NMR Study of Mott Insulator Ba_2NaOsO_6 at High Field

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Introduction

The strong spin-orbit coupling (SOC) effect in Mott insulators, in which the insulating behavior is driven by electron correlations, can give rise to a variety of exotic quantum phases, such as spin liquid, Wely semi-metal, topological insulator, etc. [1]. A representative material of Mott insulating d^1 double perovskites with cubic symmetry is Ba_2NaOsO_6, in which Na and Os ions inhabit alternate cation B sites. In light of the uncommon ferromagnetic state in Ba_2NaOsO_6, quantum models with multipolar magnetic interactions have been proposed. Based on our earlier work [2], a canted ferromagnetic phase preceded by local point symmetry breaking is found at low temperatures, in line with theoretical predictions. To provide further test of the quantum models, we extend our NMR measurement to high magnetic fields up to 34T. We find that at high field, the change of uniform magnetic field H_u is within the error bars.

Experimental

The temperature dependence of ^{23}Na NMR spectra were measured from 5K to 20K at the applied magnetic field of 34T. The measurements were done using the high homogeneity magnet at Cell 14, NHMFL, Tallahassee, FL. A ^{4}He variable temperature insert provided the temperature control. The NMR spectrum was obtained from the sum of the Fourier transforms of the standard solid echo sequence using a homemade NMR spectrometer. A high quality single crystal sample of Ba_2NaOsO_6 was mounted with the applied field parallel to the [100] crystalline axis.

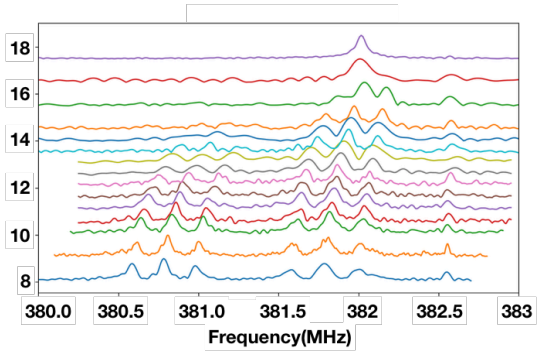

Fig. 1 Temperature evolution of ^{23}Na spectra at 34T.

Results and Discussion

Figure 1 shows the temperature evolution of ^{23}Na NMR spectra at 34 T. Above 17 K, the narrow single peak spectrum characterizes a paramagnetic (PM) state with cubic symmetry. At intermediate temperatures, NMR line broadening and triplet splitting indicate non-zero electric field gradient, marking a broken local point symmetry (BLPS) phase. The emergence of two sets of triplets at low temperatures indicates the emergence of two distinct magnetic sites in a two-sublattice canted ferromagnetic (cFM) phase [2]. In cFM phase, the uniform magnetic field H_u is defined as $H_u=1/2(\langle H_1\rangle+\langle H_2\rangle)$, where H_1 is the first moment of the left triplet and H_2 is the first moment of the second triplet. In Figure 2 we show that the variation of Hu in applied fields above 20 T is within the error bars.

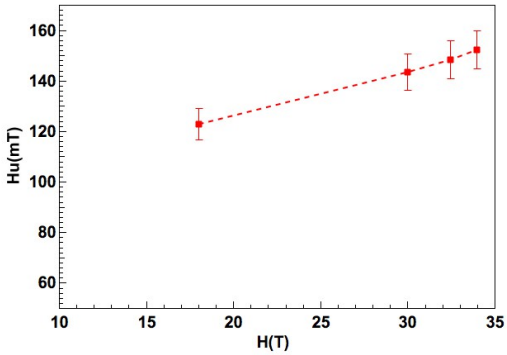

Fig. 2 The uniform magnetic field Hu at Na site at different applied external magnetic field.

Conclusions

We measured the ^{23}Na NMR spectra of a single crystal sample Ba_2NaOsO_6 under an applied magnetic field up to 34 T. A long-range order magnetic phase preceded by local point symmetry breaking is identified at low temperatures. We studied the relationship of Hu under an applied external magnetic field and find that the observed change at Hu in applied fields above 20 T are within the error bars.

Acknowledgements

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References

[1] Witczak-Krempa, W., *et al*., Ann. Rev. Condens. Matter Phys. 5, 57-82 (2014).
[2] Lu, L., *et al.,* Nat. Commun., 8, 14407 (2017)
[3] Liu, W. *et al.,* Physica B: Condens. Matter (2017)