Commensurate-Incommensurate Transition in $S=1/2$ Ising-Like Antiferromagnet BaCo$_2$V$_2$O$_8$

H. Tsujii (Kanazawa U., Physics); Y. H. Kim, Y. Takano (UF, Physics); T. P. Murphy (NHMFL); Z. He (Fujian Institute of Research on the Structure of Matter); H. Ueda, Y. Ueda (U. Tokyo, ISSP)

**Introduction**

In the spin-1/2 Ising-like linear-chain antiferromagnet BaCo$_2$V$_2$O$_8$, a transition occurs from a low-field Néel-ordered phase to high-field incommensurate phase at $H_c \approx 3.9$ T for temperatures below 1.8 K [1–3]. This transition is attracting much interest, since the incommensurate order arises from the one-dimensional physics of the underlying Tomonaga-Luttinger liquid (TTL). The specific heat at 9 T exhibits a linear temperature dependence [2], indicative of a TTL, at temperatures above the ordering temperature of 0.42 K. The magnetocaloric effect [2] shows a hysteresis accompanied by irreversible heat release, revealing that the field-induced transition is first order. The derivative $dM/dH$ of the magnetization $M$ gives additional evidence for the first-order nature of the transition [1].

**Experimental**

We have measured the magnetic torque on this material as a function of magnetic field and field direction using a cantilever magnetometer in a superconducting magnet at the NHMFL DC-Field Facility. The measurements were performed while sweeping the magnetic field mostly at the rate of 0.2 T/min at fixed temperatures.

**Results and Discussion**

The figure shows the results for four field directions close to the crystallographic $c$ axis, which is the Ising-anisotropy direction. The hysteresis accompanying the sharp feature at $H_c$ indicates that the Néel-incommensurate transition is first order, in agreement with the magnetocaloric-effect and magnetization results. $H_c$ increases as the field is tilted away from the $c$ direction.

The angle dependence of the torque for $H < H_c$, in the Néel-ordered phase, suggests that the magnetization of this phase points primarily along the $c$ axis. In contrast, the torque is nearly zero immediately above $H_c$, suggesting that the magnetization of the incommensurate phase points primarily in the field direction. The weak magnetization of the Néel-ordered phase has been interpreted to be due to uninteresting Van Vleck paramagnetism [1]. It is unclear whether this explanation is consistent with our observations.

A density-matrix renormalization-group calculation predicts a transition from the incommensurate phase to another ordered phase in which the spins have a staggered transverse component, at about 15 T [4]. The present experiment has found no evidence for such a transition at least for $H$ up to 20 T and temperatures down to 20 mK.

**Acknowledgements**

This work was supported by a Grant-in-Aid from the JSPS.

**References**