Magnetization Fluctuations near the Superconducting Transition of Deoxygenated $YBa_2Cu_3O_{7-\delta}$ Single Crystals

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Abstract

In $YBa_2Cu_3O_{7-\delta}$, the low field (XY) and high field (Lowest Landau Level) theories of the superconducting transition both provide a reasonable description of the data in the field range 10-160 kG. Taken together, these results are unphysical, since the XY and Lowest Landau Level (LLL) theories are mutually exclusive. Here, the reasons for this controversy are explained. Magnetization measurements are performed on three $YBa_2Cu_3O_{7-\delta}$ single crystals ranging from $\delta \simeq 0.05$ (optimally doped) to $\delta \simeq 0.6$ (underdoped). In the $\delta \simeq 0.6$ sample, the temperature scale T_c is reduced by a factor of 2 from its fully oxygenated value, while the magnetic field scale is reduced by a factor of 40, allowing much of the H-T phase diagram to be probed. For the deoxygenated samples, a characteristic field H_b is observed, which separates the XY ($H \lesssim H_b$) from the LLL ($H \gtrsim H_b$) scaling regions. In the fully oxygenated sample, the crossover to LLL behavior is inaccessible, but is predicted to occur at 260 kG; 3D XY fluctuations are therefore predominant in the vortex liquid phase, throughout the entire experimental field range.