Ultimate Vortex Confinement Studied by Scanning Tunneling Spectroscopy

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We report a detailed scanning tunneling microscopy study of a superconductor in a strong vortex confinement regime. This is achieved in a thin nano-island of *Pb* having a size d about 2-3 times the effective coherence length, and a thickness h such that $h << d << \lambda$, where λ is the effective London penetration depth. In this geometry the magnetic field evolution of local tunneling spectra reveals only two superconducting configurations to exist: zero and single vorticity. The normal state is reached at $H_C \approx 0.46\ T$, about 6 times the critical field of bulk *Pb*, with no higher order vorticity observed [1]. The comparison of the acquired Scanning Tunneling Spectroscopy data with the numerically resolved Usadel equations allowed us to reveal the fundamental role played in both configurations by the circulating supercurrents.

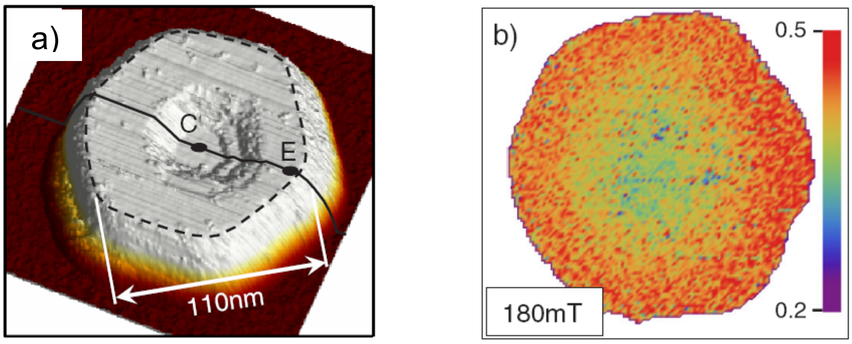

Figure 1: (a) Constant current STM image of the *Pb* island grown on *Si(111)* substrate that was selected for the study. (b) In non-zero magnetic field the tunneling spectra become spatially inhomogeneous over the island: the color-coded Zero-Bias Tunneling Conductance (ZBC) map of the island (here at $H= 180\ mT$) shows the radial distribution of ZBC values with higher ZBC observed close to the island border due to the pair-breaking effect of the circulating supercurrents.

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[1] T. Cren *et al.*, Phys. Rev. Lett. 102, 127005 (2009).