Symmetry of the magnetoelastic interaction of Rayleigh- and shear horizontal-magnetoacoustic waves in nickel thin films on LiTaO₃

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We study the interaction of Rayleigh and shear horizontal surface acoustic waves (SAWs) with spin waves in thin Ni films on a piezoelectric LiTaO₃ substrate, which supports both SAW modes simultaneously. Because Rayleigh and shear horizontal modes induce different strain components in the Ni thin films, the symmetries of the magnetoelastic driving fields, of the magnetoelastic response, and of the transmission nonreciprocity differ for both SAW modes. Our experimental findings are well explained by a theoretical model based on a modified Landau–Lifshitz–Gilbert approach. We show that the symmetries of the magnetoelastic response driven by Rayleigh- and shear horizontal SAWs complement each other, which makes it possible to excite spin waves for any relative orientation of magnetization and SAW propagation direction and, moreover, can be utilized to characterize surface strain components of unknown acoustic wave modes.

I. INTRODUCTION

Due to the wealth of useful properties of surface acoustic waves (SAW) combined with the ease of launching and detecting SAWs on a piezoelectric crystal and low cost fabrication processes, SAW technology is employed in manifold ways in our daily life as rf-filters [1], sensors [2], and lab-on-a-chip applications [3]. However, also basic research benefited very profoundly from the use of SAWs, ranging from quantum phenomena in low dimensional electron systems [4] to acoustically operated nanophotonic devices [5].

In recent years increasing attention has been paid to the coupling of SAWs with thin magnetic films. On the one hand, it was demonstrated that this coupling makes a new type of magnetic field sensors with an excellent signal-to-noise ratio possible [6]. On the other hand, SAWs can excite spin waves (SW) in magnetic films, which turns out to be a fruitful playground for studying the SAW-SW coupling mechanism itself [7,8,11,12], characterizing the SW-dispersion relations [13,14] or even developing new kinds of “acoustic diodes” [14,19] based on nonreciprocity.

Although SAW propagation is in general reciprocal, i.e. invariant under inversion of the propagation direction, the coupling mechanism with the SW, and the SW propagation itself can be nonreciprocal. First, a pronounced nonreciprocal SW dispersion relation is obtained, inter alia, due to the interfacial Dzyaloshinskii–Moriya interaction (DMI) in a ferromagnetic/heavy metal bilayer [14,18]. Secondly, the nonreciprocity of the SAW-SW coupling mechanism arises, because of a helicity mismatch between the magnetic driving fields, induced by the SAW and the fixed, right-handed rotational sense of the magnetic moments [8,14,15].

Nevertheless, both the observation and possible technological application of these interesting effects are limited to certain experimental geometries, defined by the orientation of the static magnetization M with respect to the SW wave vector kₘagnetostatic SW excitation is possible for any in-plane field k directors in the Ni thin films, the symmetries of the magnetoelastic driving fields [8]. So far, mainly Rayleigh-type (R) SAWs on piezoelectric LiNbO₃ substrates have been studied [7,8,10,13,15,17,20], which show vanishing magnetoelastic SW excitation efficiency for the often discussed backward volume magnetostatic SW mode (M∥k) and magnetostatic surface SW mode (M⊥k). Previous experiments, using shear horizontal (SH) SAW modes were not focused on resonant coupling of the SH-waves with SWs [6,21,22].

In this study, we demonstrate in detail how the SAW mode-shape determines the symmetry of the magnetoelastic interaction and its nonreciprocal behavior, caused by the SAW-SW helicity mismatch effect. Since we use a LiTaO₃ substrate, which simultaneously supports both R- and SH-wave excitation, we can directly compare the symmetry of the magnetoelastic response of both SAW modes. Because the symmetry of the magnetoelastic driving fields of R- and SH-wave complement each other, efficient SW excitation is possible for any in-plane field geometry, which in fact could be a technologically relevant aspect. In particular, the SH-wave allows efficient magnetoelastic coupling for M∥k and M⊥k.
FIG. 1. Schematic illustration of the experimental setup. R-wave and SH-wave modes can be both excited on the LiTaO\textsubscript{3} substrate. The FEM eigenfrequency simulation of the SAW modes shows the magnitude of the strain \(\varepsilon_{xx}, \varepsilon_{xy}\) in false colors (green: low strain, blue and red: large positive and negative strain) and the exaggerated lattice deformation for the LiTaO\textsubscript{3}/Ni(10 nm)/Al(5 nm) layer stack and a wavelength of 1.17 \(\mu\)m. The 1000 \(\mu\)m long Ni film is placed centered between the 1600 \(\mu\)m distant IDTs. The nonreciprocal behavior of both SAW modes is characterized by different transmission amplitudes \(\Delta S_{21}\) and \(\Delta S_{12}\) for oppositely propagating SAWs \(k_{S21}\) and \(k_{S12}\).

