Colloquium

Circuit QED with hole spins

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The entanglement of microwave photons and spin qubits in silicon represents a pivotal step forward for quantum information processing utilizing semiconductor quantum dots. Such a hybrid spin circuit quantum electrodynamics (spin cQED) architecture has become possible by imparting a substantial electric dipole moment to a spin qubit by de-localizing it in a double quantum dot under spin-orbit interaction, thereby forming a flopping-mode (FM) spin qubit. By leveraging the strong spinorbit interaction intrinsically present in the valence band of silicon, we achieve a hole spinphoton coupling rate as high as 330MHz. We, furthermore, conduct a comprehensive study of such a hole spin FM qubit embedded into a cQED architecture to shed light onto its intrinsic properties. Contrary to previous expectations, we reveal that the decoherence is dominated by photonic effects in the form of photon emission for the relaxation and photon-shot noise for the dephasing, rather than by mechanisms commonly limiting spin qubits. By mitigating these effects, we demonstrate echo dephasing times up to 5 us and Rabi frequencies as high as 120 MHz, allowing for single qubit fidelities of 99.9%. With strong spin-photon coupling and the promising single-qubit properties, hole spin flopping-mode qubits emerge as a promising platform for large scale quantum architectures.

Tuesday, April 8, 2025 11:00am - 12:00pm
Office Bldg West / Ground floor / Heinzel Seminar Room (I21.EG.101)

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