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Electron pairing without superconductivity[1]

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Strontium titanate ($SrTiO_3$) is the first and best known superconducting semiconductor. It exhibits an extremely low carrier density threshold for superconductivity, and possesses a phase diagram similar to that of high-temperature superconductors—two factors that suggest an unconventional pairing mechanism. Despite sustained interest for 50 years, direct experimental insight into the nature of electron pairing in $SrTiO_3$ has remained elusive. Here we perform transport experiments with nanowire-based single-electron transistors at the interface between $SrTiO_3$ and a thin layer of lanthanum aluminate, $LaAlO_3$. Electrostatic gating reveals a series of two-electron conductance resonances—paired electron states—that bifurcate above a critical pairing field B_p of about 1–4 tesla, an order of magnitude larger than the superconducting critical magnetic field. For magnetic fields below B_p, these resonances are insensitive to the applied magnetic field; for fields in excess of B_p, the resonances exhibit a linear Zeeman-like energy splitting. Electron pairing is stable at temperatures as high as 900 millikelvin, well above the superconducting transition temperature (about 300 millikelvin). 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 a model involving an attractive Hubbard interaction that describes real-space electron pairing as a precursor to superconductivity.

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