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EC-08. The Interaction Between Surface Acoustic Waves and Spin Waves: the Role of Anisotropy and Spatial Profiles of the Modes.

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The interaction between different types of wave excitation in hybrid systems is usually anisotropic. Magnetoelastic coupling between surface acoustic waves and spin waves strongly depends on the direction of the external magnetic field. However, in the present study we observe that even if the orientation of the field is supportive for the coupling, the magnetoelastic interaction can be significantly reduced for surface acoustic waves with a particular profile in the dirR/S-SAWection normal to the surface at distances much smaller than the wavelength. We use Brillouin light scattering to investigate thermally excited phonons and magnons in a magnetostrictive CoFeB/Au multilayer deposited on a Si substrate – see Fig.1. The experimental data interpretation is based on a linearized model of interaction and finite element method computations[1]. For propagating waves, the coupling requires matching both the frequencies and the wavelengths[2]. This condition can be fulfilled for spin waves (SWs) and surface acoustic waves (SAWs) existing in the same range of frequencies and wave vectors. However, the strength of the magnetoelastic interaction depends on the orientation of the wave vector with respect to the direction of the static magnetic field[3]. Moreover, this interaction is different for different types of SAWs, specifically, Rayleigh-SAWs (R-SAW) and Love-SAWs (L-SAW)[1,4] – see Fig.2. Thus, the coupling is strongly anisotropic and cannot be observed for arbitrary SAWs and SWs, even if their frequencies and wave vectors match. Our study reveals 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 magnetostrictve 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). The location of R-SAW nodes depends on elastic properties of the system, specifically, the elastic material parameters of the multilayer and the substrate, and the thickness of the multilayer. We have shown that this additional factor plays a role for some types of surface acoustic waves (R-SAW), while other types (L-SAW) are insensitive to it. We believe that the studies on magnon-phonon interaction in confined geometries (surfaces, cavities) are very promising and can reveal unusual interaction mechanisms. *Sample* We used naturally oxidized (001) silicon as a substrate supporting the studied $[Co_{20}Fe_{60}B_{20}/Au]_{20}$ multilayers deposited on top of a 4 nm titanium (Ti) and a 15 nm gold (Au) buffer layers. The multilayers were deposited by magnetron sputtering in argon atmosphere. *Method* We studied 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° backscattering geometry with crossed (p-s)polarization of 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 mechanic displacement and magnetization. The CoFeB/Au multilayer is treated as a 60-nm-thick effective magnetic layer, and the CoFeB/Au multilayer together with the Ti/Au buffer as an 80-nm-thick effective acoustic layer on a Si substrate. *Acknowledgement* The research leading to these results has received funding, hereby gratefully acknowledged, from the National Science Centre, Poland, project No. UMO-2016/21/B/ST3/00452. S. Mies. would like to additionally acknowledge the financial support from the National Science Centre, Poland, project No. UMO-2020/36/T/ST3/00542.

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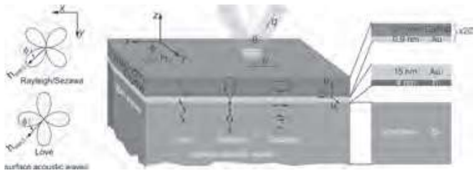

Fig.1 In the studied system acoustic waves propagate along the surface of the silicon substrate and are mostly concentrated in the CoFeB/Au multilayer cover. The multilayer can be regarded as an effective magnetostrictive medium where surface acoustic waves can interact with spin waves. The anisotropy of magnetoelastic interaction (i.e. the dependence on the orientation f of magnetic field) is different for Love and Rayleigh/Sezawa acoustic waves (L-SAW, R/S-SAW); presented on the left are the respective polar plots of the in-plane component of magneto elastic field.

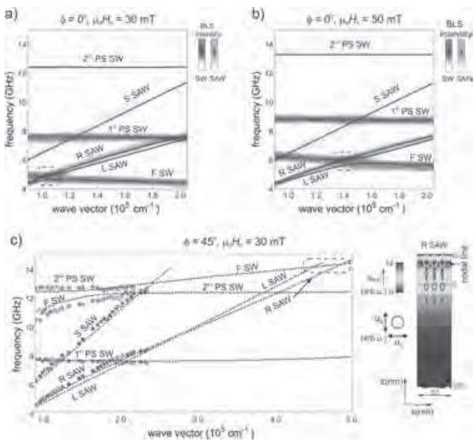

Fig.2 The BLS experimental magnetoelastic dispersion relation measured for magnons (redlines) and phonons (blue lines) with an in-plane applied magnetic field of (a) 30 mT and (b) 50 mT for Φ=0 deg. The dashed shows the regions where the frequencies of fundamental spin wave fundamental mode (F-SW) and L-SAW or R-SAW are agreed. The interactions is seen for L-SAW only. (c) For Φ=45 deg observe the lack of R-SAW/F-SW interaction, which cannot be explained based on the interaction anisotropy (see $h_{me,\parallel}(\Phi)$ for R-SAW in Fig.1). The R-SAW/F-SW interaction is suppressed to zero due to the presence of a nodal line for the ε_{xx} component of the strain tensor, which averages to zero the magnetoelastic coupling.