Investigation of extremely low energy phonon mode in quantum paraelectric SrTiO3 (STO16)

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Quantum paraelectrics (QPE's) are dielectric compound that fail to be ferroelectric at low temperature due to large zero-poin motion of their ions [1]. QPE is well known for $SrTiO_3$ (STO). The dielectric constant in STO increases up to 30 000 upon cooling, and then remains temperature independent below 3 K. There is an interesting analogy between QPE's and relaxor ferroelectrics in that both shows polar nanoregion (PNR) when dielectric constant becomes huge. Recently, we have performed neutron spin-echo (NSE) experiments on typical relaxor PMN-30PT and have found low frequency vibration mode with f ~10 GHz (ω ~40μeV) at temperatures which PNR's are formed. To investigate existence of low frequency vibration mode in QPE's STO, we performed NSE measurement with using PONTA-TASSE installed at the JRR-3. The sample was a high-quality STO single crystal with a volume of 8cc, and mounted so as to access (*hkk*) scattering plane. The data were taken with incident neutron energies of 14.7 meV.

Figure 1 shows the polarization at (0,1,1) (top) and (0.02,1,1) (middle), and intermediate scattering function $I(Q,t)/I(Q,0)$ at (0.02,1,1) (bottom) measured at $T = 10$ K using PONTA-TASSE spectrometer. In general, nuclear Bragg peak is consider to be static. The decrease in polarization at (0,1,1) can be owing to depolarization in our spectrometer setup. Diffuse scattering is usually quasielastic and shows faster drop in polarization that that in nuclear Bragg peak. However, obtained signal in STO is opposite, which gives intermediate scattering function $I(Q,t)/I(Q,0) > 1$. This may indicate that lattice itself is not static and have dynamics component, which may give large drop in polarization. Further study should be necessary to clarify this phenomena.

References

[1] S. K. Kurz, Trans. Am. Crystallogr. Assoc., 2 (1975) 63.

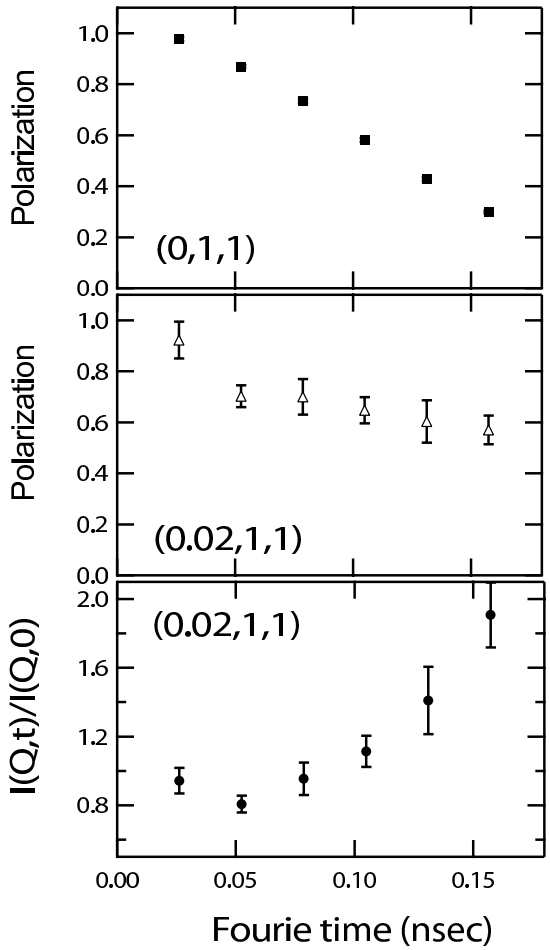

Fig. 1. Polarization at (0,1,1) (top) and (0.02,1,1) (middle), and intermediate scattering function I(Q,t)/I(Q,0) at (0.02,1,1) measured at $T = 10$ K using PONTA-TASSE spectrometer.