

ABSTRACT

Magnetic order on the pyrochlore lattice is a meeting point for several themes of contemporary research on spin waves. Pyrochlore is one of the most well-known geometrically frustrated systems and hence an ideal platform to gauge the effect of frustration on order. The lattice with many material realizations has ordered states which typically involve the interplay of exchange and anisotropic terms in the Hamiltonian. Often this results in non-collinear magnetic structures at low temperatures. These conditions are often the source of two important issues of current interest: spin wave interactions and magnon band topology. We study both aspects in a class of spin models on the pyrochlore lattice.

One part of the thesis focus on the topological aspects of the magnon bands in this model. Both the antiferromagnetic and ferromagnetic variants exhibit topological features in their spin-wave spectra. Notably, the material realization of the ferromagnetic JD model provided the first observation of the magnon thermal Hall effect. We investigate the influence of an additional spin-ice anisotropy, which is frequently present in pyrochlore systems. This bulk model exhibits non-trivial band topology, leading to the emergence of non-trivial surface modes, making studies of slab geometries essential. Growing experimental interest in thin films along high-symmetry directions further motivates our direct evaluation of magnon spectra in slab geometries. For a range of model parameters, including ferromagnetic and antiferromagnetic exchange, we compute classical ground states for various slab orientations and determine the spin-wave excitations above them. We examine the ferromagnetic splay phase, the AIAO phase and a coplanar phase, analyzing magnon dispersions for slabs oriented perpendicular to the $[111]$, $[100]$ and $[110]$ directions. We highlight differences in magnon band structures across these orientations. Finally, we present details of surface-localized magnons for all three slab orientations. For the ferromagnetic splay and AIAO phases, we investigate surface states associated with point degeneracies or nodal lines in the bulk spectrum by computing the magnonic Berry curvature and determining Weyl charges or Chern numbers.

In the other part our recent work on interacting spin waves in a pyrochlore antifer-

romagnet with Dzyaloshinskii-Moriya interactions (DMI), a model exhibiting all-in-all-out (AIAO) spin ordering is presented. We analyze the impact of magnon interactions on the linear spin-wave spectra and investigate the possibility of magnon decay by studying the two-magnon sector. Using many-body perturbation techniques, we find significant renormalization of spin-wave bands for commonly encountered DMI strengths (D). At low D values, we observe a potential phase instability, indicated by magnon frequency renormalization to negative values. Additionally, we examine the renormalized spectra under applied magnetic fields along three high-symmetry directions: $[111]$, $[100]$ and $[110]$. For a fixed DMI strength, the lowest band in the renormalized spectra decreases as the field strength increases. Furthermore, we analyze the two-magnon continuum and identify parameter regimes where higher-band magnon decay is kinematically allowed for specific ranges of D and field strengths.

In summary, this thesis provides a detailed analysis of magnon surface states and magnon interactions in pyrochlore magnets, bridging theoretical models and experimental contexts. This study encourages the future studies for bridging the gap between magnon interaction effects and topological characterers and surface states by studying them separately in a system where both these aspects are important.