Interaction of magnetic atoms with superconducting materials

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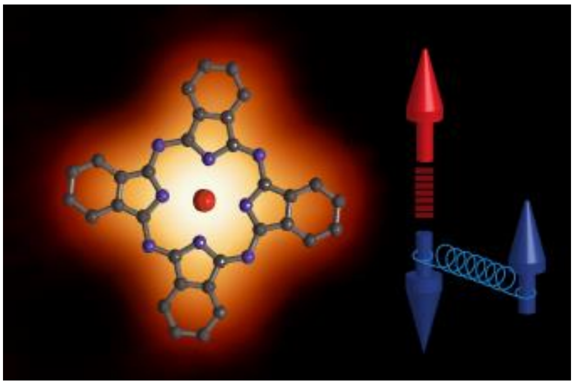
Magnetism and superconductivity are phenomena that cannot simultaneously exist in the same region of a material: weak applied magnetic fields are expelled out from the superconductor, while strong magnetic fields destroy the superconducting properties. An interesting playground to study the interplay between both phenomena are magnetic atoms interacting with a superconductor. A magnetic atom scatters Cooper pairs as a potential with broken time-reversal symmetry, what locally distorts superconductivity. The result is the formation of quasiparticles bound states inside the superconducting gap, named Yu-Shiba-Rusinov states (YSR) [1].



Using scanning tunneling spectroscopy, we investigate the YSR states caused by several atomic and molecular systems, resolving their origin and exploring basic properties of BCS superconductors [2]. We found that the shape of YSR states reflect the shape of *d* atomic orbitals [3] and are sensitive to magnetic anisotropies of the magnetic specie [4].

Increasing the exchange interaction of the impurity with the superconductor weakens the pairing energy and induce breaking of Cooper pairs. This brings the magnetic atom into a different magnetic ground state [4,5]. On the contrary, reducing the interaction by simply separating the magnetic atom from the surface remove YSR states from the gap. In this scenario, inelastic tunnelling processes mediate spin excitations between different magnetic states of the atom. An interesting outcome is that the presence of a superconducting gap at the substrate hiders the energy relaxation into the substrate, and spin excitations may survive for nanoseconds [6].

Referencias

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