Highly localized and energy efficient quantum control of spin and spin ensemble qubits with classical nanomagnets for scalable quantum computing and sensing

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Abstract:
Our group has demonstrated energy efficient electrical control of nanoscale magnetization using strain mediated switching of the magnetization of nanomagnets; and creation and annihilation of nanoscale magnetic skyrmions using direct voltage control of magnetic anisotropy (VCMA) [2]. Such nanomagnets can generate highly confined microwaves that can control proximally located spin qubits.

This talk will discuss the use of microwaves generated by voltage-controlled magnetization dynamics in such nanomagnets at the Larmor precession frequency of proximally located spins to implement single-qubit quantum gates with fidelities approaching state-of-the-art [3] in a scalable manner. Further confinement of microwaves using convergent-divergent skyrmion devices can implement even lower footprint quantum control of spins [4]. Moreover, we show that using exchange-coupled spin ensemble as a qubit could offer intrinsic error mitigation by suppressing decoherence induced by thermal noise, enabling robust high temperature qubits [5].

Further, we have experimentally shown coherent quantum control of a single nitrogen vacancy (NV) center in diamond with microwave fields generated from proximally located shape anisotropic nanomagnets of lateral dimensions down to 200 nm x 180 nm, driven remotely by surface acoustic wave (SAW) excitation [6]. Specifically, high contrast Rabi oscillations have been demonstrated. Additionally, we report T_1, T_2, T_2* times using microwave pulses generated by such proximally located nanomagnets that can be orders of magnitude more efficient than using conventional antenna [6]. Such localized and energy efficient control has potential to lead to scalable quantum computing and sensing with NV-defects in diamond and other spin qubits.

References

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