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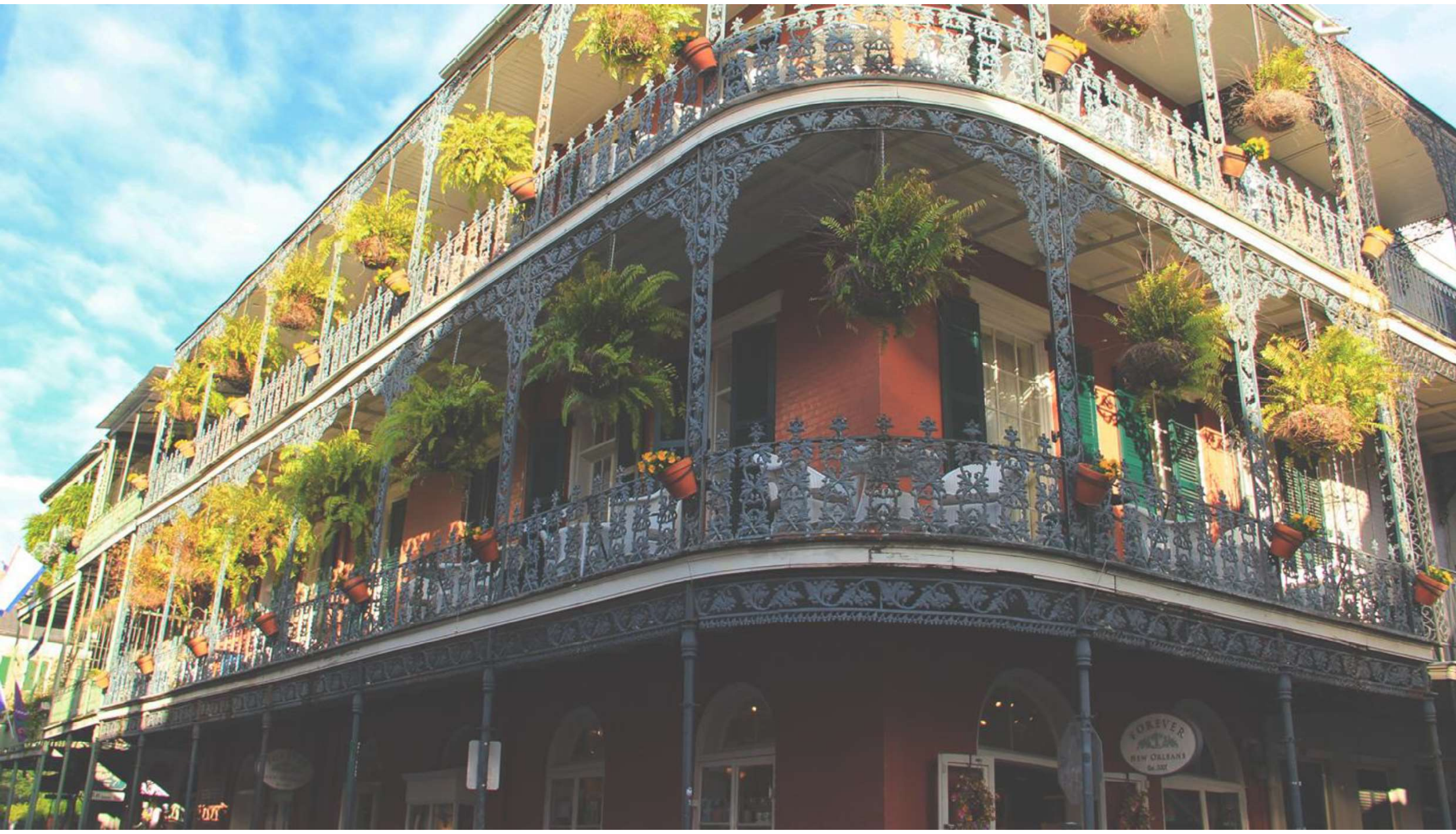
Abstract Book



Session FOC

MAGNETOELASTICS AND MAGNETOOPTICS

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INVITED PAPER

FOC-01. Conditions for effective coupling between surface acoustic waves and spin waves.

