Quasi-elastic neutron scattering measurements on the kagome lattice antiferromagnet $KFe_3(OH)_6(SO_4)_2$

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Physics of geometrically frustrated spin systems is unconventional due to the collective behavior of interacting electron spins that are influenced by the topology of the underlying lattice. One of the most frustrated lattices in 2 dimensions (2D) is a kagome lattice, which is formed by corner-sharing triangles. One ideal realization of this type of lattice is jarosite. This class of compounds is particular ideal for a study of magnetic properties of the kagome lattice because (1) it consists of single layers of undistorted kagome planes, (2) it can be synthesized with compositions that are stoichiometrically pure, and (3) large crystals can be mode for inelastic neutron scattering. Jarosite is composed of kagome planes formed by magnetic Fe^{3+} ions with spin 5/2. These magnetic ions, which are located inside tilted octahedral cages formed by six oxygen atoms, sit at each corner of the corner-sharing triangles that form the perfect kagome planes. The kagome planes are well separated by non-magnetic ions, making an interlayer coupling negligibly small. The system orders magnetically at T_N = 65 K due to Dzyaloshinskii-Moriya interactions and interlayer coupling. Our previous inelastic neutron scattering measurements show well-defined spin-wave excitations in the ordered state with the first observation of a lifted zero-energy mode [1]. Above T_N, we observe spin fluctuations with uniform spin chirality [2]. In this study, we utilized neutron scattering to investigate temperature dependence of correlation length of spin fluctuations above T_N. The measurements were performed on a single crystal sample at GPTAS (4G) with an incident energy of 14.7 meV and collimations 40-40-S-40-open in a 2-axis mode, where final energy is integrated according to quasi-elastic approximation. Pyrolytic graphite filters were placed in the incident beam to reduce higher-order contamination. The sample was cooled using a closed cycle 4He cryostat. The energy-integrated intensities of the quasi-elastic neutron scattering above T_N were measured at Q=(1,0,0). Figure 1(a) shows a typical Q-scan around (1,0,0) measured at 66 K, slightly above T_N. The intrinsic widths (correlations lengths) were extracted by fitting the data to Lorentzian convolved with the experimental resolution functions. Temperature dependence of correlation length is shown in Fig. 1(b), which shows the results from our measurements at HFIR, Oak Ridge National Laboratory. A solid line shows a fit to the Berezinskii-Kosterlitz-Thouless (BKT) theory for 2D XY model. In summary, our preliminary neutron scattering measurements show a signature of the BKT transition above T_N, consistent with the 2D XY universality class.

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[2] D. Grohol, K. Matan, J.H. Cho, S.H. Lee, J.W. Lynn, D.G. Nocera, and Y.S. Lee, Nature Materials, 4: 323-328 (2005)

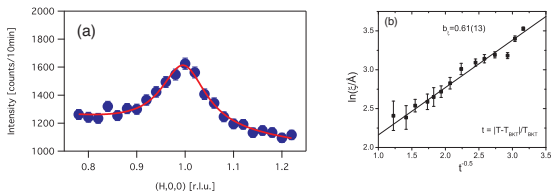

Fig. 1. (a) A representative scan of the quasi-elastic scattering around (1,0,0) at 66 K. A line shows a fit to a Lorentzian. (b) The log of correlation length is plotted as a function of a reduced temperature. A line shows a fit to the BKT theory.