Temperature dependence of waterfall feature of phonons in $(Na_{0.5}Bi_{0.5})TiO_3$

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Relaxor ferroelectrics have attracted considerable attention since the discovery of giant piezoelectricity in relaxor-based single crystals. $(Na_{0.5}Bi_{0.5})TiO_3$ (NBT) forms perovskite structure with two different ions Na^+ and Bi^{3+} at the A site of ABO_3. Recently, NBT regains attention as promising applications to piezoelectric devices containing no toxic lead. Last year, we studied the lattice dynamics in NBT and clarified so-called waterfall feature, anomalous damping of transverse optic (TO) phonons for reduced wave vector less than $q_{wf} = 0.2Å^{-1}$, which was commonly observed in typical lead-containing relaxors as PMN[1] and PZN-8%PT[2]. For PMN, it has been shown that the recovery of TO mode occurs in ferroelectric phase and at very high temperatures[3]. The purpose of the present work is to study temperature dependence of waterfall feature in detail and to confirm recovery of TO mode. Neutron scattering experiments were performed on the triple-axis spectrometers PONTA installed at the JRR-3 Reactor hall of JAEA.

Figure 1 shows profiles of constant-E scan along transverse direction from (220). Inset shows the TA and TO dispersions at $T = 670$ K, where no propagating mode was observed for $q < 0.10$ rlu, and the TO branch drops like waterfall to the TA branch. Constant-E scan at $E = 11$ meV, represented as the red arrow in inset, crosses the waterfall TO branch and shows peak at $q = 0.16$ rlu at $T = 700$ K. With decreasing temperature, the peak shifts towards Γ-point, and eventually disappears at $T = 300$ K, which indicates disappearance of waterfall feature and recovery of TO mode at $T = 300$ K. Actually, we observed TO mode at $\omega = 15$ meV at Γ-point for $T = 300$ K (not shown). Hlinka *et al.* proposed that the waterfall feature is explained by coupled damped TA and TO modes[4]. The current result indicates that such coupling is universal in relaxors and plays an important role in formation of PNR.

References

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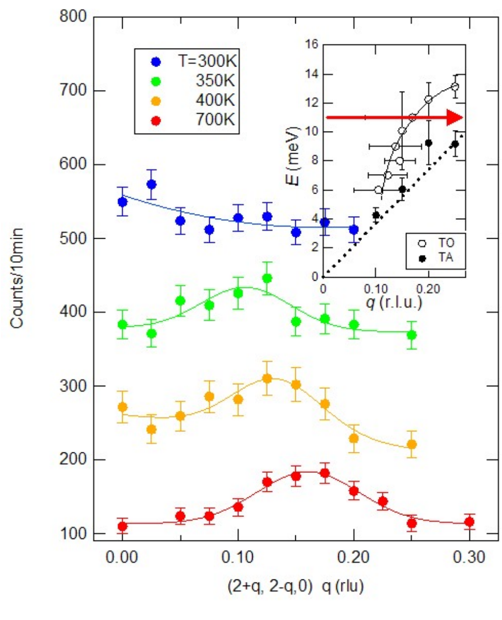

Fig. 1. Profiles of constant-E scan of $(2-q, 2+q, 0)$ with fixed energy transfer of 11 meV. The data at different temperatures are plotted with offsets.