Long-range coherence in quantum dot arrays

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The spin of a single electron in a semiconductor quantum dot provides a long-lived and well controlled quantum bit. I will first summarize our recent work on single-shot correlation measurements in double quantum dots, and on the realization of a two-qubit gate [1]. Next I will discuss new physical insights concerning single-qubit manipulation using electric-dipole spin resonance [2]. The main part of the talk will be devoted to recent work on long-range coherence in quantum dot arrays. All experiments so far rely on nearest-neighbour couplings only, and inducing long-range correlations requires sequential local operations. Here we show that two distant sites can be tunnel coupled directly. The coupling is mediated by virtual occupation of an intermediate site, with a strength that is controlled via the energy detuning of this site. It permits a single charge to oscillate coherently between the outer sites of a triple dot array without passing through the middle, as demonstrated through the observation of Landau-Zener-Stueckelberg interference. The long-range coupling significantly improves the prospects of fault-tolerant quantum computation using quantum dot arrays and opens up new avenues for performing quantum simulations in these systems.

[1] Nowack et al, Science 333, 1269 (2011)
[2] Shafiei et al, Phys. Rev. Lett., 110, 107601 (2013)
[3] F. Braakman et al, Nature Nanotechnology, accepted