II. THEORY AND FEM SIMULATION

First, we discuss the nonreciprocal transmission characteristics of the magnetoacoustic sample displayed in Fig. 1. A SAW is excited on the piezoelectric substrate, once an alternating voltage with the resonance frequency \(f = \text{c}_{\text{SAW}}/\lambda\) of the interdigital transducer (IDT) is applied. Here, \(\text{c}_{\text{SAW}}\) is the propagation velocity of the SAW and \(\lambda\) is the wavelength, given by the periodicity of the IDT. In this study, we use a 36\(^\circ\)-rotated Y-cut X-propagation LiTaO\textsubscript{3} substrate, which supports both a R-mode (\(\text{c}_{\text{SAW}} = 3232\) m/s) and a SH-mode (\(\text{c}_{\text{SAW}} = 4112\) m/s) \[23\], resulting in different IDT resonance frequencies. The lattice displacement of both modes is depicted in Fig. 1 for the LiTaO\textsubscript{3}/Ni(10 nm)/Al(5 nm) layer stack. Depending on the wave mode, either SAW will induce specific strain components in the thin ferromagnetic Ni-film and dynamically modulate the magnetic free energy due to magnetostriiction. Because of the high magnetoelastic coupling efficiency of Ni, we here neglect nonmagnetoelastic interaction, like magneto-rotational coupling \[9, 10, 14\], spin-rotational coupling \[11, 24, 25\] or gyromagnetic coupling \[12\].

The SAW-SW interaction can be described by dynamic magnetoelastic driving fields, which exert a torque on the static magnetization \(\mathbf{M}\) \[7\]. The resulting attenuated precession of \(\mathbf{M}\) is then given by the Landau–Lifshitz–Gilbert equation. As shown in Fig. 1 an external magnetic field \(\mathbf{H}\) with the direction \(\phi_H\) is applied to align the static magnetization \(\mathbf{M}\) to the angle \(\phi_0\) in the film plane. According to Ref. \[13\], the magnetoelastic driving fields \(\mathbf{h}(x,t)\) with the normalized out-of-plane component \(\tilde{h}_1\) and in-plane component \(\tilde{h}_2\), both being perpendicular to \(\mathbf{M}\), are a function of the SAW power \(P_{\text{SAW}}\)

\[
\mathbf{h}(x,t) = \left(\frac{\tilde{h}_1}{\tilde{h}_2}\right) \sqrt{\frac{k^2}{R\omega W}} \sqrt{P_{\text{SAW}}(x)} e^{i(kx-\omega t)}. \tag{1}
\]

Here, \(k\) and \(\omega\) are the wave vector and angular frequency of the SAW, respectively, \(W\) is the aperture of the IDT and \(R\) is a constant factor, depending on the type of the SAW mode. Following Dreher et al. \[8\], the symmetry of the normalized magnetoelastic driving fields \(\tilde{h}_1\) and \(\tilde{h}_2\) for vanishing strain \(\varepsilon_{xy}\) are

\[
\left(\frac{\tilde{h}_1}{\tilde{h}_2}\right) = \left(\frac{\tilde{h}_{1e} + i\tilde{h}_{1m}}{\tilde{h}_{2e} + i\tilde{h}_{2m}}\right) = 2\frac{\mu_0}{b_1} \left(\begin{array}{c}
b_{xx} \cos \phi_0 + b_{yz} \sin \phi_0 \\
b_{xx} \sin \phi_0 \cos \phi_0 - b_{xy} \cos(2\phi_0)\end{array}\right). \tag{2}
\]

The magnetoelastic parameters are \(b_{kl} = b_1\tilde{a}_{kl}\) (\(kl \in \{xx, xy, xz, yz\}\)) with an isotropic magnetoelastic coupling constant \(b_1 = b_2\) for polycrystalline films.

