Exploring Kondo Physics and Yu–Shiba–Rusinov States in MnPc Molecules on Superconducting Pb(001) Surface

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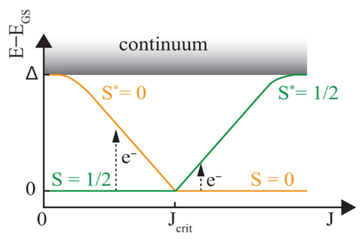
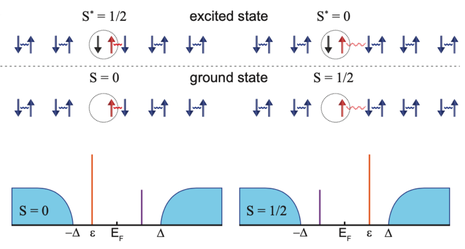
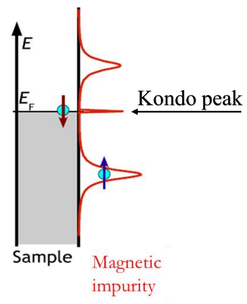
Introduction and Motivation

YSR state



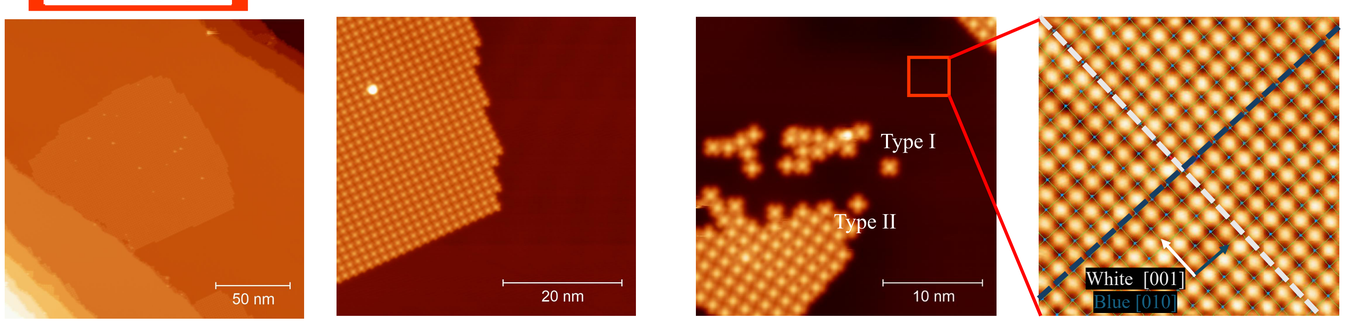


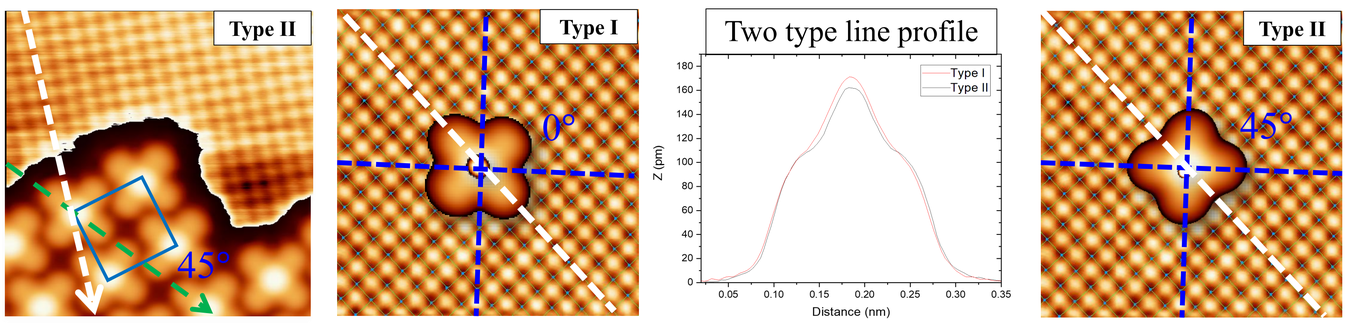


We investigate MnPc molecules on the anisotropic Pb(001) surface, extending previous studies on Pb(111). The anisotropic Fermi surface of Pb(001) significantly modifies the magnetic impurity–superconductor coupling. Pronounced Yu–Shiba–Rusinov (YSR) states with anisotropy-driven spectral features are observed. In addition, the relationship between YSR states and the Kondo effect is systematically characterized.

