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**What makes high-$T_c$ cuprate superconductors so special?**[1]

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We have measured the precise dependence of key normal- and superconducting-state parameters on doping, temperature, and external fields in $La_{2-x}Sr_xCuO_4$ (LSCO) films. This called for significant advances in both synthesis and measurement techniques. Single-crystal and mutilayer films are synthesized and engineered using atomic-layer-by-layer molecular beam epitaxy. The doping level is tuned in steps of 0.01%. The absolute value of the magnetic penetration depth $\lambda$?is measured to the accuracy better than 1%. The study took over a decade and encompassed thousands of cuprate samples. The large statistics reveals clear trends and intrinsic properties; this is essential when dealing with complex materials. The findings bring in some great surprises. Even in extremely overdoped LSCO, both the superconducting and the normal state are quite unusual, departing qualitatively from the standard BCS / Fermi Liquid paradigm.

References: Bozovic et al., Nature 536, 309 (2016); Wu et al., PNAS 113 (2016); Wu et al., Nature Mater. 12, 877 (2013); Bollinger et al., Nature 472, 458 (2011); Bilbro et al., Nature Phys. 7, 298 (2011); Morenzoni et al., Nature Comm. 2, 272 (2011); Gozar et al., Nature 455, 782 (2008).

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