MAR11-2010-006816

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

From Two Dimensional Correlations to a Disordered Ground State in the XY Pyrochlore, $Yb_2Ti_2O_7$[1]

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The tetrahedral geometry of the cubic pyrochlore lattice lends itself to strong geometric frustration, which has the effect of suppressing transitions to long range magnetic order (LRO) for certain types of magnetic exchange and single-ion anisotropy. $Yb_2Ti_2O_7$, whose magnetic Yb^{3+} ions decorate the pyrochlore lattice, is known to have ferromagnetic exchange combined with XY single-ion anisotropy. Hence it is not expected to be frustrated, and should develop an LRO state below some Tc on the order of the exchange energy ($\theta_{CW} \simeq 600$mK). Indeed, $Yb_2Ti_2O_7$ displays a specific heat anomaly around 240mK, but this does not lead to an LRO state. Our recent triple-axis neutron scattering results have revealed that the specific heat anomaly is directly related to a change in dimensionality of the magnetic correlations, causing a transition from an unusual two-dimensionally correlated state above Tc to a short range correlated 3D state below Tc. Combined with recent specific heat results, we argue that the exact transition temperature depends on the precise level of weak structural disorder in the samples, implying that structurally perfect samples may lead to a fully developed LRO state below Tc. Furthermore, our earlier time-of-flight neutron scattering measurements revealed that even for the structurally imperfect systems, an ordered state can easily be induced by the application of a small magnetic field at low temperatures, as evidenced by the appearance of sharp spin wave excitations [1].

[1] K. A. Ross, J. P. C. Ruff, C. P. Adams, J. S. Gardner, H. A. Dabkowska, Y. Qiu, J. R. D. Copley, and B. D. Gaulin. Phys. Rev. Lett. 103, 227202 (2009)

[1]Work at McMaster University supported by NSERC of Canada.