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Ultrasonic signatures at the superconducting and the pseudogap phase boundaries in cuprates

ALBERT MIGLIORI, Los Alamos National Laboratory

A major issue in the understanding of cuprate superconductors is the nature of the metallic state from which high temperature superconductivity emerges. Central to this issue is the pseudogap region of the doping-temperature phase diagram that extends from room temperature to the superconducting transition. To date there is no thermodynamic evidence for a phase boundary. We address this by measuring the elastic response of detwinned single crystals and observe a discontinuity in the elastic moduli across the superconducting transition with magnitude requiring that pair formation is coincident with superconducting coherence and a phase transition at the pseudogap boundary. In slightly overdoped YBCO that transition is below T_c , extending the pseudogap phase boundary inside the superconducting dome. This supports a description of the metallic state in cuprates where a pseudogap phase boundary evolves into a quantum critical point masked by the superconducting dome.