Seminar :

Hiroki Matsumoto[1,2,3*]

1 Department of Physics, The University of Tokyo, Japan
2 Institute for Chemical Research, Kyoto University, Japan
3 Department of Materials, ETH Zürich, Switzerland

Daigo Oue[1, 2, *]

1 Instituto de Telecomunicações, Instituto Superior Técnico, University of Lisbon
2 The Blackett Laboratory, Department of Physics, Imperial College London

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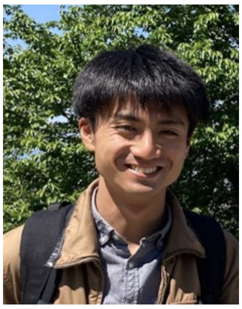
Phonon-magnon coupling in a synthetic antiferromagnet embedded in a surface acoustic wave resonator

Hiroki Matsumoto



Phonons and magnons are elementary excitations of atomic and magnetic order in a magnetic solid. A surface acoustic wave (SAW) device is a powerful tool to study phonon-magnon coupling in a ferromagnetic thin film, which is simply detected as reduction of SAW transmission due to SAW-driven ferromagnetic resonance [1,2]. Recently, phonon-magnon coupling of a ferromagnetic Ni film in a SAW resonator was studied experimentally and numerically, exploring potential of the system for quantum applications [3].

A typical SAW device has comb-shaped antennas, referred to as interdigital transducers (IDTs), on a piezoelectric substrate. The resonance frequency of SAW depends on width and gap of periodic wires in the IDT, which is typically of the order of 1 GHz. Magnon frequency in transition metal ferromagnets, however, is a few GHz or even higher, meaning that SAW phonons can couple to magnons only under a small magnetic field, where a multi-domain state is formed, which hampers coherent excitation of magnons. To get over this, we use a synthetic antiferromagnet (SAF). The frequency of magnons of SAF is smaller than its single layer counterpart under a certain magnetic field [4], which is large enough to keep the magnetizations saturated.

We experimentally and numerically investigate phonon-magnon coupling in a tri-layer synthetic antiferromagnet (SAF) using a surface acoustic wave (SAW) resonator [5,6]. The SAF is composed of an ultrathin (~ 0.5 nm) non-magnetic Ru layer sandwiched by two ferromagnetic CoFeB layers (~ 5 nm). We perform scattering matrix measurements to study transmission spectra of SAW, which are influeced by phonon-magnon coupling. Linewidth and resonance frequency of a peak in the transmission are modulated when the magnon frequency approaches to SAW resonance frequency. We assess the phonon-magnon coupling constant from the linewidth broadening. Our results show that SAF provides an ideal platform to study phonon-magnon coupling in a SAW resonator.

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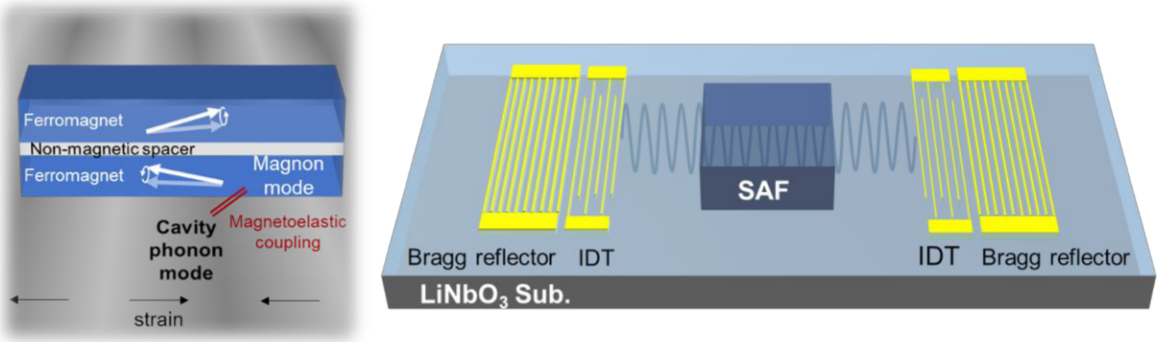

Fig. Schematic of the study. (Left) Acoustic magnon mode in a tri-layer synthetic antiferromagnet (SAF) coupling to cavity phonon mode, as a form of a surface acoustic wave (SAW). (Right) Schematic of the device used in this study. The surface acoustic wave resonator is composed of interdigital transducers (IDTs) for the excitation and detection of SAW and bragg reflectors to confine SAW inside the resonator. SAF is formed on the wave path of SAW.

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Motion-induced spin transfer

Daigo Oue

We theoretically propose a spin transport induced by inertial motion. Our system comprises two host media and a narrow vacuum gap in between [Figure (a)]. Magnons reside in and are exchanged between the two media, carrying angular momenta (spins). One of the hosts is sliding at a constant speed while the other is at rest. This mechanical motion brings about the Doppler effect, which affects the magnon spectrum and population in the moving medium. As a consequence, the population difference between the two media is induced; thereby, tunnelling spin currents may be driven. We have evaluated the spin current with a perturbative approach [Figure (b)]. The spin current can be of the order of nA, which could be detected by measuring the inverse spin Hall voltage. This scheme does not require temperature difference, voltage, or chemical potential.

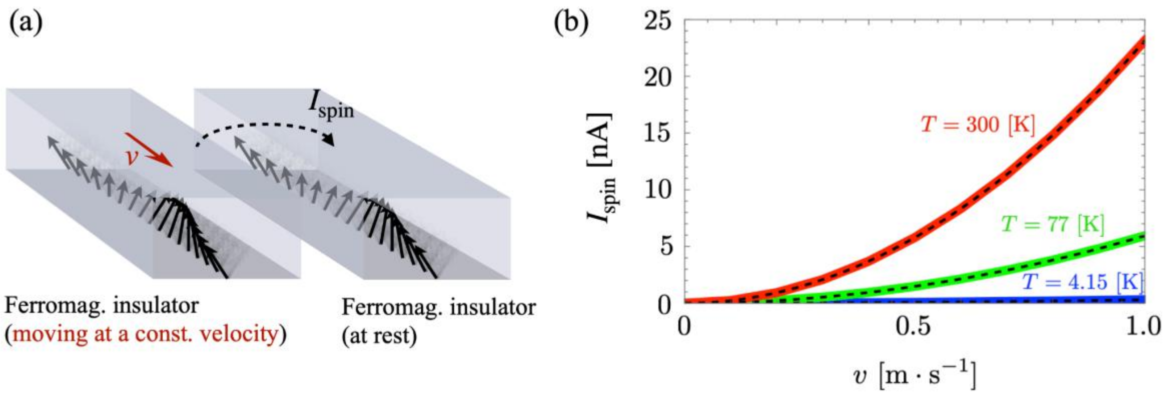

Figure: (a) the schematic image of the setup under consideration; (b) the motion-induced spin current as a function of the velocity (YIG is considered for the host media in this calculation).

References

[1] D. Oue and M. Matsuo "Motion-induced spin transfer." Phys. Rev. B 105, L020302 (2022).

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