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The half-filling paradox in $Pr_2CuO_{4+\delta}$ YOSHIHARU KROCKENBERGER, AI IKEDA, HIROSHI IRIE, HIDEKI YAMAMOTO, NTT Basic Research Labs — In a type-II superconductor, the onset of the superconducting state as a function of decreasing magnetic field H occurs at the upper critical magnetic field H_{c_2}, dictated by the pairing gap Δ through the coherence length $\xi_0 \sim \nu_F/\Delta$, via $H_{c_2} = \Phi_0/2\pi\xi_0^2$. We show that the mean-free length ℓ in superconducting Pr_2CuO_4 can be as large as 85nm, or 200 unit cell lengths. Such large ℓ values are directly related to residual resistivity ratios. While $Pr_2CuO_{4+\delta}$ is commonly known as an antiferromagnetic insulator (AFI), we show that synthesis and annealing conditions govern δ. For AFI Pr_2CuO_4, i.e. $\ell \ll 2$nm, δ is larger than 0.10 whereas $\delta \ll 0.04$ in the superconducting state. In fact, this de-intercalation of apical oxygen is mandatory for the induction of superconductivity and is counter to early conclusions that all cuprate superconductors are AFI in their undoped state. It is not surprising that the AFI state found in cuprates with 5- and 6-fold coordinated copper is not established in cuprates with 4-fold coordinated copper, i.e. $\delta < 0.04$. Such coordination-driven phase transition is at the core of the long-term assumed half-filling paradox.

Yoshiharu Krockenberger
NTT Basic Research Labs

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