The complex amplitudes of the normalized strain \(\tilde{a}_{kl} = \varepsilon_{kl,0}/(|k||u_{z,0}|)\), where \(u_{z,0}\) is the amplitude of the lattice displacement in z direction, can be determined by a finite element method (FEM) simulation \[14\]. Results and parameters of the FEM simulation are given in Table I. Figures 2(a) and 2(b) show the calculated strain components of the R- and SH-wave in the center plain of the Ni-film, as simulated for the LiTaO\textsubscript{3}/Ni(10 nm)/Al(5 nm) structure and for the resonance frequencies of the IDTs. Because the longitudinal strain \(\varepsilon_{xx}\) is dominating in the R-mode, the main symmetry of the driving field in Eq. 2 is \(\propto \sin \phi_0 \cos \phi_0\) \[7, 8, 13\]. In contrast, \(\varepsilon_{xy}\) is dominating for the SH-mode and the expected symmetry of the main driving field component is \(\propto \cos(2\phi_0)\). We thus expect qualitatively different dependencies of SAW absorption on the magnetization direction \(\phi_0\) for magnetoacoustic resonance driven by R and SH SAWs.

Smaller strain components potentially cause nonreciprocal SAW transmission due to the SAW-SW helicity mismatch effect \[8, 14, 15\]. For the R-wave (SH-wave) the strain components \(\varepsilon_{xy,xx}\) \((\varepsilon_{xx,yz})\) are phase shifted by \(+90^\circ\) \((-90^\circ)\) with respect to the main strain component \(\varepsilon_{xx}\) \((\varepsilon_{xy})\). Therefore, the corresponding amplitudes of \(\varepsilon_{kl,0}\), \(\tilde{a}_{kl}\), and \(\tilde{h}_{12}\) are complex and we can separate the real and imaginary part of \(\tilde{h}_{12}\) with \(\tilde{h}_{12}^{\text{Re}} = \text{Re}(\tilde{h}_{12})\) and \(\tilde{h}_{12}^{\text{Im}} = \text{Im}(\tilde{h}_{12})\). By reversing the propagation direction of the SAW (\(k_{S21} \rightarrow k_{S12}\)), the phase difference between the complex and the main strain components becomes inverted. Thus, the helicity of the driving fields changes. This is expressed by the inversion of the sign.
of the complex $\tilde{a}_{kl}$ in Table 1. In combination with the fixed, right-handed rotational sense of the magnetization precession, the SAW–SW helicity mismatch effect arises, inducing nonreciprocal efficiency of SAW excitation and SAW absorption.

$$P_{\text{abs}} = P_0 \left[ 1 - \exp \left( -CM_k \left[ H_0^2 - H_{11}H_{22} + (\alpha H_\omega)^2 \right] + (\alpha H_\omega(H_{11} + H_{22}))^2 \right) \times \left[ H_0^2 + H_{11}^2 + (\alpha H_\omega)^2 \right] \left( \tilde{h}_2^{\text{Re}} \right)^2 + \left( \tilde{h}_2^{\text{Im}} \right)^2 \right] + [H_\omega(H_{11} + H_{22})] \left( \tilde{h}_1^{\text{Re}} - \tilde{h}_1^{\text{Im}} \right) \left( \tilde{h}_2^{\text{Re}} + (\alpha H_\omega)^2 \right) \left( \tilde{h}_1^{\text{Re}} + (\alpha H_\omega)^2 \right) \right].$$

(3)

With respect to the initial power $P_0$, the power of the traveling SAW is exponentially decaying while propagating through the magnetic thin film. The decay rate depends on the effective SW damping constant $\alpha$ and $C$, $H_\omega$, $H_{11}$, $H_{22}$, which are defined in Ref. [14]. Eq. (3) is derived by taking into account, (i) the Zeeman energy, (ii) a uniaxial in-plane magnetic anisotropy field $H_{\text{ani}}$, under an angle $\phi_{\text{ani}}$ with the $x$ axis, (iii) an out-of-plane magnetic anisotropy field $H_k$, counteracting the magnetic shape anisotropy, and (iv) the dipolar fields of the SW [26].

