Bose-Einstein Condensation of Triplons in $BaVSi_2O_7$

Maximova, O., Vasiliev, V. (Moscow State University), Cheong, S.W. (Rutgers), Jaime, M., Weickert, F., Ding, X., Zapf, V.S. (NHMFL-PFF)

Introduction

$BaVSi_2O7$ is a compound where the spin energy gap between the singlet ground state and the first excited triplet states (triplons) is revealed upon cooling. [1] Depending on the balance between the potential energy defined by their interactions and the kinetic energy of the triplons, the field-induced states can be described as either a quasi Bose-Einstein condensate with uniform static order [2] or as a Mott-insulating state with possible super-lattice order [2]. In the second case, the geometrical frustration of exchange interactions strongly suppresses the kinetic energy of the triplons, which can lead to various patterns of localized magnetic excitations [3]. This localization leads to the appearance of numerous plateaus in the magnetization curves. The spin gap plateau regions are separated by the gapless magnetic states. The measurements of magnetization and magnetostriction in high magnetic field may help elucidate the nature of singlet – triplet transformation in $BaVSi_2O_7$ system.

Experimental

We measured the magnetization using a compensated induction coil and magnetostriction using a piezoelectric strain sensor [3] in single crystals of $BaVSi_2O_7$ as a function of *B* at selected temperatures in magnetic field up to 40-60 T. All the measurements were performed in a 65T multi shot (25 mS) magnet.

Results and Discussion

The field dependences of magnetization M and magnetostriction $\varepsilon = \Delta L/L$ are shown in Figs.1 and 2. At lowest temperatures, both M and ε show a minimal magnetic field up to B_1, then evolve linearly between B_1 and B_2, and saturate above B_2. The possibility of an impurity phase contribution a small saturating magnetization below 10 T has been described previously. Both B_1 and B_2 were found to be temperature independent, which excludes the Bose-Einstein condensation scenario for excited triplons in $BaVSi_2O_7$. However, the first derivatives, dM/dB and dε/dB, taken at about 0.5 K exhibit multiple kinks. These singularities may indicate formation of regular patterns of the triplon excitations. Note, that the interdimer exchange interactions are heavily frustrated in $BaVSi_2O_7$ due to symmetry of exchange paths via corner-sharing SiO_4 tetrahedra. Alternatively, the peak and shoulder in these curves could correspond to two different values of g-factor.

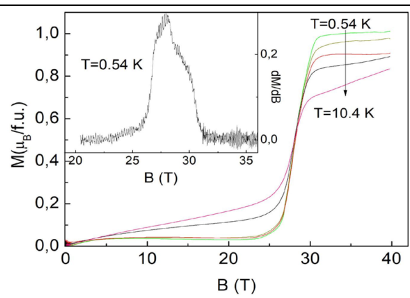

Fig. 1 Field dependence of magnetization (M) of $BaVSi_2O_7$ at B||c axis. Inset: field dependence of the first derivative of magnetization (dM/dB)

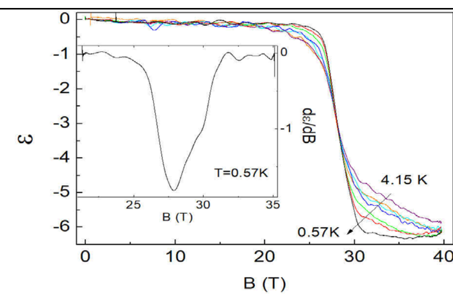

Fig. 2 Field dependence of magnetostriction (ε) in arbitrary units, of $BaVSi_2O_7$ at B||c. Inset: dε/dB)

Conclusions

We found that the process of magnetization in $BaVSi_2O_7$ differs qualitatively from that in the BEC compound $BaCuSi_2O_6$. Presumably, it is due to the weak overlap of t_{2g} orbitals of vanadium with p-orbitals of oxygen and the frustration of interdimer interactions, leading to inflection points that could be very narrow plateaus.

Acknowledgements

This work was performed at the National High Magnetic Field Laboratory, which is supported by National Science Foundation Cooperative Agreement No. DMR-1157490, the US Dept. of Energy and the State of Florida. Y.C.

References

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[3] X. Ding et al, Rev. Sci Inst. 89, 085109 (2018)