Proximity induced superconductivity in a 1D quasicrystal

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Quasicrystals with their exotic long range spatial ordering can be expected to host exotic superconducting states with novel properties compared to periodic or disordered systems. Much work has thus gone into looking for a superconducting QC alloy and one has been recently reported [1]. It will be interesting to find further examples in the future, either of BCS type or non-BCS type superconductors in strongly correlated systems. Theoretical works have studied some possible cases in 2D to elucidate properties of such superconductors [2], and a recent theoretical calculation argues that intrinsic superconductivity would be very small in the QC, possibly vanishing in the infinite size limit [3].

We consider a situation where the QC is not an intrinsic superconductor, but in which superconductivity is induced via the proximity effect. As a first step to understanding this effect, we have chosen to study proximity-induced superconductivity in a 1D quasicrystal: the Fibonacci chain. This is an important model for quasiperiodic solids for which single particle properties have been extensively explored, not only in seminal theoretical works but also in experiment. One of its most important properties, the gap labeling theorem for the gaps in the spectrum, is a robust property since it is of topological origin, and has been experimentally verified for example using polaritons in semiconducting microcavities. The system we now consider is a hybrid chain consisting of a non-interacting Fibonacci chain coupled to a periodic BCS s-wave superconductor.

Using a Bogoliubov-de Gennes mean-field self-consistent approach we show that long range BCS pair correlations are induced in the normal part of the chain. We show, in particular, how the topological indices show up in the superconducting order parameter, and how these are related to the nature of the edge states in the gaps of the spectrum. Experimental setups to investigate some of the predicted properties of these induced superconducting correlations will be discussed.

References

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[2] S. Sakai et al, Phys. Rev. B 95, 024509 (2017)

[3] R.N. Araujo and E. Andrade, condmat/arXiv 1903.09635v1