Unconventional superconductivity in double quantum dots

Björn Sothmann[1]*, Stephan Weiss[2], Michele Governale[3], and Jürgen König[2]

[1] *Département de Physique Théorique, Université de Genève, CH-1211 Genève 4, Switzerland*

[2] *Theoretische Physik, Universität Duisburg-Essen and CENIDE, 47048 Duisburg, Germany*

[3] *School of Chemical and Physical Sciences, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand*

*e-mail: `bjorn.sothmann@unige.ch`

Conventional superconductivity is well understood in terms of Bardeen-Cooper-Schrieffer theory by the formation of a Cooper-pair condensate described by a superconducting pair amplitude. The Pauli principle dictates the glocal symmetry of the pair amplitude under the exchange of two electrons but it does not determine the behaviour under exchange of spin, orbital degrees of freedom or time argument, separately. Thus, there are in total four different symmetry classes of superconductivity.

Conventional BCS superconductivity is an example of even-frequency singlet superconductivity. Even-frequency triplet correlations occur in superfluid Helium-3 as well as in nanowires hosting Majorana fermions [1,2]. Odd-frequency triplet superconductivity has been shown to exist in superconductor-ferromagnet hybrid structures [3]. Odd-frequency singlet correlations have not yet been observed so far.

Here, we demonstrate how all four classes can be generated in a double quantum dot proximity-coupled to a conventional superconductor and subject to an inhomogenous magnetic field. Such a quantum-dot structure is an interesting playground to investigate the interplay between superconducting correlations and strong interactions under nonequilibrium conditions. Furthermore, quantum dots offer the advantage of having tunable parameters.

We first characterize the superconducting correlations in the double dot and discuss conditions to generate them. We then discuss transport signatures in Andreev and Josephson current. Finally, we point out a connection to Majorana fermions and fractional Josephson effect [4].

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