Kolloquium
Theoretische Physik

Universität Konstanz

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Mo 26.06.17
13:30 Uhr
P 603

Non-local properties in hybrid quantum-dot Cooper pair splitters

The control of nonlocal entanglement in solid state systems is a crucial ingredient of future quantum technologies. We investigate theoretically a Cooper-pair splitter based on a double quantum dot realised in a semiconducting nanowire coupled to a superconductor.[1] We consider the subgap physics in the presence of tunneling between the dots and finite Coulomb repulsion.[2] We employ a generalized master-equation method, which easily yields currents, noise, and cross-correlators. For finite Coulomb interaction, we investigate how the transport properties are determined by the interplay between local and nonlocal tunneling processes. We examine the effect of interdot tunneling on the particle-hole symmetry of the currents with and without spin-orbit interaction.
In the presence of interdot tunnelling the system provides a simple mechanism to develop spatial entanglement even in absence of nonlocal coupling with the superconducting lead[3]. We discuss the possibility to control the symmetry (singlet or triplet) of spatially separated, entangled electron pairs taking advantage of the spin-orbit coupling of the nanowire. We also demonstrate that the spin-orbit coupling does not impact over the entanglement purity of the nonlocal state generated in the double quantum dot system. Finally we will discuss the thermoelectrical effects of this system and how this can be used to test the nonlocal coupling[4].

[1] J. Schindele, A. Baumgartner, and C. Schönenberger, Phys. Rev. Lett. 109, 157002 (2012).;
A. Das, Y. Ronen, M. Heiblum, D. Mahalu, A. V. Kretinin, and H. Shtrikman, Nat. Commun. 3, 1165 (2012)
[2] R. Hussein, L. Jaurigue, M. Governale and A. Braggio Phys. Rev. B 94, 235134 (2016)
[3] R. Hussein, A. Braggio and M. Governale Phys. Status Solidi B 254, 1600603 (2017)
[4] R. Hussein, et al. in preparation.