Anisotropic exchange interactions in kagome lattice ferromagnets

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The kagome lattice is one of the most fundamental systems for observing exotic topological states in condensed matter physics. The kagome lattice ferromagnet $Co_3Sn_2S_2$ is such an example and serves as a template for a number of materials that exhibit exotic topological states [1, 2, 3, 4, 5, 6, 7]. This material has shown to host a giant anomalous Hall state [1]. We probe the anisotropic exchange interactions by applying external magnetic fields in different directions along major crystal axes and recording the magneto-optical response. When magnetic fields are applied along the a-b plane, long-range magnetism forms and grows with increasing temperature. This counter-intuitive behavior does not take place when the magnetic field is applied even at a small angle off the a-b plane. In this and other magnetic field configurations the opposite effect is observed. *Ab initio* theoretical calculations reveal that anisotropic exchange interactions are the underlying mechanism leading to this peculiar behavior. Furthermore, the long-range ferromagnetic order along the c-axis is thought to coexists with an antiferromagnetic or spin glass state in the a-b plane, before it is replaced by paramagnetism above the Curie temperature [4, 5, 6, 7]. These two coexisting magnetic states are thought to compete as the temperature approaches T_c, with the antiferromagnetic or spin glass state gaining strength compared to the ferromagnetic order. This competition leads to interesting magnetization dynamics best described by the inertia model [8].

Scientific understanding of magnetic interactions, magnetic phase transitions in these advanced magnetic materials is essential in facilitating the light manipulation of spins. The techniques we use including the high magnetic fields will help elucidate the interactions that lead to the observed phase diagram and ultrafast generation of magnetization [9]. The magnetization dynamics is essential in understanding magnetic phase transitions and the phase diagram. A family of very interesting materials are the kagome lattice RMn_6Sn_6 (R = Gd - Tm, Lu). They can be ferrimagnetic, antiferromagnetic, and helimagnetic depending the rare earth R and magnetic phases that can be induced by large external magnetic fields [10, 11]. Magnetization dynamics at high magnetic fields up to 25T near and at and phase transitions of RMn_6Sn_6 materials will be presented. These results reveal new insights into the fundamental interactions in this kagome lattice family.

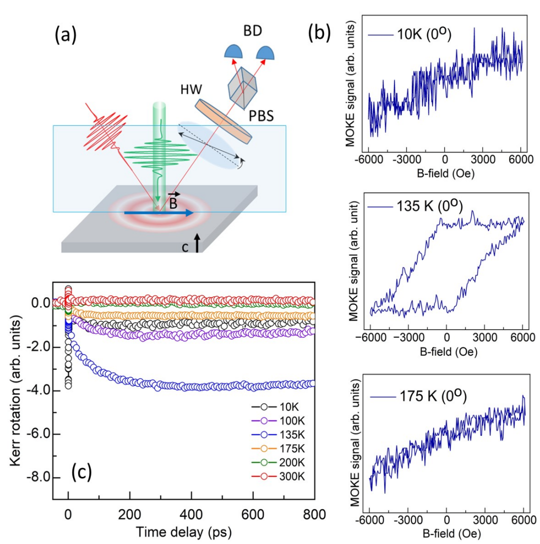

Fig. 1. (a) Experimental configurations for the longitudinal MOKE. (b) Hysteresis loops measured optically between 10K and 175K. No magnetization can be observed at 10 K. The coercivity increases with increasing temperature peaking at 135K and vanishes again neat T_c at 175K. (c) Time-dependent MOKE measuring the change in magnetization ΔM as a function of time for different temperatures at 0.6T.

References

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