Loss of Interlayer Phase Coherence at the Vortex-Lattice Melting Transition in Layered Superconductors

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Abstract

The vortex phase diagram in the layered superconductors κ-(BEDT-TTF)$_2$Cu[N(CN)$_2$]Br (ET-Br) and $Bi_2Sr_2CaCu_2O_{8+y}$ (BSCCO) was studied by the Hall-probe magnetometry and Josephson plasma resonance. By using a miniature Hall probe we found a clear step in the local magnetic induction well below H_{c2} in the organic ET-Br as well as BSCCO, which is evidence for a first-order "vortex-lattice melting" transition. The height of the step in ET-Br is of the order of 10 mG, from which the entropy change at the transition is estimated to be about 0.1 k_B/vortex/layer, which is comparable to that of high-T_c superconuductors. We also found that the organic layered superconductors show the Josephson plasma resonance (JPR) similar to that of BSCCO, which is known to be powerful probe for the interlayer phase coherence. In both ET-Br and underdoped BSCCO, we found that JPR at the transition line shows no frequency dependence in contrast to the anti-cyclotronic frequency dependence below and above the transition line. This frequency-independent JPR at the transition line means that the phase coherence between the adjacent superconducting layers abruptly changes across the transition line. These results indicate that the decoupling — the loss of coherence between the layers — takes place at the first-order "vortex-lattice melting" transition line.