Ultrafast nonlinear conversion of magnons in a canted antiferromagnet

(poster)

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Propagating magnons, or spin waves, have recently attracted a lot of interest as strongly interacting potential information carriers, which do not generate Joule heating. In antiferromagnetic materials the frequencies of the magnons lie in the THz range, compared to the GHz range in ferromagnets, allowing for orders of magnitude faster information processing in antiferromagnets [1]. The first experimental demonstration of generation and detection of the coherent propagating magnons in an antiferromagnet was recently reported [2]. The breakthrough is based on using nanoscale confinement of the laser pump pulse to excite magnons, while selectively detecting them by scattering of another probe pulse. In this work we demonstrate strong nonlinear coupling between magnons and realise the ultrafast conversion of quasi-uniform spin precession into propagating magnons with higher frequencies (energies) and wavenumbers (momenta). Our discovery enables control over the spin waves, required to make them suitable for information processing in the form of logic gates [3]. We demonstrate supressing or amplifying of THz propagating magnons, mimicking the operation of a transistor. To this end, we perform a double pump - probe experiment illustrated in figure 1. The first pump pulse launches spin dynamics, which are modulated and transformed by the second pump. The dynamics are probed magneto-optically, using the detection mechanism reported in [2]. We find that the amplitude of the detected spin wave can be controlled by the delay between the pumps (figure 1b). This amplitude modulation is intrinsically nonlinear, as we observe features at (f_k, f_k) frequencies (interference), and (f_0, f_k) frequencies (nonlinear conversion) (figure 1c), where f_k is the finite-k component of the freely propagating spin wave, and f_0 is the frequency of the uniform spin precession. Using the Lagrangian formalism for describing nonlinear spin dynamics [4], we can show that our experiment can be interpreted as conversion of the quasi-uniform spin precession to the finite-k magnon modes by a second light pulse. The converter enables ultrafast modulation of spin waves in an antiferromagnet, which is a major milestone in THz magnonics.

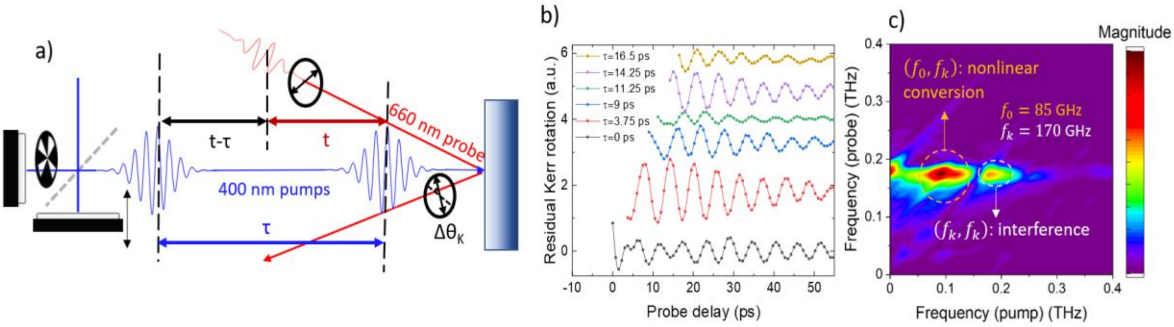

Figure 1*:* a) Experimental scheme. The spin dynamics is excited by the first 400 nm pump pulse and then controlled with a second 400 nm pump pulse. The ultrafast dynamics is probed magneto-optically, using a 660 nm pulse. b) Detected spin dynamics as a function of the delay τ between the two pumps. c) 2-dimensional Fourier transfor3m of the data in b).

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