High Field Magnetic Transition of Ca_3CoMnO_6 Up to 90 T

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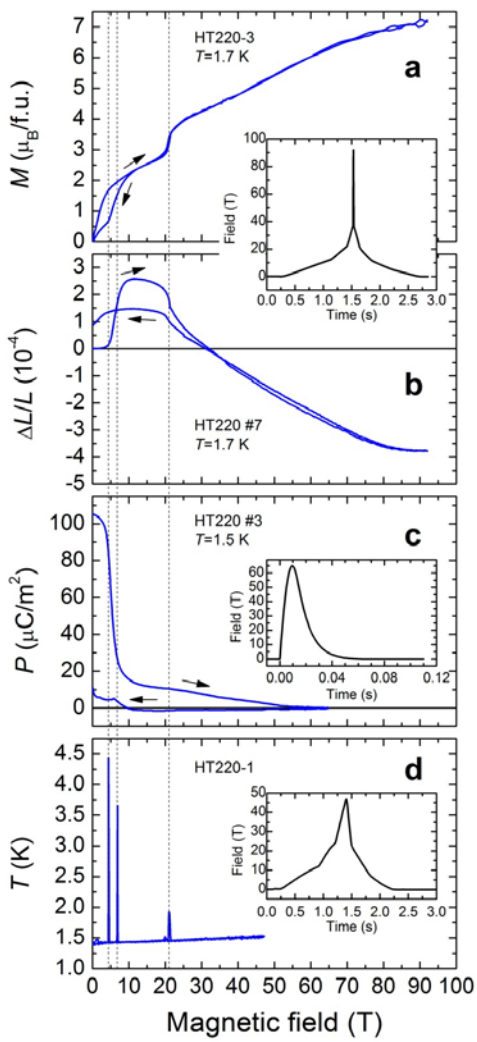

Figure 1. Magnetization (a), magnetostriction (b), electric polarization (c), and magnetocaloric effect (d) as a function of magnetic field. Insets show the magnetic field profiles of each pulse.

Introduction

There are conflicting understandings about the spin states of Co^{2+} ions Ca_3CoMnO_6. Magnetization (*M*) measurements up to 30 T showed a saturated behavior above 30 T [1] and two transitions are described as ↑↑↓↓ to ↑↑↑↓ and finally ↑↑↑↑ with both Co and Mn moments having *S*=3/2. On the other hand, X-ray absorption study showed that the Co ions possess *S*=1/2 supported by DFT calculations [2]. In this work, by using pulse magnets, we show that the true saturation field is *B*~80-90 T which strongly suggests that the Co^{2+} is in the *S*=1/2 state.

Experimental

Magnetization in pulse magnets is measured using an extraction magnetometer. Magnetostriction is measured using a fiber grating method [3]. Electric polarization is integrated from the change of charge (i.e. current) using a current amplifier. Magnetocaloric effect is measured using a field-calibrated Cernox sensor mounted on the sample. Two types of magnets were used; 1) capacitor bank driven short pulse magnet (pulse width ~50 ms) up to 65 T and 2) multi-shot magnet with generator driven long pulse magnet and capacitor driven pulse magnet combined to achieve maximum field of 100 T.

Results and Discussion

Figure 1 shows the magnetic field dependence of various measurements. Magnetization data shows jumps at ~5, 20 T. At 35 T the magnetization slope increases indicating another transition. Finally, the slope decreases at 80-90 T indicating a saturation of electron spin moments. Saturation behavior is more clearly observed in magnetostriction data.

Magnetocaloric effect (Fig. 1d) clearly shows that the transitions below 30 T are first order phase transitions.

Conclusions

The observation of magnetic transitions above 30 T and 4 μ_B/f.u. clearly states that the Co^{2+} is in low spin state with *S*=1/2. Also the different direction of magnetostriction at low and high field indicates that Mn and Co spins undergoes reorientation at different field ranges. We expect that the sudden change with hysteretic behavior is responsible for the Co ions and smooth changes above 30 T from the Mn ions.

Acknowledgements

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References

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[3] R. Daou *et al.*, Rev. Sci. Instrum. 81, 033909 (2010).