MS35-02 **Giant Improper Ferroelectricity in the Ferroaxial Magnet $CaMn_7O_{12}$.** R. D. Johnson,[ab] L. C. Chapon,[c] D. D. Khalyavin,[b] P. Manuel,[b] P. G. Radaelli,[a] and C. Martin.[d] [a]*Clarendon Laboratory, Department of Physics, University of Oxford, Oxford, Ox1 3PU, United Kingdom,* [b]*ISIS Facility, Rutherford Appleton Laboratory-STFC, Chilton, Didcot, OX11 0QX, United Kingdom*, [c]*Institut Laue-Langevin, BP 156X, 38042 Grenoble, France*, [d]*Laboratoire CRISMAT, ENSICAEN, UMR F-6508 CNRS, 6 Boulevard du Marechal Juin, F-14050 Caen, France*
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Multiferroic materials are those in which both electric polarisation and long-range magnetism coexist in a single phase. This research topic has gained great attention, with aims in finding materials that display large magnetically induced ferroelectricity at high temperatures - key for application in technology. In this contribution, we present a detailed experimental study of the complex oxide $CaMn_7O_{12}$. We show that in this material the largest reported improper ferroelectric polarisation is induced by an incommensurate helical magnetic structure that develops below 90 K. Furthermore, we demonstrate that the electric polarisation is constrained to the high symmetry axis of the rhombohedral crystal lattice, perpendicular to the plane of rotation of the magnetic moments. This behaviour cannot be explained by conventional theories of multiferroicity, but may be described by the novel mechanism of ferroaxial coupling.

Keywords: multiferroics; manganites; magnetism

MS35-03 **Depoling studies of lead-free $Na_{½}Bi_{½}TiO_3$ – $K_{½}Bi_{½}TiO_3$ piezoelectric ceramics.** David I. Woodward,[a] David Walker,[a] Pam A. Thomas,[a] Robert Dittmer,[b] Wook Jo,[b] Jürgen Rödel,[b] [a]*University of Warwick, UK,* [b]*Technische Universität Darmstadt, Germany.*
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The depoling transition in lead-free piezoelectrics based on $Na_{½}Bi_{½}TiO_3$ (NBT) has been studied by several different techniques, including X-ray diffraction (XRD), *in-situ* measurements of piezoelectric coefficient (d_{33}), pyroelectric current and second harmonic generation (SHG). For pure NBT, all techniques show that the maximum rate of depolarisation occurs at temperatures in the range 160 – 170 °C. The addition of $K_{½}Bi_{½}TiO_3$ (KBT) to form a solid solution leads to ceramics with enhanced piezoelectric properties, with d_{33} maximised for the composition 0.8NBT – 0.2KBT [1]. However, at this composition, it is found that depoling appears to take place at significantly different temperatures, depending on the technique used. Our results have shown for 0.8NBT – 0.2KBT ceramics that the depoling transition consists of three distinct steps: (1) loss of field-induced strain at 65 °C, (2) loss of polarisation at 100 °C and (3) loss of long-range coherence at 120 °C. The addition of 2 % $BiZn_{½}Ti_{½}O_3$ increases the depoling temperature as measured by all techniques without negatively affecting d_{33} [2], but the range of depoling temperatures is reduced to 110 – 140 °C.

Such observations are difficult to explain crystallographically with the classical model of displacive phase transitions. However, a model of the depoling transition, based on nucleation and growth of polar nano-regions, consistent with these observations, is presented. This model is used to show that the existence of an antiferroelectric phase, long considered controversial, is not necessary to explain the depoling transition.

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