Spin Cross-Correlation Experiments in Semiconducting-Superconducting Heterostructures

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Semiconducting-superconducting hybrid heterostructures provide an ideal system for investigating wide range of fundamental phenomena, for example to study unconventional Andreev bound states (ABSs) in multi-terminal Josephson junctions (JJs) [1] and demonstrate spin correlations in quantum mechanical systems. To this end, we have introduced ferromagnetic split-gates (FSGs) to individually polarize the electron spins in semiconducting InAs nanowire (NW) quantum dots (QDs) [2]. We then implement such spin filters in a Cooper pair splitting (CPS) device [3], an electronic device that emits electrons originating from Cooper pairs, to demonstrate the direct measurement of the spin cross-correlations [4] between the currents emitted from the 'splitting' of spin-singlet Cooper pairs. We find a negative spin correlation of -1/3, which deviates from the ideal value mostly due to the overlap of the Zeeman split quantum dot states. In addition, we show our progress towards implementing epitaxial Al-InAs JJs in a coplanar waveguide resonator for ABS spectroscopy. Our results demonstrate a new route to perform spin correlation experiments in nano-electronic devices, especially suitable for those relying on magnetic field sensitive superconducting elements, like triplet or topologically non-trivial superconductors.

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