Critical-doping universality for cuprate superconductors: Oxygen nuclear-magnetic-resonance investigation of $(Ca_xLa_{1-x})(Ba_{1.75-x}La_{0.25+x})Cu_3O_y$

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The critical oxygen levels in cuprates, where the ground state changes its nature from an antiferromagnet, to a spin glass, to superconductor, to metal, are not universal. We investigate the origin of these critical level variations by measuring the in-plane oxygen p_σ hole density in the CuO_2 layers as a function of the oxygen density y in $(Ca_xLa_{1-x})(Ba_{1.75-x}La_{0.25+x})Cu_3O_y$ [CLBLCO]. This is done using the oxygen-17 nuclear quadrupole resonance parameter ν_Q. We compare compounds with $x = 0.1$ and 0.4 which have significant critical y variations and find that these variations can be explained by a change in the efficiency of hole injection into the p_σ orbital. Our finding allows us to generate a unified phase diagram for the CLBLCO system across the entire doping range, with no adjustable parameters.