Coherent quantum phenomena in superconducting atomic monolayers Pb/Si(111): A STM study

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In 1964 V. L. Ginzburg predicted that new superconducting phases could appear in ultrathin films deposited on insulating surfaces. In 2010 superconductivity below 2K was discovered in some crystalline atomic monolayers of Pb grown on atomically clean Si(111) [1, 2]. Though, the amorphous Pb monolayer was found non-superconducting, but rather a correlated metal. Interestingly, Pb-monolayers can be on-demand made amorphous or crystalline, with or without presence of bulky superconducting Pb-nano-islands. This makes the Pb/Si(111) system useful to probe superconducting correlations in the vicinity of S-N or S-S' interfaces by STM [3,4].

When two superconducting Pb-islands are linked together by a few nanometer wide non-superconducting amorphous atomic layer of Pb, superconducting correlations may propagate between the two islands, allowing a dissipation-less Josephson current to flow through the link. In the presence of a magnetic field, the Josephson vortices are expected to appear in such S-N-S Josephson junction. Josephson vortices are conceptual blocks of advanced quantum devices such as coherent terahertz generators or qubits for quantum computing, in which on-demand generation and control is crucial.

In our lecture we describe a series of recent experiments which mapped superconducting correlations in the vicinity of S-N junctions [3,4] as well as inside SNS proximity Josephson junctions using scanning tunneling microscopy [5]. By following the Josephson vortex formation and evolution we demonstrate that they originate from quantum interference of Andreev quasiparticles, and that the phase portraits of the two superconducting quantum condensates at edges of the junction decide their generation, shape, spatial extent and arrangement [5].

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