Mitigating crosstalk in single hole-spin qubits within highly anisotropic g-tensors

Yaser Hajati
I. Heinz, and G. Burkard

Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

Yaser.hajati@uni-konstanz.de

Abstract
Spin qubits based on valence band hole states in Si and Ge are promising candidates for quantum information processing, thanks to their strong spin-orbit coupling and ultrafast operation speeds [1,2]. As these systems scale up, achieving high-fidelity single-qubit operations becomes increasingly important. However, mitigating crosstalk effects from neighbouring qubits in larger arrays, particularly for anisotropic qubits with strong spin-orbit coupling, presents a significant challenge [3,4]. In this study, we examine the effects of crosstalk on qubit fidelities during single-qubit operations and derive an analytical expression for a synchronization condition that eliminates crosstalk in anisotropic media. Our analysis reveals optimized driving field conditions that synchronize Rabi oscillations, minimize crosstalk, and exhibit a strong dependence on qubit anisotropy and the orientation of the external magnetic field. By incorporating experimental data, we identify a set of parameters that enable nearly crosstalk-free single-qubit gates, advancing the development of scalable quantum computing architectures.

References

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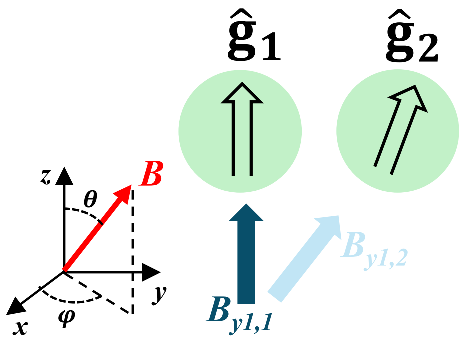

Figure 1: A schematic representation shows two hole spins located in adjacent quantum dots. The presence of spin-orbit coupling leads to real and symmetric g-tensors, labeled as g1 and g2. An external magnetic field B, with a magnitude of B and an orientation described by the angles θ and φ, interacts with the spins through their respective g-tensors. The driving strength of qubit 1 is represented by $B_{y1,1}$ which, due to crosstalk, also causes a driving effect on qubit 2 with a strength of $B_{y1,2}$.