Investigating the properties of a candidate topological material

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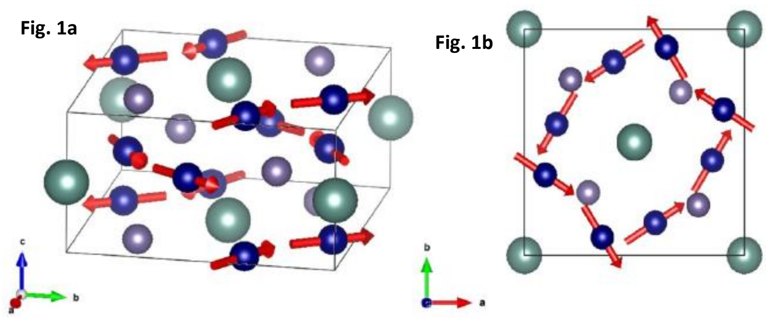
Topology in mathematics is connected to properties of geometric objects that are preserved under continuous deformations. However, in the past years the term topology has been used to study various problems and systems in different scientific fields such as physics, biology and computer science, to name a few. Particularly in condensed matter physics recent breakthroughs in the physics of electrons in solids resulted from the application of topological concepts to the quantum-mechanical wave function, highlighting the role of the Berry phase.

To this aim, in the current project we are interested in the antiferromagnetic (AFM) compound YFe_4Ge_2. This system was previously reported to crystallize in the tetragonal space group $P4_2/mnm$ at room temperature [1]. Powder neutron diffraction experiments on YFe_4Ge_2, identified a magnetostructural (ferroelastic and AFM) transition at T_N = 43 K, which is in agreement with magnetization measurements [1]. The magnetic transition is accompanied by a first-order phase transformation from a tetragonal ($P4_2/mnm$) to an orthorhombic (*Pnnm*) structure [1]. The magnetic structure below T_N is noncollinear AFM and the magnetic moments of the Fe ions at the two sites are measured to be $0.63\mu_B$ per Fe ion equally at 1.5 K (see Figs 1).



Figs 1a,1b: Crystal and magnetic structure of YFe_4Ge_2 (taken from [2]). The green, blue, and purple balls represent the Y, Fe, and Ge ions, respectively. The arrows indicate the magnetic ground state determined by powder neutron diffraction measurements [1].

Although the system is investigated in powder form until nowadays there are no reported studies in single crystal samples. We plan to grow single crystals and perform several characterization measurements in the MGML laboratory. The laboratory has capabilities to grow high-quality single crystals and carry out measurements of a number of physical properties. With magnetization measurements we will obtain temperature-magnetic field phase diagrams along the [100] and [001] high symmetry directions. With transport measurements we will investigate possible anomalous properties of this material. Finally, studies of elastic properties could potentially provide information about lattice distortions and spontaneous or field-induced phase transitions that are expected to occur in YFe_4Ge_2. These before mentioned measurements are essential for a detailed characterization of this material and can provide signatures of topological properties.

[1] P. Schobinger-Papamantellos, et al., J. Magn. Magn. Mater. 236, 14 (2001).
[2] Di Wang, et al., Phys. Rev. B 101, 115122 (2020).