Initialization of multiple quantum spins with non-equilibrium bias

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Pauli spin blockade (P-SB) is one of the important phenomena to have a well-defined electron spin configurations with relatively easy setups and low-magnetic field.[1] The finite applied bias is essential to establish high spin states in coupled quantum dots (QDs), which is signatured by the suppression of the current through the series double QDs. P-SB is used in various experiments for accurate initialization and detection of the electron spins.[2, 3] Extension of the number of electron spins more than two is a critical step for the' scalable ' system for quantum information processing.

The purpose of this work is to theoretically argue the possibility of this direction. There are two ways to extend ordinary P-SB with two electrons and two QDs, which we call (1,1) P-SB, to three QD system:

- (2,1) configuration, where two QDs, QD1 and QD2, in the higher bias side and single QD, QD0, in the lower bias side, and there are tunnel couplings between QD1-QD0 and QD2-QD0 (Fig.1(a)).

- (1,2) configuration, where one QD, QD0, in the higher bias side and two QDs, QD1 and QD2, in the lower bias side, and there are tunnel couplings between QD0-QD1 and QD0-QD2 (Fig.2(b)).

In both configurations, we disregard the direct tunneling between QD1 and QD2. One electron transport in (2,1) configuration had been studied, and shows strong current suppression by the effect of coherent population trapping (CTP).[4] Here we found strong current suppression for two[5] and three electron states, however, in contrast to the conventional (1,1) P-SB, the spin state is mixed state because of CTP. In contrast, (1,2) configuration with three electrons shows current suppression with forming quadruplet spin dark state. We argue the level energy dependence of the leakage current and spin purity to compare recent experiments. *Part of this work is supported by Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST).*
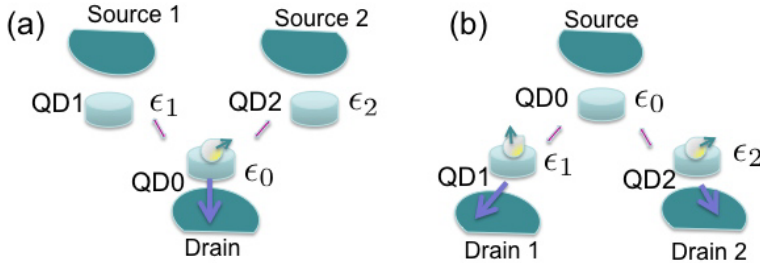

Fig.1 (a) Schematics of (2-1) P-SB, (b) (1-2) P-SB

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