Study of the dielectric and magnetic properties of Multiferroic Ca$_3$Mn$_2$O$_7$

EHAB ABDELHAMID, AMBESH DIXIT, GAVIN LAWES, Wayne State University — Materials exhibiting simultaneous magnetic and ferroelectric order are widely studied because of the strong spin-charge coupling that can arise in these systems together with their applications to novel magnetoelectric devices. While it has long been recognized that Ca$_3$Mn$_2$O$_7$ develops magnetic order below 120K, recent theoretical calculations suggest that this system may undergo a structural transition to a ferroelectric state above this temperature. Ca$_3$Mn$_2$O$_7$ is a member of the Ruddlesden Popper series $A_{n+1}B_nC_{3n+1}$ with $n=2$, which has a tetragonal crystal structure at high temperatures but undergoes a transition to an orthorhombic structure at lower temperatures. We prepared a powder sample of Ca$_3$Mn$_2$O$_7$ using a conventional ceramic technique and investigated the structure using X-ray diffraction and temperature dependent Raman spectroscopy. We measured the temperature dependent magnetization, which shows the development of weak ferromagnetism near 120K, together with evidence for some Mn$_3$O$_4$ impurity phase. We find marked shifts in the Raman peaks near the magnetic ordering temperature, suggesting significant spin-lattice coupling in Ca$_3$Mn$_2$O$_7$. Finally, measurements of the temperature dependent dielectric response and pyroelectric current find anomalies consistent with a ferroelectric transition just below room temperature showing a polarization of $1\mu$C cm$^{-2}$ developing below 280K.

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