Melting of the Vortex-Pancake Lattice in Layered superconductors

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Abstract

Although a rather complete picture now exists for the melting of the vortex lattice in a continuous anisotropic superconductor such as YBCO, the details of this melting transition are not as well understood in the more strongly layered materials such as BSCCO. There are two important consequences of the weak coupling between the layers: (i) The melting fields are very low, and the inter-vortex distance is comparable to the in-plane penetration depth $\lambda_{||}$; (ii) a vortex pancake description is appropriate, where the pair-wise pancake interactions have a term of electromagnetic origin plus a term arising from the weak Josephson coupling between neighboring layers.

We start by ignoring the Josephson interactions. In this case there is the result that an isolated line will be coherent over a length $\lambda_{||}$ until an evaporation transition which occurs at the Kosterlitz-Thouless temperature T_{KT}. The alternative well-known limit is the two-dimensional melting in the absence of interlayer interactions, which occurs at a much lower temperature $T_m^{2D} < T_{KT}$.

In the intermediate temperature range we describe the melting transition within a self-consistent approach, providing an upper limit for the melting field $B_m(T)$. Finally we consider the effect on melting of a finite but small Josephson coupling. The differences between melting into a three-dimensional liquid and the sublimation to a gas of pancakes are discussed.