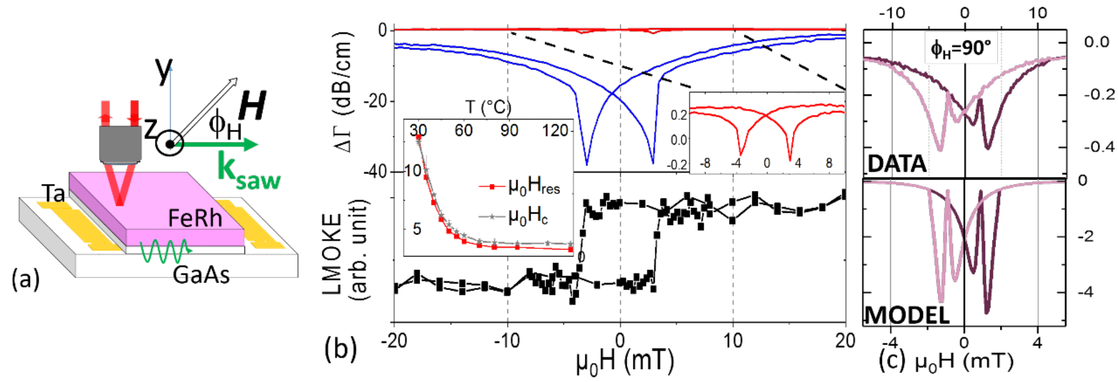

Figure 1. (a) Sample geometry and longitudinal Kerr microscopy setup. The SAW is generated using piezoelectric GaAs by applying a radio-frequency pulse on the left interdigitated transducer (IDT). The voltage on the receiving IDT is recorded versus magnetic field. (b) [top] SAW amplitude variations at T=130°C (field along the k_{saw}) for f_{SAW}=299 MHz (red, zoomed in the inset) and 889 MHz (blue). [bottom] Longitudinal Kerr cycle obtained by averaging a microscopy image of the FeRh mesa taken in front of the exciting IDT. The left inset shows a perfect correlation between SAW FMR resonance field (red symbol) and coercive field (gray symbol) when varying the temperature. (c) Example of a SAW FMR curve (data and model) for a field perpendicular to k_{SAW}. The peaks and dips are well rendered by a hysteretic macrospin approach.

References

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[2] A. K. Vythelingum, T. Tremblais, D. Nguyen, D. Ourdani, E. Dandeu, V. Laude, C. Gourdon, and L. Thevenard, *https://cnrs.hal.science/hal-04930503*.