Nano-Scaled Magnon Transistor

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With the fast growth in the volume of information being processed, researchers are charged with the primary task of finding new ways for fast and efficient processing and transfer of data. Spin excitations – spin waves and their quanta magnons – open up a very promising branch of high-speed and low-power information processing[1]. The realization of single-chip all-magnon information systems demands for the development of circuits in which magnon currents can be manipulated by magnons themselves. In Ref. [2] we presented and tested experimentally a proof-of-concept magnon transistor. The density of magnons flowing from the transistor's source to its drain could be decreased three orders of magnitude by the injection of magnons into the transistor's gate. The operational principle of the transistor is based on a nonlinear four-magnon scattering process. We have shown that the transistor can be used directly for designing logic gates in all-magnon circuits and enables the amplification of signals coded into the magnon density using an additional interferometer structure. A maximum gain factor of 1.8 was predicted for this device[2].

Here we use micromagnetic simulations to propose a conceptually different approach for the realization of a magnon transistor. In this device, a three- rather than four-magnon scattering process is utilized for the manipulation of one magnon current by another. Gate magnons of frequency 9.8 GHz are injected into the transistor's gate. The source magnons of almost twice smaller frequency of 4.4 GHz are injected in the transistor's source and propagate towards the gate. When the source magnons reach the gate region, they interact with the gate magnons boosting a three-magnon scattering process in which one gate magnon scatters into one new source magnon and into one idle magnon of frequency 5.4 GHz. As a result, the number of the source magnons at the drain is increased and the transistor acts as an amplifier of magnon signals. Our studies have shown that the source magnon's density at the transistor's drain can be enhanced 6.3 times in the presence of the gate magnons.

Our studies show that this type of magnonic transistor can be used for amplification of magnonic currents as well as for performing logic operations in future all-magnon magnonic circuits.

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[1] A. V. Chumak, V. I. Vasyuchka, A. A. Serga, and B. Hillebrands, *Magnon spintronics*, Nat. Phys. **11** (2015) 453-461.

[2] A. V. Chumak, A. A. Serga, and B. Hillebrands, *Magnon transistor for all-magnon data processing*, Nat. Commun. **5** (2014) 4700