Small-angle Neutron Scattering Study of Josephson Vortices in a Superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$

J. Suzuki, N. Metoki, S. Miyata, M. Watahiki, and K. Nakamura

Japan Atomic Energy Research Institute (JAERI), Tokai 319-1195, Japan

K. Kimura, N. Kataoka, and K. Kadowaki

Institute of Materials Science, University of Tsukuba, Tsukuba 305-0006, Japan

M. Tachiki

National Research Institute for Metals, Tsukuba 305-0047, Japan

Abstract

We report the results of the small-angle neutron scattering experiments in a highly anisotropic superconductor $Bi_2Sr_2CaCu_2O_{8+\delta}$ single crystal. We measured the Bragg scattering form the flux-line-lattice as a function of angle, θ, between the applied magnetic field and the crystalline c-axis. We found that the Bragg scattering intensity from the triangular lattices rapidly decreases as θ is increased and it diminishes above $\theta > 15°$. This strongly implies that the ordered Abrikosov triangular lattice is lost above 15° tilting angle by additional small parallel field component to the ab-plane. For $\theta = 90°$, we observed a streaked scattering due perhaps to the one dimensional array of vortices, which is tilted about 10∘ from the ab-plane below the critical temperature ($T_c = 89$ K) instead of the Bragg scattering from triangular lattices. The integrated intensity of the streak remarkably increases upon cooling the crystal. This result indicates that the vortices closely coupled

each other almost along the c-axis like a chain, but the chain-chain distance in the ab-plane is separated more than 300 nm even at a field of 5 T. It is qualitatively consistent with the recent results of numerical simulations, which suggest a chain structure for the Josephson vortices in the case of extremely large anisotropy.