Electron Pairing Without Superconductivity

JEREMY LEVY, G. CHENG, M. TOMCZYK, S. LU, University of Pittsburgh, J.P. VEAZEY, Grand Valley State University, M. HUANG, P. IRVIN, University of Pittsburgh, S. RYU, H. LEE, C.-B. EOM, University of Wisconsin-Madison, C.S. HELLBERG, Naval Research Laboratory — Strontium titanate (SrTiO$_3$) exhibits an extremely low carrier density threshold for superconductivity, and possesses a phase diagram similar to high-temperature superconductors; two factors that suggest an unconventional pairing mechanism. We describe transport experiments with nanowire-based quantum dots localized at the interface between SrTiO$_3$ and LaAlO$_3$. Electrostatic gating of the quantum dot reveals a series of two-electron conductance resonances—paired electron states—that bifurcate above a critical magnetic field $B_p$ 1-4 Tesla, an order of magnitude larger than the superconducting critical magnetic field. For $B < B_p$, these resonances are insensitive to applied magnetic fields; for $B > B_p$, the resonances exhibit a linear Zeeman-like energy splitting. Electron pairing is stable at temperatures as high as $T = 900$ mK, far above the superconducting transition temperature ($T_c = 300$ mK). These experiments demonstrate the existence of a robust electronic phase in which electrons pair without forming a superconducting state. Key experimental signatures are captured by an attractive-U Hubbard model that describes real-space electron pairing as a precursor to superconductivity.

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