STM Measurement Results

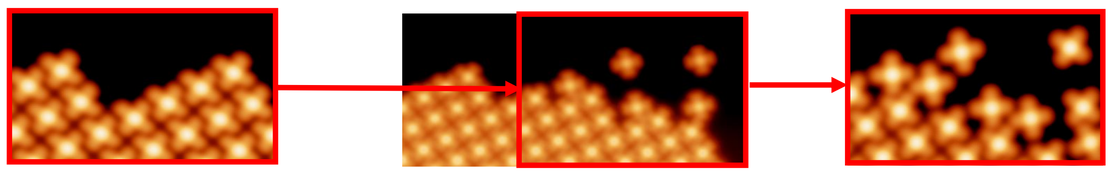
STM Topography





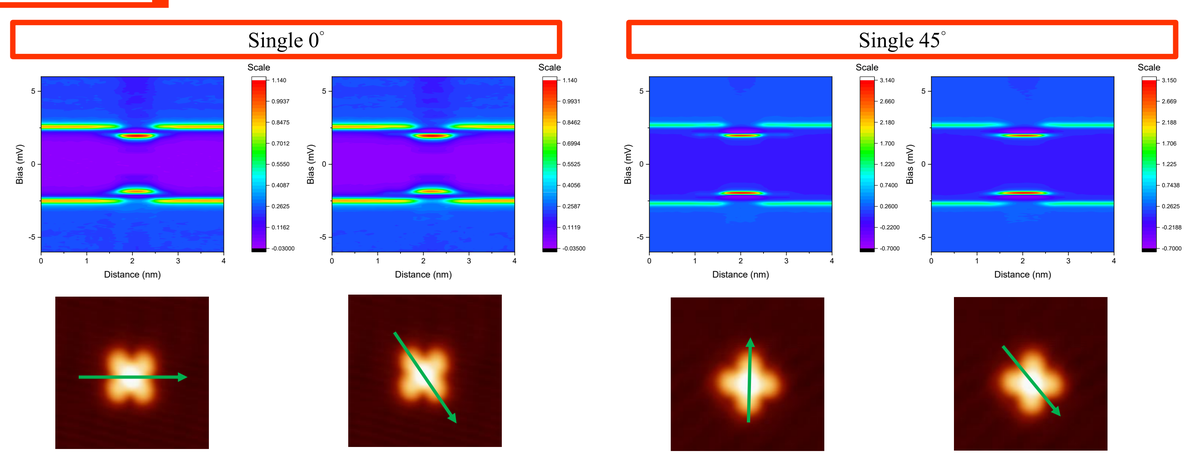
From the STM line profile images, we found that the MnPc monolayer exhibits a uniform Type II configuration, whereas isolated single MnPc molecules adopt orientations of 0° and 45° relative to the Pb substrate

Moving molecules



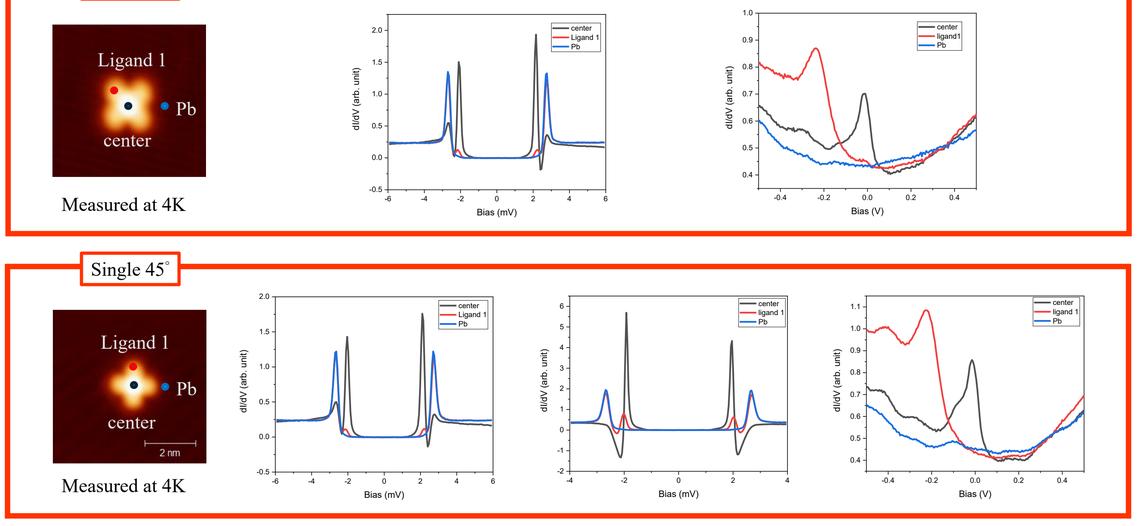
By applying a bias voltage with the STM tip, the boundary region can be opened. The tip is then brought close to a single MnPc molecule released during this process and used to manipulate it to a location suitable for measurement.