Finally, to directly fit the exponent of Eq. (3) to the experimentally determined relative change of the SAW transmission $\Delta S_{ij}$ on logarithmic scale, the fit equation is given by

$$\Delta S_{ij} = 10 \log \left( \frac{P_0 - P_{\text{abs}}}{P_0} \right).$$

(4)

The symmetry of $\Delta S_{ij}$ is determined by the symmetry of the driving fields, as discussed before. We obtain for the main symmetry of R-waves (SH-waves) $\Delta S_{ij} \propto (\sin \phi_0 \cos \phi_0)^2 (\Delta S_{ij} \propto \sin^2 2\phi_0)$. Employing the FEM study, the real and imaginary terms in Eq. (2) can be identified. For R-waves and SH-waves, the expected leading term which causes nonreciprocity ($\Delta S_{21} - \Delta S_{12} \neq 0$) is $\tilde{h}_1^{\text{Re}} \tilde{h}_2^{\text{Re}}$. This nonreciprocity for R-waves (SH-waves) is mediated by the strain component $\varepsilon_{xx}$ ($\varepsilon_{yy}$) with the symmetry of the nonreciprocity being proportional to $\sin \phi_0 \cos^2 \phi_0$ ($\sin \phi_0 \cos 2\phi_0$).

III. EXPERIMENTAL METHODS

To prove the theoretical predictions for R- and SH-waves, we fabricated a heterostructure, as depicted in Fig. 1(a) IDTs with a periodicity of 3.4 $\mu$m and a 200 $\mu$m aperture were e-beam lithographically defined on a 36°-rotated Y-cut X-propagation LiTaO$_3$ substrate, evaporating 5 nm Ti and 70 nm of Al. The rectangular-shaped Ni(10 nm)/Al(5 nm) film was magnetron sputtered (base pressure $<10^{-8}$ mbar) at room temperature and positioned in the middle between the two 1600 $\mu$m spaced IDTs. The Ar pressure was kept constant at $3.5 \times 10^{-3}$ mbar and the sample holder was rotated during sputtering.

We carried out superconducting quantum interference device-vibrating sample magnetometry measure-
ments (SQUID-VSM) to determine the saturation magnetization ($M_s = 408$ kA/m). Additionally, broadband ferromagnetic resonance (FMR) measurements were performed to obtain values for the g-factor, the out-of-plane magnetic anisotropy $H_{kFMR}$ and the effective damping constant $\alpha_{effFMR} = \mu_0 \Delta H / (2 \omega) + \alpha_{FMR}$ [14], which includes Gilbert damping $\alpha_{FMR}$ and inhomogeneous line broadening $\Delta H$.

To characterize the delayline sample, and to measure the magnitude of the complex transmission signal $S_{ij}$ with $ij \in \{xx, xy, xz, yz\}$ we employ standard network analyzer measurements [31, 32]. Nonreciprocal effects are studied by comparing $S_{ij}$ obtained for oppositely propagating SAWs with $k_{S21}$ and $k_{S12}$.

### IV. DISCUSSION

The acoustic wave transmission magnitude $S_{21}$ in the time-domain as a function of frequency is characterized in Fig. 3(a) at a quite high magnetic field of $-200$ mT, therefore far off the SW resonance. The obtained spectrogram contains electromagnetic crosstalk at $t \approx 0$, acoustic bulk waves, SAWs, and also some higher harmonic resonances, as described in more detail in the caption of Fig. 3. By comparing the SAW propagation velocities $c_{SAW} = 1600 \mu m/t$ with the results from the FEM simulation given in Table I, we identify the R-mode at 515 ns (3107 m/s) and the SH-mode at 390 ns (4103 m/s).

Now, we turn towards the detailed study of the symmetry of the magnetoacoustic response and its nonreciprocity for both different SAW modes. To do so, we use adjusted time gates for both modes, as depicted in Fig. 3(b). Then we apply inverse Fourier transformation to solely measure the peak transmission of each individual SAW mode in the frequency domain at 4.5 GHz for the R-mode and at 3.5 GHz for the SH-mode. The relative change of the background-corrected SAW transmission magnitude, which is caused by SAW-SW interaction is defined as $\Delta S_{ij}(\mu_0 H) = S_{ij}(\mu_0 H) - S_{ij}(-200 \text{ mT})$.

Figures 3(a) and 3(b) show $\Delta S_{ij}$ for the R-mode as a function of the external magnetic field magnitude $H$ and direction $\phi_H$. Since the resonance fields $H_{res}$ are much higher ($> 30$ mT) than the uniaxial in-plane anisotropy ($1.4$ mT), fit results in Table I, $M$ and $H$ are approximately parallel ($\phi_0 \approx \phi_H$) for $H_{res}$ and the symmetry of the main driving field shows up in Figs. 3(a) and 3(b). As expected from theory, we observe the four-fold symmetry $\Delta S_{ij} \propto (\sin \phi_0 \cos \phi_0)^2$ for the R-wave [7, 8, 13].

