Nanoscale magnonic devices

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Spin waves, and their quanta magnons, are of great interest as potential data carriers in future low-energy computing devices. The phase of a spin wave provides an additional degree of freedom, while the scalability of structures and wavelengths down to the nanometer regime [1] are further advantages. Recently, a set of magnonic data processing units was demonstrated. However, the development of each of them requires specialized investigations and, usually, one device design is suitable for one function only. Moreover, an integrated all-magnonic circuit, which is suitable for the cascading of multiple magnonic units, has not yet been demonstrated.

Here, we present the experimental realization of a nanoscale magnonic directional coupler, which consists of two single-mode spin-wave waveguides with 350 nm width, separated by a gap of 320 nm [2,3]. A U-shaped antenna is used to excite spin waves and space-resolved Brillouin Light Scattering (BLS) spectroscopy is exploited for detection. It is shown that the data is coded into the spin-wave amplitude is guided towards one of its two outputs depending on the signal frequency, magnitude, and on the magnetic field. Using micromagnetic simulations, we also propose an integrated magnonic half-adder that consists of two directional couplers and we investigate its functionality for information processing within the magnon domain.

Furthermore, we propose a new field of inverse-design magnonics which combines magnonics with the very active field of machine learning. The functionality can be specified first, and a feedback-based computational algorithm is used to obtain the device design. To demonstrate the universality of this approach, linear, nonlinear and non-reciprocal functionalities of magnonic devices are explored using the examples of magnonic (de-)multiplexer, nonlinear switch and circulator [4].

References:

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