Line STS



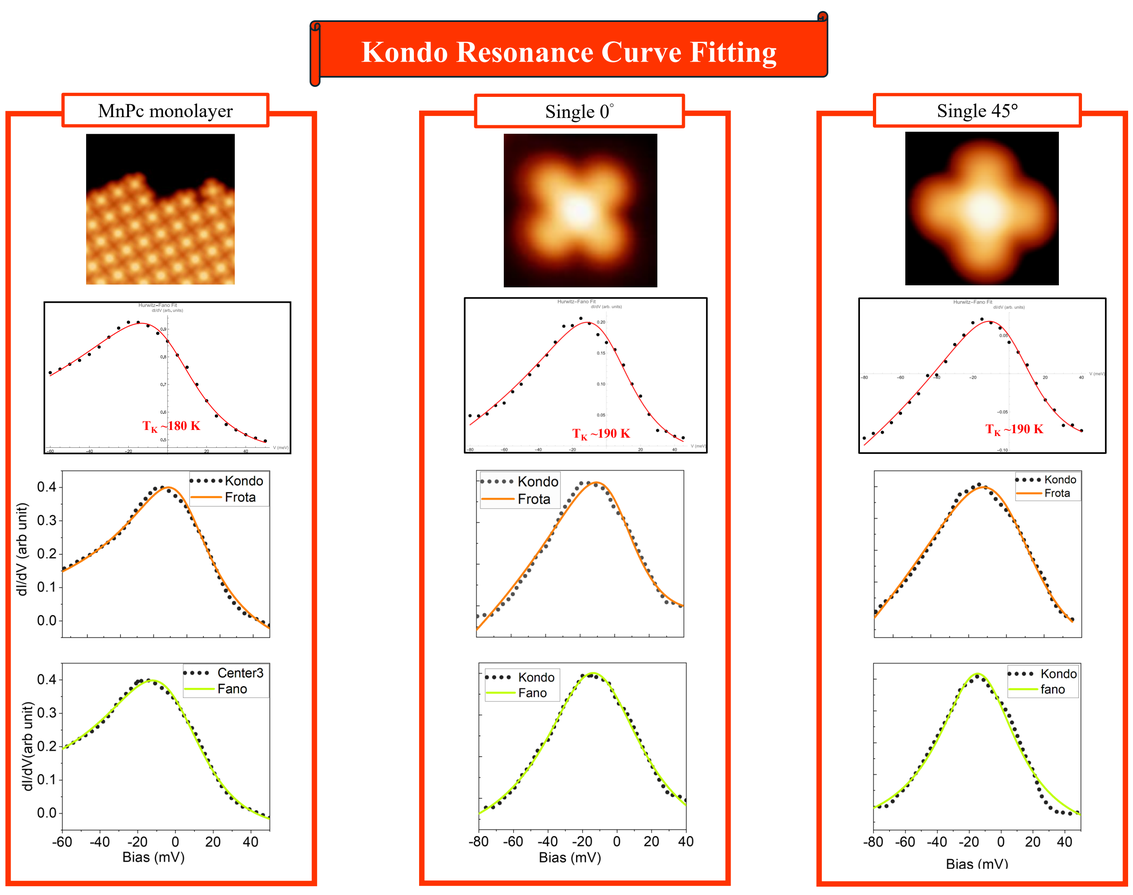
Line STS measurements reveal that the YSR-related spectral features are spatially confined to the vicinity of the MnPc molecules.

YSR and Kondo peak



Using STS, we observed weakly coupled YSR peaks and Kondo peaks for both types of MnPc. However, strongly coupled peaks were detected only for MnPc molecules oriented at 45 degrees.

Kondo Resonance Curve Fitting



Compared the Kondo temperatures obtained from three different fitting methods; among them, the Hurwitz–Fano fitting gives the best result, yielding a Kondo temperature of about 190 K.

Grid Spectroscopy

All of bias need to divide by 100

The grid measurement allows us to resolve the spatial evolution of the YSR states, revealing regions of weak and strong coupling between MnPc and the Pb substrate.

Summary

1. Kondo resonances and Yu–Shiba–Rusinov (YSR) states were clearly observed, with both molecular configurations remaining in the weak-coupling regime and strong-coupling spectra detected.

2. The Pb(001) surface, featuring an anisotropic Fermi surface, provides a suitable platform for further studies of anisotropy effects in magnetic-impurity–superconductor interactions.

Reference

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