### FIG. 3
Figure 3. (a) Various acoustic wave modes are visible in the $S_{21}(t, f, \mu_0 H = -200 \text{ mT})$ spectrogram. Signal components, which we identified are (i) electromagnetic crosstalk at $0 \text{ ns}$, (ii) SH*-mode at 349 ns (discussed later), (iii) two harmonic resonances of the SH-mode at 390 ns, (iv) bulk waves that are multiple times reflected on the upper and lower side of the LiTaO$_3$ substrate at 475 ns, and (v) three harmonic resonances of the R-mode and additionally bulk waves at 515 ns. (b) Line cuts of (a) at 3.5 GHz and 4.5 GHz, which correspond to the 3rd and 5th harmonic resonance frequency of the SH- and R-mode. The adjusted time gates for the SAW modes are depicted in grey. The peak at 515 ns and 3.5 GHz does not show a magnetoelastic response and is thus attributed to bulk waves.

### TABLE I. Results of the FEM simulation. The normalized complex amplitudes of the strain tensor are $\tilde{a}_{kl} = e_{kl0}/(|a_{kl0}| |k|)$ with $k \in \{xx, xy, xz, yz\}$. The errors are assumed to be in the order of $\pm 10\%$ of $\tilde{a}_{xx}$ ($\tilde{a}_{xy}$) for the R-wave ($\text{SH}$-wave).

| $f$ (GHz) | $c_{SAW}$ (m/s) | $\tilde{a}_{xx}$ | $\tilde{a}_{xy}$ | $\tilde{a}_{xz}$ | $\tilde{a}_{yz}$ |
|-----------|----------------|----------------|---------------|----------------|----------------|
| R         | 4.47           | 3105           | 0.613 ± 0.024 | ±0.037         | 0              |
| SH        | 3.47           | 4075           | ±i0.53        | 4.85           | -0.18          | ±i0.21         |

### FIG. 4
Figure 4. Transmission nonreciprocity of the R-wave at 4.47 GHz. The experimental data $\Delta S_{21}$ (a) and $\Delta S_{12}$ (b) demonstrates the expected four-fold symmetry, caused by dominant longitudinal strain $\epsilon_{xx}$. Additionally, the nonreciprocal behavior $\Delta S_{21} - \Delta S_{12}$ in (c) is four-fold and induced by the $\epsilon_{xx}$ strain component. Experiment and fit (d)-(f) show excellent agreement.

Eqs. (1)-(4) are used to fit the experimental results of Figs. 4(a) and 4(b), following the curve fitting procedure, described in Ref. [14]. Because we do not know
the parameter $R$ in Eq. (1), the fitting parameters are $\alpha$, $H_k$, and $b_k/\sqrt{R}$ with $kl = xx, xy, xz, yz$. The fits in Figs. 4(d) and 4(e) show excellent agreement with the experiment. Furthermore, the fit results, as being summed up in Table II, are in accordance with the FMR data for $H_k^{\text{FMR}}$ and $\epsilon^{\text{FMR}}$. Please note that the FMR experiments were performed on reference samples (same sputter run as SAW samples) 20 months after the SAW measurements had been carried out, explaining slight deviations due to degeneration of the Ni thin film.

The experimentally determined symmetry of the nonreciprocity $\Delta S_{21} - \Delta S_{12}$ of the R-mode is depicted in Fig. 4(c). As expected from theory, the nonreciprocity is caused by the vertical shear strain $\epsilon_{yz}$ and is proportional to $\cos^2(\phi_0) \sin(\phi_0)$. Excellent agreement between Fig. 4(c) and Fig. 4(f), which is obtained by subtracting the fit curves of Fig. 4(d) and Fig. 4(e), further validates the theoretical model.

The results for the SH-wave are shown in Fig. 5. Since the main strain component of the SH-wave $\epsilon_{xy}$ induces driving fields with a symmetry proportional to $\cos(2\phi_0)$, the experimental response $\Delta S_{ij}$ in Figs. 5(a) and 5(b) differs, but complements the symmetry of the R-wave. The fit results in Figs. 5(d) and 5(e) reproduce the experiment again very well. Moreover, the fit parameters $H_k$ and the effective damping $\alpha$, which depends on the SAW frequency, are in good agreement with the parameters of the R-wave and with the FMR measurements given in Table II.

