

Abstract English.

This thesis explores the potential of Co₂Mn-based Heusler compounds for bridging the gap between nonlinear magnonic and spintronic applications, with a particular focus on the half-metallic Co₂MnSi. The overarching goal positions this work right at the heart of state-of-the-art research efforts towards overcoming timely societal challenges linked to the increasing importance of Artificial Intelligence and the resulting exploding demand in computation power and unconventional computing approaches.

A key potential for unconventional computing lies in the field of magnetism, notably in the sub-fields of magnonics and spintronics, where the intrinsic nonlinearity of the magnetisation dynamics promises vast possibilities for a natural device functionality beyond the conventional CMOS technology. Hereby, research in magnonics is centred around spin waves, the collective excitations of an ordered magnetic system, and their application for information transport and processing. Spintronic applications make use of spin-dependent electron transport in the form of spin (polarised) currents and its interaction with the magnetisation of a material.

Recently, sub-communities in both fields have increasingly developed towards an exploitation of the intrinsic nonlinearity, notably in the direction of nonlinear spin wave dynamics in magnonics, and nonlinear magnetisation dynamics driven by spin (polarised) currents in spintronic oscillators. Advances in both fields promise great potential for neuromorphic computing approaches. Naturally, the two fields increasingly intertwine and many promising advances and preliminary device prototypes aim at combining the "best of both worlds". This request for a combination naturally comes with a few challenges and open issues to address.

Notably, the concept of spin polarisation and its implications in combination with magnonic spin transport becomes increasingly important for research at the intersection between both fields, an open issue which is particularly timely also in view of the recently increasing interest in the spin polarisation of altermagnets and its fundamental implications.

An ideal model system intrinsically positioned at the intersection of magnonics and spintronics is given by half-metals, magnetic materials which present a full spin polarisation linked to their peculiar band structure. In particular the Heusler compound Co₂MnSi promises great potential for nonlinear applications combining desirable key parameters with the experimentally proven full spin polarisation, and additionally the high saturation magnetisation and a record-low magnetic damping for metallic films. Yet, while exploration has been done on the spintronics side, research on the magnonics side is still scarce.

In view of this context, this thesis is dedicated to an evaluation of the suitability of the half-metallic Heusler compound Co₂MnSi for an exploitation towards nonlinear magnonic and spintronic applications.

To this aim, several key aspects are addressed, resulting in a few major conclusions:

- Record-low nonlinear threshold powers are obtained in a micro-sized Co₂MnSi device with experimentally verified half-metallicity.
- A significant signature of the self-induced nonlinear shift is observed and can enable a frequency selective self-enhancement/self-capping behaviour as commonly sought-after in neuromorphic circuits.
- A defect-less device fabrication preserving an impeccable L_{2,1}-order is achieved, showcasing the successful patterning of structures down to the smallest intended structure sizes of $w \approx 50$ nm waveguide width.
- A significant cubic anisotropy is determined, not only defining the nonlinear instability ranges, but also pointing towards a significant second order term with a peculiar fingerprint on the expectable spin wave characteristics.

With these major findings, the thesis consolidates the potential of the half-metallic Heusler compound Co₂MnSi as a model system even at the nanoscale. Moreover, the results pave the way for a future exploitation in hybrid magnonic and spintronic applications, and outline several promising perspectives for future work in this freshly opened field of half-metal magnonics.