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The frequencies and wave vectors of dipolar dominated spin waves (SW) and surface acoustic waves (SAW) cover the same ranges. Therefore, the propagating waves of both kinds can potentially scatter each other - in other words, the necessary condition for the interaction in a linear regime can be satisfied. The simplest structure in which the magnetoelastic coupling between SW and SAW can be observed is the magnetostrictive layer deposited on the substrate. The confinement of SWs in the magnetic layer is necessary to induce the dipolar interaction and surface localization of SAW ensures the co-existence of both kinds of waves in the magnetostrictive layer deposited on the surface. The strength of the magnetoelastic interaction depends on the orientation of the wave vector concerning the direction of the static magnetic field[1]. Moreover, this interaction is different for different types of SAWs, specifically, Rayleigh-SAWs (R-SAW) and Love-SAWs (L-SAW)[1,4] – see Fig.1. Thus, the coupling is strongly anisotropic and cannot be observed for arbitrary selected SAWs and SWs, even if their frequencies and wave vectors match. This effect is well-known and broadly discussed in the literature[1]. Our study shows an additional factor limiting the interaction between SAWs and SWs. The SAW/SW coupling proves to require an appropriate profile of the elastic wave near the surface of the magnetostrictive structure, at distances much smaller than the wavelength. For R-SAWs the tangential component of displacement u_x can have nodes within the magnetic layer, resulting in a reduction of the net strength of magnetoelastic interaction even if the strain ε_{xx} is locally significant. In an L-SAW the displacement u_y does not have any nodes (u_y changes monotonously in the normal direction). We have shown that this additional factor plays a role for some types of surface acoustic waves (R-SAWs), while other types (L-SAWs) are insensitive to it. We think that the studies on magnon-phonon interaction in confined geometries (surfaces, cavities) are very promising and can reveal unusual interaction mechanisms. *Sample* We studied $[Co_{20}Fe_{60}B_{20}/Au]_{20}$ multilayer of the thickness 60 nm as a magnetostrictive medium. In $Co_{20}Fe_{60}B_{20}$ layers (2.1 nm) the magnetization is oriented in-plane and the presence of Au layers (0.9 nm) reduces the SWs' frequencies due to out-of-plane anisotropy. The multilayer was deposited on top of a 4 nm titanium (Ti) and a 15 nm gold (Au), which buffers the naturally oxidized (001) silicon substrate. *Method* We measured the dispersion relations of thermally excited SAWs and magnetostatic SWs using a six-pass tandem Brillouin spectrometer (Scientific Instrumentsc©TFP2-HC), which ensures a contrast of 10^{15}. A frequency-stabilized diode-pumped solid-state laser (Coherentc©VERDI V5) operating at λ_0= 532 nm was used as a source of incident light. The measurements were performed in the 180^o backscattering geometry with crossed (p-s)polarization of the incident and scattered light for SWs and non-crossed (p-p) polarization for SAWs. Using the finite element method in COMSOL Multiphysics$^©$, we solve numerically the coupled equations of motion for magnetization and mechanic displacement. *Acknowledgement* The authors hereby acknowledge the financial support from the National Science Centre, Poland, project No. UMO-2016/21/B/ST3/00452. S. Mies. would like to additionally acknowledge the support from the National Science Centre, Poland, project No. UMO-2020/36/T/ST3/00542.

[1] L. Dreher, M. Weiler, M. Pernpeintner, et al., Phys. Rev. B, Vol. 86, p. 134415 (2012) [2] N. K. P. Babu, A. Trzaskowska, P. Graczyk, et al., Nano Lett., Vol. 21, p.946 (2020) [3] Y. Hashimoto, D. Bossini, T. H. Johansen, et al., Phys. Rev., Vol. 97, p.14040 (2016) [4] M. Geilen, F. Kohl, A. Nicoloiu, et al., Appl. Phys. Lett., Vol. 117, p. 213501 (2020) [5] N.E. Khokhlov, P.I. Gerevenkov, L.A. Shelukhin, et al., Phys. Rev. Applied, Vol. 12, p. 044044 (2019)

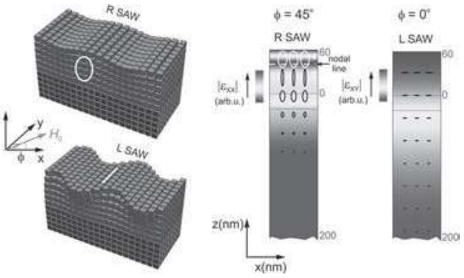

Fig.1 (left) - the illustration of the Rayleigh and Love surface acoustic waves (R SAW and L SAW). (right) -the numerically calculated profiles of the strain tensor playing the most significant role for magnetoelastic interaction of spin waves with R SAW (magnetic field applied the 45 deg) and L SAW (magnetic field applied at 0 deg). Please note that the interaction with R SAW can be canceled due to the nodal line.

CONTRIBUTED PAPERS

FOC-02. Enhanced Magnetic Actuation of Magnetorheological Elastomers Using Nano-Magnetic Particles.

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Magnetorheological elastomers (MREs) constitute ideal candidates for enabling magnetic control and reconfigurability of soft, integrated interfaces, such as valves for microfluidics, tactile displays for haptics, or actuators for flexible electronics or robotics [1-2]. MREs are composite materials made of a soft elastomeric matrix and magnetic micro- or nanoparticles. Just a few studies have focused on the actuation of MREs, which can undergo very large and rapid deformations upon application of magnetic fields [3–5]. Additionally, prior studies primarily fabricated MREs utilizing relatively large particles with sizes on the micron scale [2–8], which prevent these materials from being utilized to recreate shapes requiring sharp film curvatures in small spaces. We fabricated films with isotropic and anisotropic particle arrangements with different compositions. Anisotropic films present a steeper magnetization curve with larger remanent magnetization than their isotropic counterparts (Fig. 1a). Also, the stiffness of the films