Spin exchange processes in gated arrays of quantum dots

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I will present our recent work on controlling spin exchange dynamics between neighboring quantum dots, in order to implement coherent operations in multidot devices.

Using a linear array of quantum dots in a GaAs heterostructure, defined and controlled by top gates, we explore different configurations and choices of inducing coherent spin exchange processes. I will explain the use of pulsed barriers to implement symmetric exchange pulses, resulting in an enhancement of two-electron coherence at electrical sweet spots [1]. I will then show the symmetric tuning of triple-dot qubits, yielding multidimensional electrical sweet spots in the three-electron spin spectrum, and demonstrate coherent control using an IQ-modulated resonant control tone [2]. As an application of high-quality exchange pulses (employing more than a a thousand control pulses), I will demonstrate notch filtering of the nuclear spin noise present in these samples [3,4]. In fact, at high magnetic fields we find that qubit depasing originates from nuclear Larmor precessions, occurring at well-defined discrete frequencies associated with ^{69}Ga, ^{71}Ga, and ^{75}As nuclear spins. By applying pulse sequences that implement notch filters at exactly these discrete frequencies we extend qubit coherence times to 0.87 ms, i.e. more than five orders of magnitude longer than the duration of a exchange gate in the same device. Finally, I will show coherent spin exchange processes that involve a large multielectron dot (occupied by approximately 100 electrons). We find that the resulting spin-exchange coupling can have opposite sign compared to exchange between singly-occupied dots, indicating the presence of non-trivial electron correlations [5]. By coupling two singlet-triplet qubit to a multielectron dot, we map out different configurations useful for long-distance spin exchange, including superexchange, direct spin exchange, and on-site exchange mediated by the multielectron dot.

Our results show a pathway to implementing fast, non-nearest neighbor two-qubit gates in semiconducting spin qubits.

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