Damped acoustic phonon in the relaxor ferroelectric $Pb(Mg_{1/3}Nb_{2/3})O_3$

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Relaxor ferroelectrics have gained great interest recently due to their promising application as piezoelectric devices. $Pb(Mg_{1/3}Nb_{2/3})O_3$ (PMN) is a typical relaxor which shows a broad and frequency dependent peak in dielectric susceptibility. It is widely believed that the polar nanoregions (PNR) occurring at temperatures much above T_c, the so-called Burns temperature T_d, play an important role in such relaxor behavior. Neutron scattering measurements by Naberezhnov *et al.* on PMN revealed the onset of strong diffuse scattering at or very near $T_d \sim 600$ K [1], indicating a close connection between the PNR and the diffuse scattering. The lattice dynamics in PMN are characterized by a soft, zone center, transverse optic (TO) mode observed below T_d. Thus, it is expected that the local crystal distortion in PNR is driven by the soft TO. However, recently, the soft TO mode was observed in the normal ferroelectric PMN-40%PT [2], which casts doubt on the soft mode concept of the PNR. To elucidate the lattice dynamics in PNR, we investigated the acoustic phonon and low energy excitations in PMN. Neutron scattering experiments were performed on the triple-axis spectrometers HER installed at the JRR-3 Reactor of the JAEA.

Figures 1 show the constant Q spectra at (1.1 1.1 0) and (1.1 0.9 0) taken at $T =$ 650, 500, and 400 K. At $T = 650$ K ($\geq T_d$), a well-underdamped transverse acoustic (TA) phonon and longitudinal one (LA) shown by dotted lines were observed at 2.67 ± 0.03 and 3.57 ± 0.15 meV, respectively. At $T = 500$ K, the TA mode becomes overdamped and a resolution-limited peak at $E = 0$ (central peak: dotted line) develops at (1.1 0.9 0), while the LA mode remains underdamped and no enhancement of the central peak was observed at (1.1 1.1 0). The central peak corresponds to the (110) diffuse scattering which elongates along the transverse directions. In addition, a quasielasctic scattering (dotted and broken line) appears below $T = 500$ K. The central peak and quasielastic scattering develops especially at (1.1 0.9 0) with decreasing temperature. The overdamped TA mode coupled with the strong diffuse scattering and quasielastic scattering indicates a coupling between TA mode and PNR, which is consitent with the uniform phase shift concept proposed by Hirota *et al.* [3] On further cooling, the underdamped TA mode recovers and the quasielastic scattering disappears below $T_c \sim 213$ K at which PMN becomes ferroelectric on electrical field-cooling.

References

[1] A. Naberezhnov *et al.* , Eur. Phys. J. B, **11**, 13 (1999).
[2] C. Stock *et al.* , Phys. Rev. B, **73**, 64107 (2006).
[3] K. Hirota *et al.* , Phys. Rev. B, **65**, 104105 (2002).

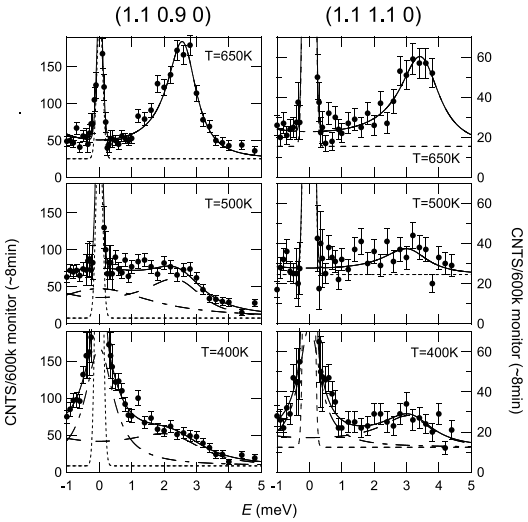

Fig. 1. Constant Q scan at (1.1 1.1 0) and (1.1 0.9 0). Solid lines showfits to the sum of a sharp Gaussian peak at $E = 0$ (dotted line), a broad Lorentzian peak at $E = 0$ (dotted and broken line), and a damped-harmonic-oscillator peak (broken line).