Magnetoelectric Effect of Antiferromagnet $MnTiO_3$

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Introduction

The magnetoelectric (ME) effect is a phenomenon where magnetic moment and electric polarization is closely related each other via spin-phonon coupling. $MnTiO_3$ is an antiferromagnet where Mn^{2+} spins order antiferromagnetically along the *c*-axis. The asymmetric arrangement of the Mn^{2+} ions is also expected to give local electric polarization [1], which enable us to study ME effect by measuring dielectric constant.

Experimental

The dielectric constant of $MnTiO_3$ single crystals was measured using a 7 T magnet of Quantum Design MPMS and NHMFL 31 T magnet (cell 9). Ac electric fields of 600 V/cm amplitudes were applied along two different directions (*a*- or *c*-axis) to measure capacitance of the samples while magnetic fields applied along the magnetic easy axis (*c*-axis).

Results and Discussion

Fig. 1 shows dielectric constant (κ) as a function of temperature and field for two different electric field directions. There are two distinctive features related with ME effect. (1) A very sharp single peak around 64 K at low fields (H < 7 T); (2) a less temperature dependent polarization emerging from low temperatures for H >6.5 T. The latter eventually dominates at higher fields (H> 7T) and also has different behaviors depending on the applied electric field direction. For instance, κ_a increases gradually with field for $H>H_{SF}$ while κ_c increases sharply at $H=H_{SF}$ followed by gradual decrease at higher fields. It is clear that the observed polarization is due to ME effect associated with antiferromagnetism of $MnTiO_3$ (with $T_N \sim 64$ K and spin-flop field (H_{SF}) ~ 7 T). Although the large ME effect for E||a configuration is unpredicted, it is likely that both magnetostriction and Dzyaloshinsky-Moriya interaction play important roles for the observed ME effect.

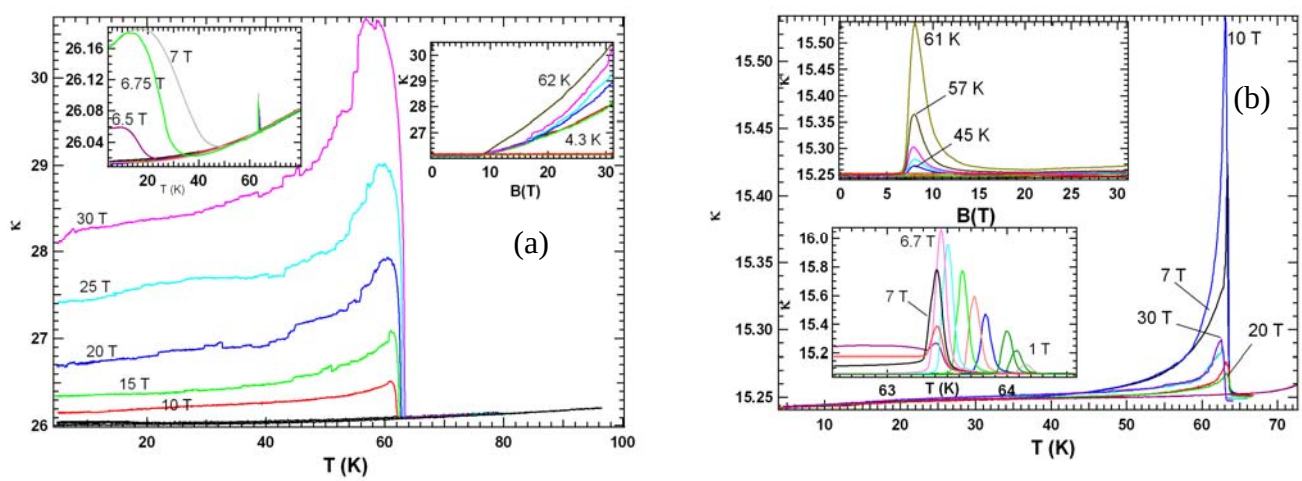

Fig. 1. Dielectric constant as a function of temperature at different fields for (a) E||a, H||c and (b) E||H||c. The insets are low field data and dielectric constant as a function of field.

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References

[1] Toyosaki, H., *et al*., Appl. Phys. Lett., **93**, 072507 (2008).