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Phase transition from a magnetic-field-free stiffness meter and LEM viewpoints

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A new method to measure the superconducting stiffness tensor $\bar{\rho}_s$, without subjecting the sample to magnetic field, is applied to $La_{2-x}Sr_xCuO_4$ (LSCO) [1]. The method is based on the London equation $\mathbf{J} = -\bar{\rho}_\mathbf{s}\mathbf{A}$, where $\mathbf{J}$ is the current density and $\mathbf{A}$ is the vector potential. Using rotor free $\mathbf{A}$ and measuring $\mathbf{J}$ via the magnetic moment of superconducting rings, we extract $\bar{\rho}_s$ at $T \to T_c$. The technique, named Stiffnessometer is sensitive to very small stiffness, which translates to penetration depth on the order of a few millimeters. We apply this method to two different LSCO rings: one with the current running only in the CuO_2 planes, and another where the current must cross planes. We find different transition temperatures for the two rings, namely, there is a temperature range with two-dimensional stiffness. The same method is also used to measure the coherence length ξ_0, by increasing A to a point where linear response break. Finally, we compare our result with a LEM experiment performed on the same samples and discuss the advantage and disadvantage of each technique.

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