Monte Carlo Study of Vortex State in Heavy-Ion Irradiated Bi-2212

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Abstract

We study the vortex phase diagram in high-T_c superconductor $Bi_2Sr_2CaCu_2O_8$ when columnar defects are introduced by heavy-ion irradiation, by using Monte Carlo simulation based on the Lawrence-Doniach model. At finite temperatures, we numerically found that a magnetic-field(B)-driven transition occurs in the trapping rate of pancake vortices to the defects, at a critical field of $B/B_\Phi \simeq 1/3$ well below the matching field B_Φ [Sugano *et al.*, Phys. Rev. Lett. **80**, 2925 (1998)]. Around this transition, the c-axis vortex correlation changes dramatically with increasing field, and the melting curve $T_m(B)$ of the Bose glass shows an anomalous re-entrant behavior. The transition in the vortex liquid phase is accompanied by a discontinuous jump of the interlayer coherence, where the decoupled vortex liquid appears to partially couple along the defects. On the other hand, a partial decoupling of the vortex-line glass occurs below $T_m(B)$. This field-driven transition could illustrate several anomalous behaviors observed experimentally, including double resonant peaks in the Josephson plasma measurement ($T > T_m$) [Kosugi *et al.*, Phys. Rev. Lett. **79**, 3763 (1997); Sato *et al.*, *ibid.*, 3759 (1997)] and a "third" peak effect in the irreversible magnetization ($T < T_m$) [Chikumoto *et al.*, Phys. Rev. B in press; Hirata *et al.*, in *Advances in Superconductivity* (Springer Verlag, in press)].