Two-Dimensional Artificial Spin Ice Systems for Long-Distance Spin-Wave Propagation

S. S. Kunnath,[1] M. Zelent,[1] P. Gruszecki,[1] and M. Krawczyk[1]

[1] *Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland*

Artificial spin-ice systems are a type of magnetic material with interesting physical properties and potential applications. These properties include frustration, the formation of magnetic monopole states, and large number of reprogrammable states, which are useful for the realization of artificial neural networks. However, the study of wave phenomena in ASI is limited to ferromagnetic resonance due to the weak dipolar interactions that govern frustration but suppress wave propagation. To overcome this limitation, we propose a hybrid platform based on a thin, multilayered, ferromagnetic film with perpendicular magnetic anisotropy (PMA) with ASI nanoelements formed via focused ion beam (FIB)-reduced PMA. We demonstrate that this system enables coherent spin-wave propagation over one micrometer via exchange-mediated coupling between subsystems and evanescent spin-wave tunneling through out-of-plane magnetized regions [1]. Furthermore, we show that this hybrid ASI system enhances magnon-magnon coupling between ASI spin-wave modes and oscillations in the PMA matrix via exchange interactions [2,3]. This system overcomes the limitations of standard ASIs while preserving their fundamental properties. Thus, it provides a platform for studying spin-wave phenomena in frustrated ASI systems and paves the way for exploiting them in analog signal processing with spin waves.

References:

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