Spin excitations and interactions on superconductors – probed and manipulated with a scanning tunneling microscope

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Magnetic impurities in conventional superconductors induce a pair-breaking potential, which leads to bound states inside the superconducting energy gap. These states are called Yu-Shiba-Rusinov states, or short: Shiba states. Although theoretical predictions on the properties of these states reach back by several decades, their characterization by experiments has only been possible with the advent of high-performance low-temperature scanning tunneling microscopes (STM) [1,2].

Here, we explore the Shiba states of individual magnetic adatoms on superconducting Pb substrates [3]. When the adatoms are brought into sufficiently close proximity, they hybridize [4] and form extended Shiba bands in atomic chains [5]. Such chains became particularly fascinating, because they may host Majorana zero modes [6].

In the second part of the talk, I will address a different regime of spin excitations on superconductors. Dressing the magnetic atom with an organic skeleton, as, e.g., in transition-metal porphyrins, the magnetic scattering potential for the Cooper pairs in the substrate becomes negligible. The superconducting energy gap then acts as a protection for excited spin states in the molecule [7]. Furthermore, the flexibility of the porphyrin allows for tuning the magnetic properties of the molecule with the STM tip [8,9].

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