Andreev bound states probed in three-terminal quantum dots

JournalArticle (Originalarbeit in einer wissenschaftlichen Zeitschrift)

ID 4133550
Author(s) Gramich, Jörg; Baumgartner, Andreas; Schönenberger, Christian
Author(s) at UniBasel Schönenberger, Christian ; Baumgartner, Andreas ; Gramich, Jörg Benedikt ;
Year 2017
Title Andreev bound states probed in three-terminal quantum dots
Journal Physical review B: Condensed matter and materials physics
Volume 96
Number 19
Pages / Article-Number 195418
Keywords K_Supra K_CPS K_CNT
Andreev bound states (ABSs) are well-de ned many-body quantum states that emerge from the hybridization of individual quantum dot (QD) states with a superconductor and exhibit very rich and fundamental phenomena. We demonstrate several new electron transport phenomena mediated by ABSs that form on three-terminal carbon nanotube (CNT) QDs, with one superconducting (S) contact in the center and two adjacent normal metal (N) contacts. Three-terminal spectroscopy allows us to identify the coupling to the N contacts as the origin of the Andreev resonance (AR) linewidths and to determine the critical coupling strengths to S, for which a ground state (or quantum phase) transition in such S-QD systems can occur. In addition, we ascribe replicas of the lowest-energy ABS resonance to transitions between the ABS and odd-parity excited QD states, a process we call excited state ABS resonances. In the conductance between the two N contacts we find a characteristic pattern of positive and negative differential subgap conductance, which we explain by considering two nonlocal processes, the creation of Cooper pairs in S by electrons from both N terminals, and a novel transport mechanism called resonant ABS tunneling, possible only in multi-terminal QD devices. In the latter process, electrons are transferred via the ABS without effectively creating Cooper pairs in S. The three-terminal geometry also allows spectroscopy experiments with different boundary conditions, for example by leaving S floating. Surprisingly, we find that, depending on the boundary conditions and the device parameters, the experiments either show single-particle Coulomb blockade resonances, ABS characteristics, or both in the same measurements, seemingly contradicting the notion of ABSs replacing the single particle states as eigenstates of the QD. We qualitatively explain these results as originating from the nite time scale required for the coherent oscillations between the superposition states after a single electron tunneling event. These experiments demonstrate that three-terminal experiments on a single complex quantum object can also be useful to investigate charge dynamics otherwise not accessible due to the very high frequencies.
Publisher American Physical Society
ISSN/ISBN 1098-0121 ; 1550-235X
edoc-URL http://edoc.unibas.ch/58120/
Full Text on edoc Available;
Digital Object Identifier DOI 10.1103/PhysRevB.96.195418
ISI-Number WOS:000414738200009
Document type (ISI) Article