Depolarization Field Effect in Dynamical Critical Phenomena of Ferroelectrics

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Recent theoretical studies have established that static critical phenomena of ferroelectrics are well explained by the mean field approximation including the logarithmic correction. (1) This result is based upon no divergence of the long wavelength polarization fluctuation with the longitudinal wave vector owing to the depolarization field of the dipole-dipole interaction. This "depolarization field effect" is expected to play an important role also in dynamical critical phenomena. From this point of view, a theoretical and experimental review is made on critical anomalies of transport coefficients in order-disorder type ferroelectrics. The main attention is paid to those of the spin-lattice relazation time T_1 and the line width in N.M.R. and of the absorption coefficient and the sound velocity change in ultra- and supersonic (Brillouin scattering) studies carried out in our laboratories. (2)(3) From the standpoint of the generalized Langevin equation, these transport coefficients are represented as the Fourier transform of the time correlation function of random forces which are some functions of a dipolar configuration, and are related to anomalies of polarization fluctuations and energy fluctuations. Since these anomalies have characteristic features origination from the depolarization field effect, these transport coefficients are expected to display characteristic temperature dependences near the transition temperature T_c.

Experimental results are summarized below in the present stage. The existence of the depolarization field effect is demonstrated by measuring ultra- and supersonic attenuation coefficients of longitudinal acoustic waves propagating along the polar axis and along the perpendicular direction to this axis. (3)(4) Ultrasonic and N.M.R. studies are experiments of rather low frequency to detect a characteristic frequency of the critical slowing down. In this sence, Brillouin scattering experiments will be a convenient

method. In fact, we can determine a dipolar relaxation time by measuring a maximum temperature of the Brillouin line width. [4] Though there is an ambiguity in analyzing experimental data how to subtract the backgound or the normal part which does not show an anomaly at T_c, observed anomalous temperature dependences in ultrasonic [3][5] and NMR [2][6] studies seems to be described by a logarithmic divergence better than by a power law. These logarithmic divergences are explained as the leading term owing to the depolarization field effect in a unified manner. We are going to confirm this experimental fact by studying on nonferroelectric substances which undergo phase transitions without the depolarization field effect.. Moreover, this simple logarithmic divergence is not rigorous in the very vicinity of T_c as is pointed out by Larkin and Khmelnitskii [7] in the specific heat. Further precise experiments are necessary to make apparent this critical phenomena in ferroelectrics. On the other hand, further calculation on anomalous critical behaviours of T_1^{-1} and of the line width is in progress.

(1) see e.g. M. Tokunaga and T. Mitsui, Ferroelectrics 11 (1976).

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(3) I. Tatsuzaki and M. Tokunaga, Ōyo Butsuri **44** 918 (1975) (in Japanese).

(4) T. Yagi, M. Tokunaga and I. Tatsuzaki, J. Phys: Soc. Japan (to be published).

(5) I. Todo, J. Phys. Soc. Japan **39** (1975).

(6) T. Takoshima and I. Tatsuzaki, J. Phys. Soc. Japan **39** (1975) 427.

(7) A. I. Larkin and D. E. Khmelnitskii, Sov. Phys. -JETP **29** 1123 (1969)