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Spin wave band structure of artificial square ices[1] EZIO IACOCCA, University of Colorado - Boulder, Co, USA; Chalmers University of Technology, Sweden, SEBASTIAN GLIGA, ETZ, Switzerland; PSI, Switzerland, ROBERT STAMPS, University of Glasgow, UK, OLLE HEINONEN, Argonne National Laboratory, IL, USA — Artificial square spin ices are structures composed of magnetic elements located on the sites of a geometrically frustrated, two-dimensional square lattice. Using a semi-analytical approach, we show that square spin ices exhibit a rich spin wave band structure that is tunable both by external magnetic fields and the magnetic state of individual elements. Internal degrees of freedom can give rise to equilibrium states with bent magnetization at the edges of each element, leading to characteristic excitations; in the presence of magnetostatic interactions these form separate bands analogous to impurity bands in semiconductors. Full-scale micromagnetic simulations corroborate our semi-analytical approach. This study shows that the magnon spectra, and therefore group and phase velocities and band gap, can be manipulated by external fields, temperature, or more sophisticated techniques such as using spin torque on individual elements, and suggesting that artificial square spin ices can be used as metamaterials for spin waves. Our results close the gap between the research fields of artificial spin ices and magnonics.

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