Magnetic structure of a new Dresselhaus magnet

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Antiferromagnetic spintronics has attracted much attention recently, since antiferromagnets have several advantages over ferromagnets for future applications like memory storage devices [1]. Antiferromagnets produce no stray fields, leading to robustness against external perturbations. Access speed in memory for writing and erasing—if achieved—is generally limited by the resonance frequency, which for antiferromagnets can be much higher than ferromagnets. While a practical implementation of antiferromagnetic spintronics is missing, several potential avenues toward this goal remain unexplored.

Quite recently, a new theory has been proposed for insulating antiferromagnetic spintronics [2]. The Rashba and Dresselhaus spin-orbit coupling in a metal combines the spin and motional degrees of freedom of electrons, resulting in a spin texture. In insulators, where the motional degree of freedom is quenched, the spin degree of freedom remains, and spin current can be carried by the collective motion of spin waves on momentum space. The ordered moments in antiferromagnets are associated with a two-fold degeneracy in the magnon polarizations [3] (precession motion direction of the spin) that serve as internal degrees of freedom analogous to electron spins. The Dzyaloshinskii–Moriya interaction in the spatial inversion symmetry (SIS) broken system couples these two magnon degrees of freedom as a function of the magnon momentum, leading to a rich texture even in insulators.

The effects on the magnon dispersion due to broken SIS are observed in noncentrosymmetric magnets such as MnSi and α-$Cu_2V_2O_7$ [4]. The Dzyaloshinskii–Moriya interaction (D) shifts two-fold degenerate magnon branches in opposite momentum directions, and the dispersion relation is actually confirmed by neutron scattering studies. In addition, a specific combination of magnetic anisotropy, D, and the magnetic field is predicted to stabilize momentum-dependent magnetic moments [2]. In this proposed experiment, we commence studying magnon dispersion on a model compound prior to the observation of the magnon texture using unpolarized neutrons.

As a model compound, we raise the noncentrosymmetric 2D Dresselhaus antiferromagnet $Sr_2MnSi_2O_7$. The compound shows a transition at T_N = 3.4 K, and we have refined that the magnetic structure is of G-type with in-plane moments. We also calculate the dynamical susceptibility using values of the spin-exchange inferred from the sister compound $Ba_2MnGe_2O_7$ [5]. The prime interaction is about J = 27 μeV, which facilitates controlling the dispersion relation with a few teslas of the magnetic field. Given that the compound is really suited for a critical test of the theory, we here propose a neutron scattering experiment that determines magnon dispersion relations.

A neutron scattering measurement was performed on C1-1 HQR. We successfully observed magnetic excitations at the base temperature, and refined magnetic interactions such as in-plane, inter-plane coupling constants and easy-plane anisotropy, through the linear spin-wave calculation.

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