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Hard superconductivity of a soft metal in the quantum regime[1]

M.M. OZER, J.R. THOMPSON, H.H. WEITERING, Physics, Univ. Tennessee, Knoxville, TN, 37996 & ORNL, Oak Ridge, TN, 37831 — Superconductivity is a collective quantum phenomenon that is inevitably suppressed in reduced dimensionality. Questions of how thin superconducting wires or films can be before losing their superconducting properties have important technological ramifications and go to the heart of understanding formation, coherence, and robustness of the superconducting state in quantum confined geometries. Here, we exploit quantum confinement of itinerant electrons in a soft metal (Pb), to stabilize atomically-flat superconductors with lateral dimensions of mm and vertical dimensions of only a few atomic layers. They show no indication of defect- or fluctuation- driven suppression of superconductivity and support macroscopic super-currents of up to ~10% of the depairing current density. The hardness of the critical state can be attributed to the presence of intrinsic vortex traps that are stabilized by quantum confinement. The study presents a conceptually appealing picture of a model nano-scale superconductor with calculable critical state properties, suggesting the possibility of achieving and exploiting superconductivity in the ultimate low-dimensional limit.

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