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Revealing the Superfluid Lambda Transition in the Universal Thermodynamics of a Unitary Fermi Gas[1] MARK KU, ARIEL SOMMER, LAWRENCE CHEUK, MARTIN ZWIERLEIN, Department of Physics, MIT-Harvard Center for Ultracold Atoms, and Research Laboratory of Electronics, MIT, Cambridge, Massachusetts 02139, USA — We have observed the superfluid phase transition in a strongly interacting Fermi gas via high-precision measurements of the local compressibility, density and pressure down to near-zero entropy. We perform the measurements by in-situ imaging of ultracold ^{6}Li at a Feshbach resonance. Our data completely determine the universal thermodynamics of strongly interacting fermions without any fit or external thermometer. The onset of superfluidity is observed in the compressibility, the chemical potential, the entropy, and the heat capacity. In particular, the heat capacity displays a characteristic lambda-like feature at the critical temperature of $T_c/T_F = 0.167(13)$. This is the first direct thermodynamic signature of the superfluid transition in a spin-balanced atomic Fermi gas. We measure the ground-state energy of the superfluid to be $3/5\xi NE_F$, with $\xi = 0.376(4)$. The experimental results are compared to recent Monte-Carlo calculations. Our measurements provide a benchmark for many-body theories on strongly interacting fermions, relevant for problems ranging from high-temperature superconductivity to the equation of state of neutron stars.

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Mark Ku
Dept of Physics, MIT-Harvard Center for Ultracold Atoms, and
Research Laboratory of Electronics, MIT,
Cambridge, Massachusetts 02139, USA

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