Leveraging the tunability of hole spin qubits

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Hole nanostructures are leading candidates for large-scale quantum computers due to their pronounced spin-orbit interactions (SOIs) and remarkable tunability. In this presentation, I will discuss various strategies for harnessing this tunability to enhance the performance of current hole spin qubits, with a focus on both silicon and germanium qubits.

One avenue of exploration involves exploiting the tunable nature of hole spin qubits to mitigate the impact of charge and hyperfine noise, which directly influences the qubit decoherence time [1,2]. By identifying optimal operating conditions, referred to as sweet spots, where such noise is effectively eliminated, the performance of the qubits can be significantly improved.

Moreover, charge noise presents a significant obstacle for shuttling spins [3], a critical requirement to establish long-range connectivity between distant qubits. Here, I will explore how SOIs can induce intricate spin dynamics that effectively filter out low-frequency noise, thereby improving the efficiency of spin shuttling processes.

Furthermore, the influence of SOIs extends to two-qubit gates, where exchange anisotropies [4,5], induced by these interactions, offer avenues for accelerating the execution of two-qubit gates without compromising fidelity. This implies that by leveraging the unique properties of SOIs, novel methods can be devised to expedite gate operations, paving the way towards large-scale spin based quantum information processing.

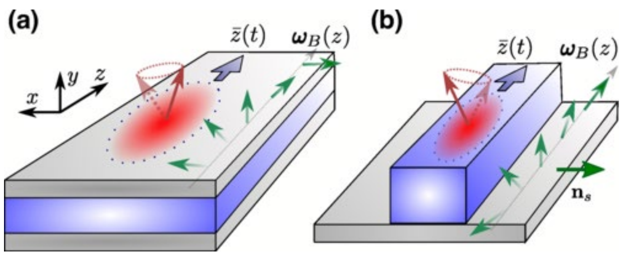

Fig. 1*: Shuttling hole spins in a large SOI and inhomogeneous Zeeman field in a planar germanium heterostructure and a silicon finFET.*

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[2] Bosco S. & Loss D. (2021) Phys. Rev. Lett. 127, 190501.
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