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Magnetization of high-T_c superconductors

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Abstract. We have tried to understand the field dependence of magnetization of high temperature superconductors in the light of phenomenological theory. Especially, the field dependence of $dM/d\ln B$ of polycrystalline Bi(2212) is understood by incorporating the overlap of vortices in the London theory.

Keywords. High-T_c superconductors; magnetization; phenomenological theory.

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The magnetic properties of high temperature superconductors (HTSCs) in magnetic fields are very unusual near the transition temperature T_c and are different for different HTSCs. Near T_c, the magnetization (M) of Y(123) is proportional to $(T - T^*)^2$, where T^* is almost field independent and close to T_c [1,2]. It has also been observed that the magnetization of Y(123) is approximately logarithmic in B_a in the reversible region and can be understood by using 3D description of the London theory [3–5]. It has also been applied to understand the temperature dependence of specific heat in magnetic field [6], whereas, the field dependence is understood by incorporating the overlap of vortices in the London theory [7]. Incorporating the overlapping of vortices in the London theory the magnetization for 3D superconductors can be written as [7]

$$M = M_L = \frac{B - H}{4\pi} = -\frac{\phi_0}{32\pi^2\lambda_{\text{eff}}^2}\ln\left(\frac{B_{c2}}{B_a}\right) = -\frac{\phi_0 f^2}{32\pi\lambda^2}\ln\left(\frac{B_{c2}}{B_a}\right). \quad (1)$$

This is similar to the result obtained from the variational model [8] in the London limit. The temperature dependence of penetration depth and the upper critical field is given by [9]

$$\lambda(T) = \frac{\lambda_0}{\sqrt{2}(1-t)^{\beta}} \quad \text{and} \quad B_{c2} = B_{c20}(1-t)^{2\nu}, \quad (2)$$

where $t = T/T_c$. The ν is 1/2 in the mean field region and 2/3 in the critical region. Similarly the β takes the value as 1/2 and 1/3 in the mean field and critical region respectively.

The field dependence of magnetization according to different models are shown in figure 1. It is noted that the vortex overlapping mechanism at low fields gives results