Surface states superconductivity by scanning tunneling microscopy

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Surface state superconductivity is one of the ultimately thin two-dimensional (2D) superconductors, which emerges in metallic electronic states formed by a few-monolayer deposition of metallic elements on a semiconducting substrate. One of the advantages if compared with other 2D superconductors is that atomically well-ordered structures can be easily formed in macroscopic dimensions because of the thermal stability through the self-organized structural reconstruction. Basic properties such as atomic structure and electronic states are well characterized by standard surface science techniques including scanning tunneling microscopy (STM), and can be modify in a controlled manner through deposition and adsorption of additional materials.

One ubiquitous feature of the 2D electronic systems is the natural presence of atomic steps. Atomic steps are considered to strongly affect electron transport as they decouple neighboring surface terraces [1]. We have demonstrated that the steps of the √3x√3-In/Si(111) surface superconductor behave as a Josephson junction and hold elongated vortices called Josephson vortices along the steps [2]. On striped incommensurate (SIC) phase of Pb/Si(111) the steps are found to block the propagation of the superconducting proximity effect and enhance it when they are located within the coherence length [3].

In two-dimensional superconductors usual orbital pair breaking of the superconductivity by in-plane magnetic field can be suppressed, allowing the Zeeman pair breaking to determine the critical magnetic field. There is however no protection against perpendicular magnetic fields. Using STM, we found that in narrow terraces of the Pb/Si(111) surface whose width is less than the coherence length the superconductivity is protected against perpendicular magnetic fields. It is presumably due to the suppression of orbital pair breaking by the step confinement. Since the density and the coupling strength of the steps can be controlled, our study opens a way to design 2D superconductors that maintain the pairing under magnetic field in all directions.

References:

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