Anomalous normal state gap in an underdoped n-type cuprate

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The cuprate superconductors host a mysterious pseudogap phase, where the density of states near the Fermi level is partially suppressed. While the microscopic origin of the pseudogap phase in the p-doped cuprates is not yet agreed upon, the pseudogap of around a few hundred meV in the n-type cuprates is thought to arise from short-ranged antiferromagnetism order. This antiferromagnetic pseudogap evolves into the full antiferromagnetic gap when long-range order is achieved below about x = 0.12 in $Nd_{2-x}Ce_xCuO_4$ (NCCO). Here, we show through angle-resolved photoemission spectroscopy that underdoped NCCO with long-range antiferromagnetic order hosts another distinct normal state gap that is not compatible with antiferromagnetism and charge order [1]. This gap opens on the reconstructed small Fermi pockets centered at the (0, π) points in the Brillouin zone, and its doping dependence smoothly evolves into the (0, π) superconducting gap near optimal doping. These observations suggest that the ground state of the underdoped n-type cuprates are not conventional antiferromagnetic metals, but possibly hosting incoherent Cooper pairs with an energy scale up to ~40 meV and a temperature scale up to ~150 K.

Keywords: Angle-resolved photoemission spectroscopy, high Tc superconductors, pseudogap

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[1] K.-J. Xu et al., "Anomalous normal-state gap in an electron-doped cuprate", *Science* **385**, 796-800 (2024).

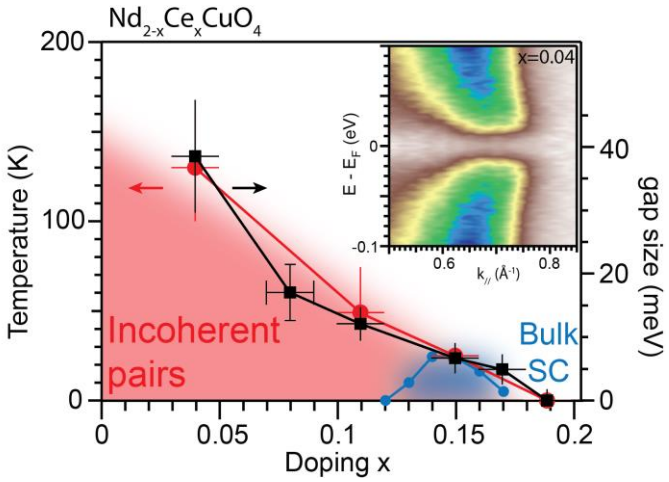

Figure 1. Simplified phase diagram of $Nd_{2-x}Ce_xCuO_4$. Bulk superconductivity, as defined by resistivity, is in blue. The normal state gap phase consistent with incoherent pairs is in red. Black data point indicate the gap size at the Brillouin zone boundary, and red data points indicate the gap filling temperature. Inset is the symmetrized ARPES spectra showing the normal state gap at *x*=0.04. Not shown are AF and charge order at higher temperature scales.