Proposition of Artificial Spin Ice System suitable for Spin-Wave Propagation

S. S. Kunnath, M. Zelent, P. Gruszecki, M. Krawczyk
Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznań, Poland

Artificial spin ice (ASI) systems are magnetic materials with interesting physical properties and potential applications. These properties include frustration and the formation of magnetic monopole states and Dirac strings, resulting in a large number of reprogrammable states. However, the study of wave phenomena in ASI is currently very limited. This is due to the weak dipolar interactions between ASI nanoelements, which govern frustration but suppress spin wave propagation. To overcome this limitation, we propose a hybrid platform with perpendicular magnetic anisotropy (PMA) consisting of a thin, multilayered film composed of ferromagnetic and heavy metals, as well as ASI nanoelements formed via focused ion beam (FIB)-reduced PMA. Through micromagnetic simulations, 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, 2, 3]. The proposed 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 these phenomena in analog signal processing with spin waves. To participate in TRTM 2025 without giving a presnetation, simply email the TRTM secretary to inform us about your intention.

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