Quasi-particle excitation in the mixed state of $Bi_2Sr_2CaCu_2O_y$

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Abstract

Study of high-frequency electromagnetic response of superconductors in the mixed states provides rich information on the vortex dynamics and quasi-particle excitations. In cuprate superconductors, a number of high-frequency response studies have been made in the mixed states. However, most of measurements were performed on relatively dirty samples and the changes in the high-frequency response at the first-order vortex-lattice melting transition (VLMT), which is only observed in clean samples, have not been investigated yet. Therefore, we have measured the in-plane millimeter-wave complex resistivity in an FZ-grown $Bi_2Sr_2CaCu_2O_y$ single crystal at 98 GHz. In this crystal, the first-order VLMT was clearly visible using 2DEG-based Hall probe magnetometry. To avoid any extrinsic effects associated with swept magnetic field, all the high-frequency measurements were performed under field-cooled conditions. We found that the real and imaginary parts of the complex resistivity show a clear kink at the VLMT and rapidly increase in the vortex liquid phase. The extrapolated values of both parts of the resistivity from the vortex liquid phase to the zero field are larger than their values measured in the absence of magnetic field. This result implies that a pair breaking mechanism sets in at the VLMT and the superfluid density decreases in the vortex liquid phase. This pair breaking mechanism is considered to be related to the vortex state in the *d*-wave superconductor.