**Antiferromagnetic Ordering in Pyrochlore Yb2Ge2O7**

Zhou, H. D. (Univ. Tennessee/NHMFL); Dun, Z.L. (Univ. Tennessee); Lee, M.S. (FSU/NHMFL) and Choi, E.S. (NHMFL)

**Introduction**

Recently, the pyrochlores with spins constrained in the XY plane (the plane normal to the local <111> axis) has received a lot of attention due to exotic magnetic ground states. For examples, the XY-pyrochlore Er2Ti2O7 exhibits a quantum fluctuation induced order by disorder state (QOBD) and Yb2Ti2O7 exhibits unconventional ferromagnetic ordering. So far for Yb-pyrochlore, no antiferromagnetic ordering has been found. Our ability to make new Yb-pyrochlroe Yb2Ge2O7 using high temperature, high pressure technique gives another opportunity to explore new magnetic ground states in XY-pyrochlores.

**Experimental**

The AC susceptibility measurements were performed with a home-made setup in SCM2 at the NHMFL. The neutron diffraction measurements were performed in ORNL.

Figure 1(a) Elastic neutron scattering pattern and Rietveld refinement for Yb2Ge2O7 at T = 0.3 K and H = 0 T. (b) The difference between the patterns measured at 0.3 K (with H = 0 and 2 T) and 1.6 K. (c) The field dependence of the (220), (311), and (400) Bragg peaks intensities at 0.3 K. (d) The ac susceptibility at different temperatures. Inset: The dc magnetization measured at 0.6 K. (e) The magnetic phase diagram of Yb2Ge2O7.



**Results and Discussion**

Fig. 1d shows the AC susceptibility measured at low temperatures for Yb2Ge2O7. It is obvious there are two anomalies one is around 0.05 T and one is around 0.15 T (at 0.075 K) [1]. Combining our previous AC susceptibility results [2], which confirms the sample antiferromagnetically orders at 0.65 K, we are able to plot the phase diagram, as shown in Fig. 1(e). Meanwhile, our neutron diffraction experiments under magnetic field (Fig. 1-c) confirms that (i) at zero field, the magnetic ground state is an antiferromagnetic ordering with magnetic Bragg peak at (220) positions, which is the same as that of Er2Ti2O7. This indicates that Yb2Ge2O7 is another possible candidate for QOBD state; (ii) with applied magnetic field, the ground state will change to a ferromagnetic structure above 0.15 T.

Therefore, our result is the first time to show that in Yb-pyrochlroes, the magnetic ground state can switch from ferromagnetic (in Yb2Sn2O7 and Yb2Ti2O7) to antiferromagnetic (in Yb2Ge2O7) and the QOBD could be realized in Yb-pyroclores too. Lately, we combine our results with the recent theories to propose that the exchange interactions change under the chemical pressure is the main reason for this dramatic ground state change.

**Acknowledgements**

A portion of this work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490, the State of Florida, and the U.S. Department of Energy. Z. L. Dun and H. D. Zhou thank the support from NSF-DMR-1350002.

**References**

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