Colloquium on Solid-State Physics

Department of Physics
SS 2023

Thursday, 15st June 2023, 17.15 h
Lecture Hall III, Department of Physics, Garching

Frequency multiplication and spin wave generation by nonlinear magnetization dynamics

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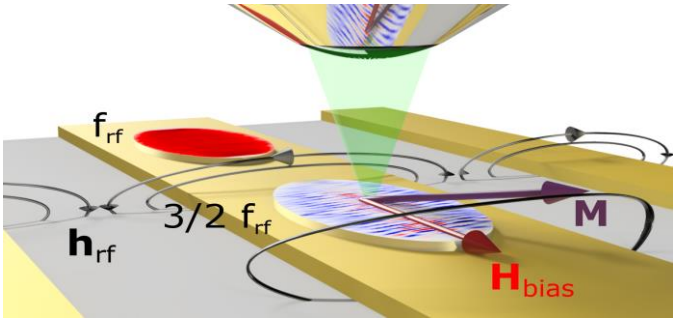
Abstract:



Frequency multiplication and frequency conversion are important processes in modern electronics in which harmonics of the input frequency are generated in nonlinear electronic circuits. Devices based on the propagation and interaction of spin waves represent a promising alternative to conventional electronics. However, the characteristic frequency of spin waves is in the gigahertz range, and thus cannot be easily combined with conventional electronics. We investigate the magnetic excitations in magnetic materials using optical methods and show that excitation at frequencies in the megahertz range can cause magnetic switching processes on the micrometer scale, and these lead to coherent spin wave emission in the gigahertz range [1]. Moreover, at high modulation amplitudes, we demonstrate a new class of nonlinear spin waves that oscillate with half-integer harmonics of the excitation. Imaging of these parametrically generated spin waves enables measurement of the wave vectors and determination of the coherence properties [2]. In addition, we demonstrate the existence of two degenerate phase states, each of which can be selected by the phase position of an external signal source. The frequency multiplication process occurring within the magnetic medium covers more than six octaves and opens new perspectives for applications such as fully magnetic mixers or "on-chip" signal generators. The phase-coherent excitation and control of half-integer harmonic spin waves is highly interesting for applications such as amplifiers and phase-encoded spin-wave-based information processing.

Magneto-optical measurement of the non-linear excitation of half-integer spin waves in a structure made of NiFe. The excitation is performed by the microwave field of a waveguide structure. Imaging is performed using magneto-optic super Nyquist sampling [3].

[1] C. Koerner, R. Dreyer, M. Wagener, N. Liebing, H.G. Bauer, and G. Woltersdor, Science **375**, 1165–1169 (2022)

[2] R. Dreyer, A.F Schäffer, H.G. Bauer, N. Liebing, J. Berakdar, and G. Woltersdorf, Nat. Commun. **13**, 4939 (2022)

[3] R Dreyer, N Liebing, ERJ Edwards, A Müller, G Woltersdorf, Phys. Rev. Mat. **5**, 064411 (2021)

There will be coffee, tea, and cookies in front of the lecture hall at 17.00 h