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Non-universal character of the Kosterlitz-Thouless transition in layered superconductor: the role of the vortex-core energy

The Kosterlitz-Thouless (KT) transition, namely the possibility to have a phase transition with a vanishing order parameter but algebraic decay of the correlations, is undoubtedly one of the most fascinating aspects of collective phenomena. It finds experimental realization in a wide range of systems, the most well known being superfluids or superconducting films, and recently cold atomic systems. A typical signature of the KT transition is the occurrence of a "universal" (i.e., sample independent) jump of the superfluid density at the transition, measured long ago in 4He superfluid films. Moreover, signatures of KT physics can be expected also in layered superconductors with weak interlayer coupling. However, a general question arises: how much of the "universal" character of the pure 2D case survives in layered systems? To address this issue we employ the mapping of the KT transition on the sine-Gordon model, that we extend to the case of layered superconductors and we analyze by means of a renormalization-group approach. We show that in the presence of a 'relevant' perturbation, as it is the interlayer coupling, the system looses the "universal" character typical of the pure 2D case. Thus, the temperature T_d where vortices drive the transition to the normal state is no necessarily identified by the temperature T_{KT} where the universal value of the superfluid density is reached in the 2D case. Instead, T_d is in general controlled by the competition between the interlayer coupling and the vortex-core energy, which measures the energetic cost needed to create a vortex on the smallest length scale. When applied to cuprates these results suggest the emergence of a non trivial behavior of the vortex-core energy in these systems.

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