Predictive simulation of gate coupling strengths in a spin qubit device

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Abstract

Spin qubit device community explores various semiconductor heterostructures and gate designs to build a fault-tolerant quantum computer. Characterizing a semiconductor heterostructure experimentally is a demanding task, with the full development cycle taking at least months of work. While numerical simulations are more time-efficient, their predictive power is limited due to the unavoidable disorder and device variations [1]. In the current work, we develop a spin-qubit device simulation that predicts the coupling strengths between the electrostatic gate potentials and the effective device Hamiltonian. By comparing our simulation results with the experimental data from Ref. [2], we demonstrate that the gate couplings to the dot chemical potential and the interdot coupling are correctly predicted even in presence of disorder. To demonstrate the flexibility of our approach, we also analyse an alternative non-planar geometry inspired by FinFET devices.

References

[1] P. Barthelemy and L. M. K.Vandersypen, Annalen der Physik 525 (2013) 808.

[2] T.-K. Hsiao et al., Phys. Rev. Applied 13 (2020) 054018.

Figures

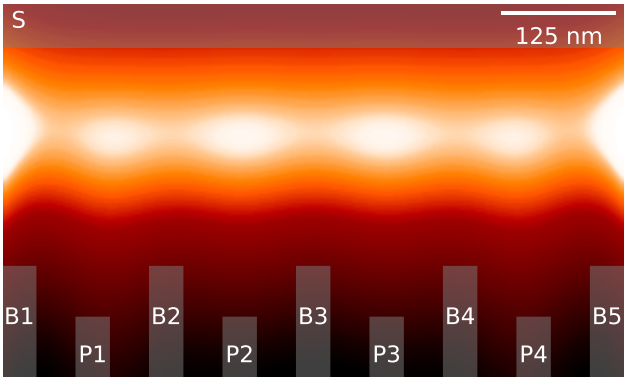

Figure 1: Confinement potential of four quantum dots in the plane of 2DEG. Plunger gates (P1, P2, P3, P4) are used to tune the chemical potential of each dot and barrier gates (B2, B3, B4) are used to tune the interdot tunnel couplings. Screening gate (S) forms a tunnel barrier between the qubit dots and sensor dots (not shown in the image). Gates B1 and B5 control the electron tunnelling rate between a corner dot and neighbouring electron reservoir.