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Temperature Dependence and Relaxation Phenomenon of Small Angle Neutron Scattering Intensity on $La_{2-x}Sr_xCuO_4$

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On observations of vortex lattices in high-T_c superconductors by the neutron scattering, only a little signal can be detected due to the weak contrast of magnetic induction in the sample. It is, therefore, very important to subtract the background scattering produced by inhomogeneities in the sample from row data. Though it has been considered that the scattering from inhomogeneities is almost temperature independent by now, it turned out to be strongly dependent on the history of temperature in $La_{2-x}Sr_xCuO_4$ (LSCO). In order to investigate the behavior of scattering intensities to the temperature history, we performed small angle neutron scattering (SANS) measurements with $La_{2-x}Sr_xCuO_4$ sample.

The sample is synthesized by traveling solvent floating zone (TSFZ) method and the content of Sr is x=0.20 ($La_{1.8}Sr_{0.2}CuO_4$, T_c=30K). SANS measurements were performed with SANS-J apparatus at JRR-3M reactor in JAERI-Tokai. The total scattering intensity in no field is shown in Fig.1 in a function of temperature. It apparently increases at around 30K and shows irreversible behavior in cooling and warming process. Keeping the temperature at a constant lower than around 30K, the relaxation phenomenon that total intensity increases as time was observed. This phenomenon was enhanced by the applied field and didn't saturate in about ten hours. It should be noticed that this relaxation phenomenon was observed in no applied field. Even though in the field, it wasn't changed. So this case of relaxation is different from typical flux creep relaxations seen as the response to the change of the applied field.

About the origin of additional scattering, it is considered as follows. [1] magnetic induction, [2] atomic spin interaction, [3] nuclear interaction to be the potential for the neutron. For [1], though applied field is indeed zero, some gauss of residual field is detected around the sample. As the observation of Bitter pattern is reported in Bi2212[1)] and Y123[2)] at 8 [G] and 5.5 [G] respectively. So it is though to be possible in also LSCO. But the radial distribution function (I(q)-q profile) is not consistent with existence of vortices, because there is no signal of spatial correlation (even short range correlation) in it. For [2], antiferromagnetic ordering of Cu spins are, in general, thought to be broken in the over-doped region. For [3], tetra-ortho phase transition point is comparable to this anomalous point (30K). In fact, such a phenomena of increasing of intensity and relaxation were not observed in the under-doped sample (x=0.136), which tetra-ortho transition point is quite high temperature far above 30K.

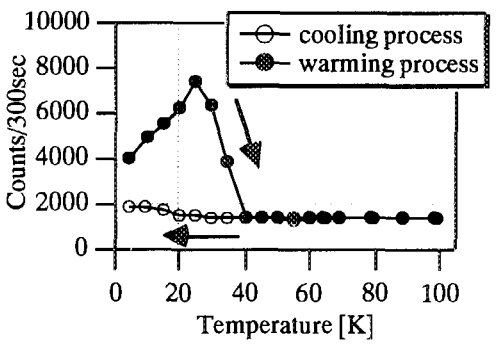

Fig.1 Temperature dependence of total counts of neutrons scattered from LSCO(x=0.20) sample in no field. It icreases apparently at low temperature (under around 30K).

References

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2) K.Sasaki *et al.*, Jpn J. Appl. Phys., 32(1993), L990-L993.