MA 23: Magnonics II

Time: Wednesday 9:30–11:00 Location: EB 107

MA 23.1 Wed 9:30 EB 107

Dipolar interactions and critical dynamics in Ni — •Lukas Beddrich[1], Johanna K. Jochum[1], Steffen Säubert[2,3], Christian Franz[4], and Peter Böni[5] — [1]Research Neutron Source Heinz Maier-Leibnitz (FRM II), Technical Universtity of Munich, Garching, Germany — [2]Physik-Department E51, Technische Universität München, Garching, Germany — [3]Department of Physics, Colorado State University, Fort Collins, USA — [4]Jülich Centre for Neutron Science JCNS-MLZ, Forschungszentrum Jülich GmbH Outstation at MLZ FRM II, Garching, Germany — [5]Physik-Department E21, Technische Universität München, Garching, Germany

The spin wave dispersion of an isotropic ferromagnet is described by the Holstein-Primakoff theory, which takes dipolar interactions into account. At low q, the dispersion shows linear behavior instead of $E_{\mathrm{SW}} \propto q^2$, which would be expected. This is attributed to the long-range dipolar interaction between the magnetic moments. The subtle influence of these interactions on the magnon spectrum can be expressed by the dipolar wave vector q_{D}.

Utilizing the modern MIEZE method, a neutron resonance spin-echo technique, we investigated the critical spin dynamics in nickel above and below T_{C}. The measruements were performed at small momentum and energy transfer, reaching an energy resolution that has not been achieved before.

Our results show excellent agreement with spin wave and dynamical scaling theory. However, due to the improved resolution, the measurements strongly suggest q_{D} to be smaller than previously reported.

MA 23.2 Wed 9:45 EB 107

Analysis of magnetoacoustic waves in epitaxial Fe_3Si/GaAs hybrid structures — Marc Rovirola[1], Muhammad Waqas Khaliq[1,2], Blai Casals[1], Michael Foerster[2], Miguel Angel Niño[2], Lucía Aballe[2], Jens Herfort[3], Joan Manel Hernàndez[1], Ferran Macià[1], and •Alberto Hernández-Mínguez[3] — [1]University of Barcelona, Barcelona, Spain — [2]ALBA Synchrotron Light Source, Cerdanyola del Vallès, Spain — [3]Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany

The magnetoelastic interaction provides an efficient dynamical coupling between surface acoustic waves (SAWs) and spin waves (magnons) in micro- and nanometric magnetic systems. In this contribution, we quantify via magnetic imaging in an x-ray photoelectron microscope the amplitude of magnetoacoustic waves (coupled SAW and spin waves) in a hybrid structure consisting of a 74-nm-thick ferromagnetic Fe_3Si film grown epitaxially on a piezoelectric substrate, GaAs. The cubic anisotropy of Fe_3Si, together with a low damping coefficient, allows for the observation of magnetoacoustic waves with 500 MHz frequency in both resonant and nonresonant conditions, reaching up to 1.5° precession amplitude of the magnetization vector around its equilibrium direction. Finally, we compare the experimental behavior with micromagnetic simulations to quantify the magnetoelastic shear strain constant in Fe_3Si, obtaining $b_2 = 10 \pm 4$ MJ/m^3.

[1] M. Rovirola *et al.*, Phys. Rev. Appl. **20**, 034052 (2023)

MA 23.3 Wed 10:00 EB 107

Higher harmonics generation from low intensity spin waves using a magnon concentrator — •Stephanie Lake[1], Seth Kurfman[1], Rouven Dreyer[1], Georg Woltersdorf[1], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany

Nonlinear magnon interactions, such as magnon-magnon scattering, are well-documented processes in yttrium iron garnet (YIG) films and microstructures[1,2]. In many of these studies, high frequency signals induce ferromagnetic resonance, causing nonlinear processes to occur. However, this method of excitation lacks spatial resolution and typically requires high initial magnon intensities due to propagation losses.

In this work, we demonstrate nonlinear higher harmonic generation from low-intensity spin waves (SWs). First we fabricate a funnel-shaped YIG device, i.e. magnon concentrator, which employs demagnetizing fields to collect and steer SWs. Then with magneto-optical Kerr effect (MOKE) microscopy and micromagnetic simulations, we investigate the propagation of low-intensity SWs through the concentrator, where they ultimately cross the nonlinearity threshold at the focus. These results can facilitate magnonic applications where both precision and nonlinearities are required.

[1] Ordóñez-Romero, César L., et al. *Physical Review B* 79.14 (2009).

[2] Liu, HJ Jason, et al. *Physical Review B* 99.2 (2019).

