Electron Correlation Effects in Superconducting Spin Qubits

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Abstract

Yu-Shiba-Rusinov ingap states induced in superconductors by natural or artificial magnetic impurities are often regarded as single-particle phenomena. However, in general they are complex many-body excitations for which electron correlations play an important role. We discuss several instances of this that include molecular systems on superconducting surfaces studied using STM[1,3] and mesoscopic devices [2,3,4]. Specifically, we consider: i) A magnetic impurity coupled to a superconductor/ferromagnetic insulator hybrid and show that Kondo physics plays an important role in determining the energy splitting of superconducting spin qubits [2]. ii) The realization of a "proof of concept" spin-singlet qubit, immune to decoherence in the form of random Overhauser noise, in a molecular system consisting of a chain of triangular nanographene (triangulene) on a superconductor, see Fig. 1. The latter is encoded in a resonant valence bond of four collective spin-1/2 excitations, two of them being the "topological" edge states of the chain and the other two, two quasi-particles from the superconducting substrate. The insights gained by studying such system allow us to design a mesoscopic device that "emulates" the molecular system while allowing a more efficient operation of the spin-singlet qubit using state of the art electronics [3]. Time permitting, we will also report on a recent study [4] that maps the stability of spin qubits in superconducting pseudogap systems. The latter include graphene in proximity to conventional superconductors and unconventional d + i s-wave superconductors.

References

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Figures

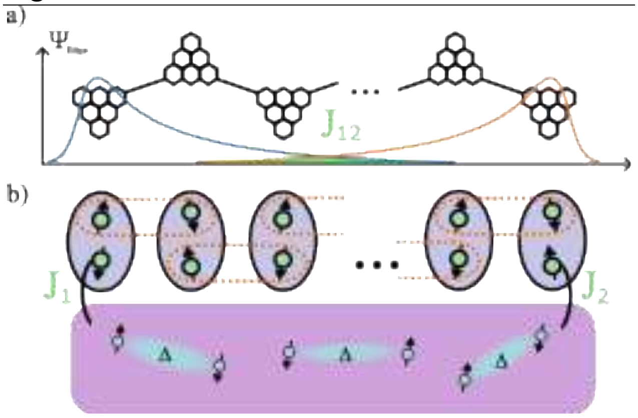

Figure 1: Figure 1: Illustration of the (spin-1) chain of triangular nanographenes (triangulene) on a superconducting surface. The topological edge states of the chain couple to the superconductor via Kondo exchange. Since the latter is weaker than the antiferromagnetic exchange between the inner spin-1 triangulenes, the central region remains decoupled in a valence bond solid (VBS) phase. This system can host a resonanting valence bond (RVB) singlet qubit which is tunable by modifying the Kondo exchange of one of the edges with the superconducting substrate. See Ref. [3]