Magnetic Interaction Between Mn atoms on β-Bi_2Pd Revealed by their Yu-Shiba-Rusinov States

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Abstract

In the last decade, the interest in studying the coupling between magnetic atoms arranged in linear chains on superconducting surfaces increased.[1,2,3] This is due to proposals suggesting emergence of Majorana bound states (MBS) in condensed matter systems, that have potential applications in topological quantum computing.[4] A powerful way to investigate the coupling is looking at how it modifies the Yu-Shiba-Rusinov (YSR) states inside the superconducting gap. These states are generated by the exchange coupling between a magnetic impurity and the Cooper pair condensate of the superconductor.[5] The coupling mechanism can be investigated by monitoring the sub gap YSR fingerprint during the construction of atomically precise structures.[6,7] By means of a low temperature scanning tunneling microscope (STM) working at 1.3K, we perform atomic manipulation of Mn atoms on β-Bi_2Pd superconductor (T_c=5.4K, Δ=0.78mV). A major advantage is achieved doing atomic manipulation directly with superconductive tips, studying the coupling with high energy resolution in Mn dimers, trimers, cross like structures, chains, and other more complex structures. Depending on the distance and crystallographic directions different coupling effects occurs, with signatures of ferromagnetic and antiferromagnetic coupling. In linear chains, there is evidence of collective behavior that lowers the overall energy of the YSR states, effect that saturates for lengths that exceed 6-7 atoms.

References

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Figures

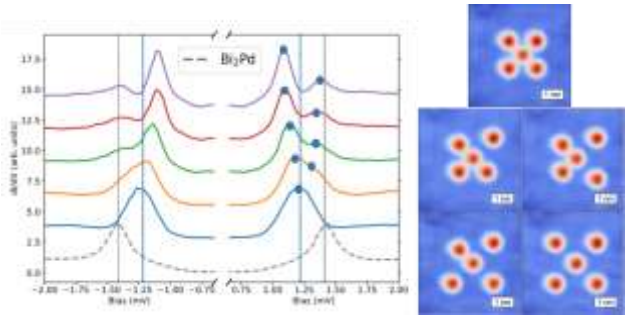

Figure 1: Intra-gap density of states of Mn nanostructures built on β-Bi_2Pd by atomic manipulation. The spectra are measured on the central atom and an increasing splitting is observed upon adatom addition.