MAGNETIC-FIELD-INDUCED QUANTUM PHASE TRANSITITON IN $BiMn_2O_5$

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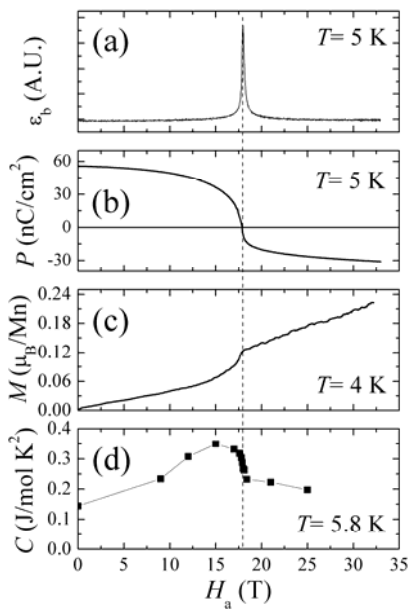
In our previous investigations of magnetic field-temperature phase diagram of multiferroic RMn_2O_5 (R= Tb, Dy, Y, and Bi) compounds [1], we have discovered a common phase boundary with similar shape at high field (>18 T) for all compounds. Particularly for $BiMn_2O_5$, polarization (P) change from low field positive to high field negative at the phase boundary. Interestingly, a large peak in dielectric constant (ε) is found at the zero polarization state. This magnetic-field-induced ferroelectric transition has been studied in detail by dielectric constant, electric polarization, magnetization and heat capacity measurements.

A home-made transport stick with 12 coaxial wires and 18 phosphor-bronze wires is used for ε and P measurements. Heat capacity is measured with a Si-based heat capacity probe. Magnetization is measured with a compensated coil susceptometer adapted for use in a pulse magnet at LANL-NHMFL. All other measurements are done in a DC resistive magnet in NHMFL, Tallahassee. The electric contacts were made in the b-plane and magnetic field is applied along the a-axis of the sample.



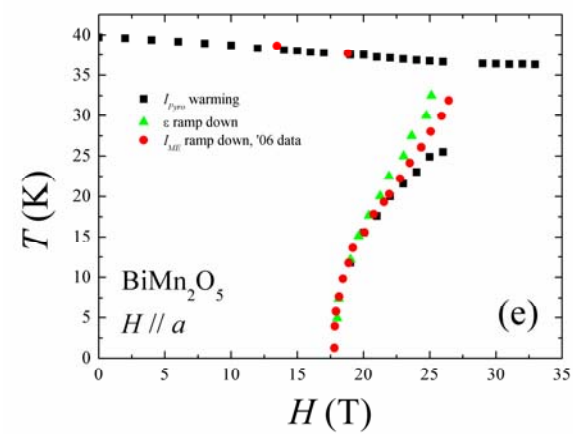


FIG. 1. (Left panel) Magnetic field dependent (a) dielectric constant, (b) electric polarization, (c) magnetization and (d) heat capacity at fixed temperatures. (Right panel) (e) Magnetic field-temperature phase diagram of $BiMn_2O_5$. A single magnetic field induced transition exists down to 0.6 K.

Fig. 1 (a)-(d) shows the magnetic field dependent dielectric constant, polarization, magnetization, and heat capacity of $BiMn_2O_5$, respectively. The dielectric constant shows a sharp peak at the critical field ~ 18 T. Polarization changes sign from positive to negative, and magnetization shows a sharp increase near the critical field. With increasing field, heat capacity increases up to ~ 15 T. After a maximum value at 15 T, heat capacity decreases steeply near the critical field and decreases slowly up to 25 T. Magnetic field-temperature phase diagram of $BiMn_2O_5$ is plotted in (e). The trajectory of the phase boundary at high field follows the scaling relation $T_c(H)\sim(H-H_c)^{1/2}$, which is similarly found in quantum paraelectrics or incipient ferroelectrics such as $KTaO_3$ and $SrTiO_3$ [2].

These observations supports an interesting possibility that $BiMn_2O_5$ can be the first system to exhibit quantum fluctuation of ferroelectricity tuned by magnetic field.

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[2] W. R. Abel, Phys. Rev. B **4**, 2696 (1971); K. A. Muller and H. Buckard, Phys. Rev. B **19**, 3593 (1979).