Summary

Magneto–Optical Effects from Band Topology in Kagome Magnets

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In this thesis, I investigated the fascinating electronic and optical properties of a variety of kagome lattice based magnets with magneto–optical spectroscopy. By performing magneto–optical Kerr effect (MOKE) studies on $Co_3Sn_2S_2$ and Fe_3Sn_2, I was able to disentangle the intrinsic and extrinsic contributions to the anomalous Hall effect (AHE) by using the spectroscopic information of the Hall effect spectrum provided by broadband MOKE measurements. Their respective energy ranges enabled the clear distinction beyond the phenomenological assignment commonly obtained from applying scaling relations on magnetotransport data. Beyond this straightforward separation of contributions, the spectroscopic fingerprints of topological band features especially in the Hall effect spectrum in combination with *ab initio* calculations additionally allowed to pinpoint the specific bands that generate the anomalous response. While in principle also angle resolved photoemission spectroscopy (ARPES) can reveal the linear band degeneracies, the major advantages of the magneto–optical approach demonstrated here are the high energy resolution and the direct information obtained about the Berry curvature in the optical Hall effect spectrum.

Once I had assigned optical features to specific interband transitions, I could use this information to monitor the manipulation of the topological states by external fields, as demonstrated for $Co_3Sn_2S_2$. While a number of theoretical works predicted that in these kinds of systems, the topological properties can be tuned by magnetic state, actual experimental observations of such effects are rare, mainly due to the incompatibility of other spectroscopic methods with magnetic fields. For the presented results on $Co_3Sn_2S_2$, the magneto–optical spectra revealed the key role of spin–orbit coupling in the generation of topological phenomena, as I could directly probe its reduction upon the magnetisation reorientation.

These findings demonstrate that while topological band structures are generally considered robust, breaking underlying crystal symmetries with external magnetic fields provides an efficient way to manipulate them even in collinear systems. This handle on the electronic properties of these magnets presents a central prerequisite for applications in spintronics or quantum information technology. This approach opens exciting avenues for investigating materials with more complex magnetic structures and even to study the interplay of real– and momentum–space topological states.

An initial step along this direction was taken with the investigation of the highly frustrated metamagnetic states in HoAgGe. While the dc transport properties show a strongly non–monotonous magnetic field dependence, the observed optical response follows the magnetisation instead. This suggests a reconstruction of the bands and a strong coupling between electronic and magnetic degrees of freedom in this spin–ice candidate.

Overall, despite various experimental challenges, such as small sample sizes, the need to extend spectral ranges, the multiband nature and complex electronic and magnetic structures of the investigated compounds, I was able to successfully perform magneto–optical spectroscopy and gain valuable insights into the topological and magnetic properties in all investigated kagome metals. These studies prove magneto–optics as a versatile and reliable tool to investigate topological bands and hints to the potential for future works to study and control these features beyond the capabilities of other experimental techniques.