Accessing topological magnonic excitations in non-equilibrium

In-depth report

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Topological bosonic excitations must, in contrast to their fermionic counterparts, appear at finite energies. This is a key challenge for magnons, as it prevents straightforward excitation and detection of topologically-protected magnonic edge states and their use in magnonic devices. However, magnonic systems can be easily driven out of equilibrium through spin-orbit torques, opening up new pathways for accessing topological magnonic excitations. This allows us to realize *non-equilibrium* and *non-Hermitian topology* in magnonic systems. In this talk I will discuss how this approach offers direct access to topological magnonic excitations.

First, I will propose a general non-equilibrium strategy to access the topologically protected edge states in a magnon Chern insulator.[1,2] In this non-equilibrium state, stabilized by spin-orbit torques, the topologically-protected chiral edge modes lie at zero frequency, while the bulk modes remain gapped, as shown in Fig. 1. I will discuss the stability of this setup and the transport properties in the presence of disorder, and show how the presence of opposite frequency magnons can be detected.

In a non-Hermitian topological magnon phase the edge modes can be externally controlled by applying a spin-orbit torque, as shown in Fig. 2. I will demonstrate that this effect leads to a hybrid skin effect and the amplification or damping of the edge modes, which is robust against disorder. This opens up the possibility of realizing non-Hermitian topological phases in magnonic systems.

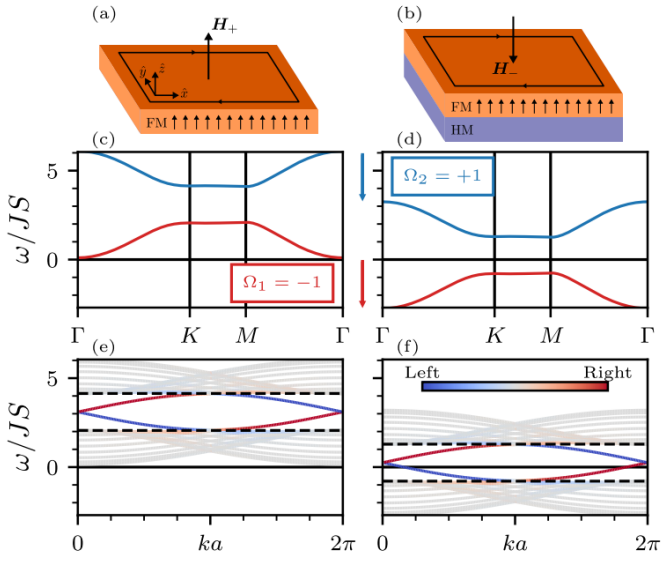

Fig. 1 Strategy for generating zero-frequency chiral magnonic edge states in a magnon Chern insulator ferromagnet (FM), comparing the equilibrium (a,c,e) with the non-equilibrium (b,d,f) state.

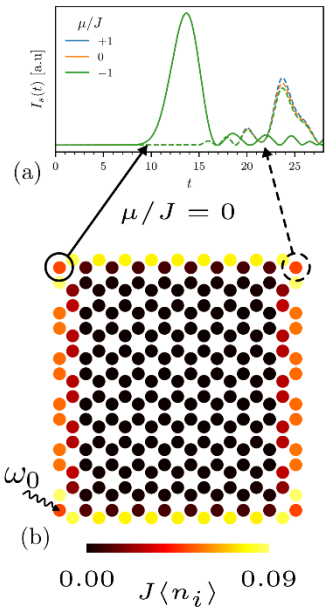

Fig. 2 The injected spin current at two locations, after injection of a pulse at frequency ω_0. The spin-orbit torque μ controls the amplification and damping. The colorscale indicates the thermal occupation of the edge mode.

[1] Pieter M. Gunnink, Joren S. Harms, Rembert A. Duine, Alexander Mook, Phys. Rev. Lett. **131**, 126601 (2023).
[2] Joren S. Harms, H. Y. Yuan, Rembert A. Duine, arXiv:2210.16698 (2022).