MA 23.4 Wed 10:15 EB 107

Fabrication and Characterization of Suspended YIG Microstructures — •Seth W. Kurfman[1], Frank Heyroth[2], and Georg Schmidt[1,2] — [1]Institut für Physik, Martin Luther Universität Halle-Wittenberg, Halle, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany

Efficient coupling between magnetic excitations and acoustic modes is hindered by enhanced phonon loss into the substrate bulk. These losses can be minimized through the fabrication of suspended magnonic microstructures where the acoustic modes of the magnonic material are isolated from the substrate.

Here, we demonstrate the fabrication of low-loss suspended YIG microstructures with a single attached support point. We additionally show characterization of excited magnon modes via optical techniques (*e.g.* TR-MOKE) and inductive measurements. Due to confinement effects, these structures exhibit acoustic resonant modes in the GHz regime and therefore provide an avenue towards efficient coupling of magnetic and acoustic modes. In conjunction with optical techniques (*e.g.* Brillouin Light Scattering) to measure the acoustic modes, these YIG microstructures promise application potential ranging from efficient microwave-to-optical light frequency conversion [1] to quantum systems utilizing coherent multipartite coupling [2].

References:

[1] Engelhardt *et al., Phys. Rev. Appl.* **18**, 044059 (2022).

[2] Lachance-Quirion *et al., Appl. Phys. Express* **12**, 070101 (2019).

MA 23.5 Wed 10:30 EB 107

Nonlinear spin waves in a half-metallic Co_2MnSi waveguide with ultralow magnetic damping — •Anna Maria Friedel[1,2], José Solano[3], Yves Henry[3], Sébastien Petit-Watelot[1], Matthieu Bailleul[3], Philipp Pirro[2], and Stéphane Andrieu[1] — [1]Institut Jean Lamour, UMR 7198 CNRS–Université de Lorraine, Nancy, France — [2]Fachbereich Physik and Landesforschungszentrum OPTIMAS, RPTU Kaiserslautern-Landau, Kaiserslautern, Germany — [3]Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504 CNRS–Université de Strasbourg, Strasbourg, France

We observe nonlinear spin wave excitation processes at particularly low excitation power thresholds in an epitaxial, half-metallic Co_2MnSi waveguide. Co_2MnSi proofs to be of high interest for magnonics due to the combination of high saturation magnetisation around 1000 kA/m and ultralow Gilbert damping parameters in the 10^{-4} range [1]. The ultralow damping is linked to the compound's 100% spin polarisation, which was confirmed in the investigated waveguide by spin wave Doppler shift measurements. Performing time-resolved Brillouin light scattering microscopy, we study the excitation, propagation and decay of linear and nonlinear spin wave modes. We find a reduced threshold for the observation of 2$^{\mathrm{nd}}$ order instabilities compared to previous studies on sputtered Heusler compounds [2], which we link to the comparably low Gilbert damping parameter in our epitaxial Co_2MnSi waveguide. This research was funded by ANR Contracts No. ANR-20-CE24-0012 (MARIN) and ANR-20-CE24-0023 (CONTRABASS).

[1] Phys. Rev. Appl. **11**, 064009 (2019) [2] PRL **113**, 227601 (2014)

MA 23.6 Wed 10:45 EB 107

Direct measurement of emergent coherence in magnonic condensates — •Malte Koster[1], Matthias R. Schweizer[1], Vitaliy Vasyuchka[1], Dmytro Bozhko[2], Burkard Hillebrands[1], Mathias Weiler[1], Alexander A. Serga[1], and Georg von Freymann[1,3] — [1]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Department of Physics and Energy Science, University of Colorado Colorado Springs, CO 80918 USA — [3]Fraunhofer Institute for Industrial Mathematics ITWM, 67663 Kaiserslautern, Germany

The formation of magnon Bose-Einstein condensates (BECs) in parametrically overpopulated magnon gas is a subject of long-standing interest to the scientific community. Recently, the possibility of electromagnetic detection of magnon condensates with a frequency resolution finer than the spectral line width of the magnon BEC has been demonstrated. Here, we present a new measurement technique for performing direct electromagnetic measurements of the magnon phases and correlation characteristics in a parametrically pumped magnon gas. In experiments with parametrically driven perpendicularly magnetized yttrium-iron-garnet films, we observe the spontaneous formation of the homogeneous Kittel mode with a random initial phase. Our measurements provide convincing experimental evidence for the spontaneous emergence of coherence in the condensate phase.

This research was funded by the Deutsche Forschungsgemeinschaft in frame of TRR 173/2*268565370 Spin+X (Project B04).