Nonuniformly magnetized rezonators for spin wave-based neuromorphic computing

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Reservoir computing, an emerging framework of recurrent neural network theory, is well-suited for sequential data processing. A non-linear, fixed system known as a reservoir maps input signals into higher-dimensional computational spaces, while a readout performs pattern recognition from the reservoir states. These characteristics make physical systems prone to non-linearity feasible candidates for reservoir-based computations. As it happens, the Landau-Lifshitz-Gilbert equation governing spin wave (SW) dynamics possesses inherent non-linearity arising from dipolar and exchange interactions. Consequently, systems based on magnons, quanta of SWs, have been proposed for the implementation of reservoir computing. In particular magnonic nanoresonators placed over ferromagnetic layers or waveguides have been shown to be promissing structures for creating hardware artificial neural networks based on SWs [1]. In this work, instead of uniformly magnetized chiral magnonic resonators [1], we propose to use discs in a vortex state and non-uniformly magnetized bowtie-shaped resonators to exploit non-collinear magnetic configurations that are stable at low bias fields. These resonators constitute nonlinear scattering centers over a low-damping medium for propagating SWs. Using micromagnetic simulations, we design a two-layer mesh of such resonators that scatter incident SWs. We demonstrate that this system can act as a reservoir performing neuromorphic computation, exhibiting full adder functionality while nonlinear scattering encodes binary information.

References:

[1] K. G. Fripp, Y. Au, A. V. Shytov, V. V. Kruglyak; Nonlinear chiral magnonic resonators: Toward magnonic neurons. Appl. Phys. Lett. 24 April 2023; 122 (17): 172403.

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