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# Manifestation of local polar regions in spectroscopic investigations in ferroelectrics and relaxors

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A number of unique properties of ferroelectrics with a diffuse phase transition are determined by noncentrosymmetric polar nanoregions which appear in the paraelectric phase. To study the role of polar nanoregions in ferroelectrics and relaxors, spectroscopic studies in the typical relaxor $Pb_3(MgNb_2)O_9$ (PMN), conventional ferroelectric crystal $BaTiO_3$ and $Sr_xBa_{1-x}Nb_2O_6$ (SBN-*x*) are carried out. Transformation of a conventional ferroelectric to a relaxor within the same class of symmetry occurs in SBN-*x*: these crystals exhibit properties of both relaxors ($x > 0.6$) and conventional ferroelectrics ($x < 0.6$).

Brillouin spectra and generation of the second optical harmonic in a series of SBN-*x* crystals, PMN and $BaTiO_3$ are investigated in the 115-850 K temperature range. The second harmonic generation (SHG) is observed in paraelectric phase in all crystals under study, revealing the presence of polar regions in the paraelectric crystals. The spectral width of the SHG spectrum does not exceed 0.3 $cm^{-1}$ and is temperature independent. Upper limit of the spectral width of the SHG spectrum provides lower limit of the lifetimes of polar regions, which are longer than 15 ps. It suggests that the doubled frequency signal in the paraelectric phase is generated in areas with lifetimes longer than 15 ps.

Elastic modulus $C_{33}$ extracted from the Brillouin experiment revealed peculiarities of its temperature behavior near the phase transition temperature. Comparison of the SHG temperature dependences with ones of the elastic modules showed that the coupling of elastic modulus and polar state via electrostriction provides the description of the acoustic anomalies. The temperature dependences of the relaxation times of local polar regions are determined from the anomaly of width of the Brillouin peak in the vicinity of the phase transition.

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