Magnonic resonators as building blocks of reservoir computers

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We report on nonlinear magnonic resonators as viable building blocks of unconventional computing architectures. We demonstrate that the spin-wave modes confined in magnonic resonators [1-3] exhibit a strongly nonlinear response owing to energy concentration when resonantly excited by incident linear spin waves [4]. We use this nonlinearity to design and optimize nonlinear magnonic reservoirs for reservoir computing in the time domain. The designed reservoirs consist of one or more resonators coupled either actively (via an additional microwave feedback ring) or passively (via multiple spin wave reflections between the resonators). Their performance is analysed for a range of benchmark tests on analog and noisy binary data, using standard time-multiplexing protocols for realistic device parameters informed by micromagnetic simulations and experiments. Our tests reveal that the passive reservoirs can show superior performance for simple short memory tasks, such as retrieving previous / predicting next sample, parity checks and majority gates, simple arithmetic operations. For binary inputs, fidelity of better than 99% may be achieved even for noise levels of up to 10%. At the same time, the actively coupled reservoirs perform better on more complex tasks, such as NARMA10 or NARMA20 time series prediction, while the feedback coefficient proves a useful handle for fine-tuning the reservoir. Our magnonic reservoirs may be concatenated to form more complex and powerful reservoir computing architectures.

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