**Dielectric Constant Studies on the New Magnetic Quantum Paraelectric Material BaFe12O19**

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**Introduction**

It is called quantum paraelectricity when a (anti)ferroelectric phase transition is impeded by the strong quantum fluctuations closely related to the zero point energy motion. One widely celebrated system is SrTiO3 [1]. The distinctive feature of the quantum paraelectricity is the plateau-like behavior at low temperatures in the temperature dependence of dielectric constant while the high temperature phase is described by the Curie-Weiss law. The strong fluctuation effect stabilizing the quantum paraelectric phase indicates that the phase is fragile and highly susceptible to any type of external stimulus. Therefore, the quantum paraelectric material provides a useful playground to study quantum phase transition. A renowned hexaferrite permanent magnet BaFe12O19 has been also suggested as a new ferrimagnetic quantum paraelectric material [2, 3].

**Experimental**

A single-crystal sample was polished into a plate with typical dimensions of 4 × 4 × 0.1 mm3 to have a parallel-plate capacitor geometry for dielectric constant measurement. The normal vector to the large surface is parallel to the *c*-axis. The electrical contacts were made with silver epoxy on the two large surfaces. The capacitance of the sample was measured with an Andeen-Hagerling AH-2700A capacitance bridge, and the dielectric function was obtained by assuming the sample as an ideal parallel-plate capacitor. The dielectric constant was measured 0.3 K < *T* < 30 K at various magnetic field. The SCM2 magnet of the milikelvin facility in Tallahassee was used for the experiment.

**Results and Discussion**

We observed the clear plateau-like behavior below 10 K in the dielectric constant measurement as shown in Fig. 1 (a). An unusual T2 dependence of the inverse dielectric function is observed in BaFe12O19 between 10 K and 20 K (Fig. 1 (b)), a feature also detected in well-known quantum paraelectric material, SrTiO3 and KTaO3. Moreover, a particularly interesting downturn in the dielectric function around 1.4 K, which is robust to the external magnetic field is also observed as shown Fig. 1 (c). The downturn can be understood in terms of quantum phase transition where the dipolar long-range interaction and the coupling between electric polarization and acoustic phonons are in play. This downturn feature is also observed when the quantum paraelectric system exists on the board of ferroelectricity and paraelectricity like SrTiO3 and KTaO3 [4]. These observations strongly suggest that the BaFe12O19 is indeed quantum paraelectric material.



Figure 1 (a) Temperature dependence of dielectric constant. (b) The unconventional T2 dependence of the inverse of dielectric constant. (c) Temperature dependence of dielectric constant at various magnetic fields.

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**References**

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