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Chiral magnonic resonators for neuromorphic computing

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We explore chiral magnonic resonators [1-5] as building blocks of artificial neural networks. Via micromagnetic simulations and analytical modelling, we demonstrate that the spin-wave modes confined in the resonators exhibit a strongly nonlinear response owing to energy concentration when resonantly excited by incoming spin waves. This effect may be harnessed to implement an artificial neuron in a network. Thereby, the confined and propagating spin-wave modes can serve as neurons and interneural connections, respectively. For modest excitation levels, the effect can be described in terms of a nonlinear shift of the resonant frequency ('detuning'), which results in amplitude-dependent transmission of monochromatic spin waves, which may be harnessed to recreate a sigmoid-like activation function. At even stronger excitation levels, the nonlinearity leads to bistability and hysteresis, akin to those occurring in nonlinear oscillators when the excitation strength exceeds a threshold set by the decay rate of the mode. In magnonic resonators, the latter includes both the Gilbert damping and the radiative decay due to the coupling with the medium. The results of our simulations are well described by a phenomenological model in which the nonlinear detuning of the confined mode is quadratic in its amplitude, while the propagation in the medium is linear.
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