The experimentally determined nonreciprocity of the SH-wave in Fig. 5(c) has a different symmetry with a lower magnitude than the R-wave. As expected from theory, the strain $\epsilon_{yz}$ causes the SAW-SW helicity mismatch effect with the symmetry being proportional to $\sin(2\phi_0)$, as observed in the experiment. Again, the difference of the fits $\Delta S_{21} - \Delta S_{12}$ in Fig. 5(f) agrees well with the nonreciprocity of the experiment, confirming the theoretical model also for SH-waves.

So far, we have presented the results for the 5th and 3rd harmonic resonance frequency of the R- and SH-mode. We performed similar measurements for all transmission peaks, visible in Fig. 3(a). Since only surface modes are expected to induce considerable magnetoelastic driving fields, we make use of this assumption and identify the surface modes by looking at the magnitude of the absorbed SAW power, caused by the SAW-SW interaction $\Delta S_{ij}(\mu_0 H, \phi_B)$. None of the other transmission peaks in Fig. 3(a) shows a magnetoelastic response, except the weak but still detectable SAW mode at $t = 349$ ns. This mode can not be identified both from literature search [23] as well as from our FEM eigenfrequency simulations. We still name this mode SH*-mode.

Given the example of this SH*-mode, we demonstrate that also an unknown SAW mode can be characterized in terms of its strain components by employing SAW driven SW spectroscopy. The magnetoelastic response $\Delta S_{ij}$ of this SH*-mode is depicted in Fig. 6. Because the symmetry of $\Delta S_{ij}$ is an unambiguous indication of the strain component $\epsilon_{xy}$ in Eq. (2), we conclude and experimentally confirm that this mode must be a shear horizontal type wave. The smaller strain components, which are phase shifted with respect to the main strain component, show up in the nonreciprocal response in Fig. 5(c). Despite low signal-to-noise ratio, the nonreciprocity of the SH*-wave agrees with the nonreciprocity of the SH-wave, caused by the phase shifted strain $\epsilon_{yz}$. We infer that the SH*-mode is also a surface acoustic wave with low transmission and strain tensor elements, which indicate it to be similar to the SH-mode.

To find out more details about the SH*-mode, we carried out additional time-dependent FEM simulations, using the exact geometry of the LiTaO$_3$ sample. These simulations include, in contrast to the eigenfrequency FEM simulation, acoustic wave reflections, and secondary induced acoustic waves due to electromagnetic crosstalk. The time-dependent simulation shows that electromagnetic crosstalk causes low-amplitude secondary acoustic wave excitation at the edge of the magnetic film, close to the exciting IDT. Due to the reduced propagation path, the propagation time of this secondary mode is lowered by about $300 \mu$m / (4075 m/s) = 74 ns in comparison to the SH-mode. This, however, does not agree with the experimental findings for the SH*-mode (time delay of 42 ns in Fig. 3). Since the propagation time of none of the acoustic wave modes of the simulation matches with the propagation time of the SH*-mode of 349 ns, we have to conclude that we can not reproduce the SH*-mode in the FEM simulations.

Finally, we discuss the magnitude of the magnetoelastic driving fields of the fits $b_k/\sqrt{R}$ (Table II) by comparing these values with $\delta_{k,0}$ of the FEM simulation (Ta-
Thus, the normalized strain components of the symmetry as the SH-wave response shown in Fig. 5.

FIG. 6. Experimental results for the transmission nonreciprocity of the SH*-wave at 3.52 GHz, revealing a similar symmetry as the SH-wave response shown in Fig. 5

The excellent agreement, except for \( \epsilon_{xx,0} \) (SH), between FEM simulation and experimental results again confirms the theory. Due to additional, non-magnetoelastic coupling mechanisms like magneto-rotational coupling \([9, 10, 14]\) or spin-rotational coupling \([11, 24, 25]\), corrections for the driving fields are necessary, confirming the theoretical model. The SAW-SW interaction is observed for any in-plane field geometry \([34]\). So far, data with SWs in magnonics are usually carried out in the \( M \perp k \) or the \( M \parallel k \) geometry \([24]\). So far, it was not possible to excite SWs with Rayleigh waves in these geometries in an efficient way. As we demonstrate in this study, efficient magnetoacoustic excitation of SWs in exactly these geometries is achieved by using SH-waves. This could be additionally used to ex-
cite backward volume magnetostatic SWs ($\mathbf{M} \parallel \mathbf{k}$) in a magnonic waveguide without the need of an external magnetic field. Taken together, we hope that this study will motivate SH-wave based magnetoelastic approaches for future applications in magnonics.

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