CSQC

ABSTRACT

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Title

Correlated Spin Transport in Nanostructures: Entanglement Creation and Spin Filtering

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Abstract:

The ability to have nonlocal and pairwise entangled qubits is important for many quantum computing and quantum communication tasks.

I review our proposals towards the realization of a solid state electron spin entangler, a device that creates a charge current carried by spin-entangled electrons which are nonlocal (EPR-pair) in space. An s-wave superconductor (SC) serves as the source of spin-entanglement in terms of Cooper pairs (spin-singlets). In a non-equilibrium situation, the SC tunnel-coupled to two outgoing normal leads can result in a stationary current of pairwise spin-entangled electrons in the normal leads (each electron in a different lead) due to Andreev tunneling of two electrons forming a Cooper pair in the SC. We propose several mechanisms to suppress unwanted processes where two electrons coming from the same Cooper pair enter the same outgoing lead. For this, we use strong Coulomb blockade effects between the two electron charges of a pair, arising either in quantum dots tunnel-coupled to the SC [1], in leads with Luttinger liquid properties (e.g. metallic carbon nanotubes) [2] or in leads possessing a finite resistance [3].

Our transport calculations show that such entanglers should be efficient in parameter regimes of experimental accessibility.

Ultimately, such entanglers could be used to detect spin-entanglement via shot noise (current-current correlation) measurements. For this, the spin correlations have to be converted into charge correlations (noise), e.g. by using spin filters working at the single-spin level . I discuss the possibility to implement such a spin filter using a quantum dot subjected to a magnetic field and operated in the Coulomb blockade regime [4]. Our calculations show that this spin filter should be very efficient at low temperatures or high magnetic fields which is supported by recent experiments [5]. The spin filtering effect could also be used to read-out a single spin in a quantum dot which is a necessary task when using electron spins in quantum dots as qubits [6].

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