Pairing, Pair-Breaking, and the Critical Temperature in the Cuprate Superconductors
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In conventional superconductors, the pairing strength sets the majority of the physical properties including the superconducting transition temperature, $T_C$. However, the cuprates show no such link between the pairing interactions and $T_C$. Using a new variant of photoelectron spectroscopy, we measure both the pair-forming ($\Delta$) and pair-breaking ($\Gamma_S$) processes with greatly improved accuracy over a wide range of doping and temperatures. We find that, across the phase diagram, $\Delta$ directly scales with the temperature marking the onset of pairing, $T_{\text{Pair}}$, rather than those for the onsets of superconductivity, $T_C$, or the pseudogap, $T^*$. Instead, $T_C$ is set by a simple ratio of $\Delta(T_C)$ and $\Gamma_S(T_C)$, in contrast to conventional superconductivity in which the pairing alone, $\Delta(T=0)$, sets $T_C$. This finding shows the pair-breaking processes are a critical limiting factor for superconductivity in the cuprates. Finally, we will discuss the merits of the potential candidates for the origin of $\Gamma_S$. 