Coherent displacement of individual electron spins in a two-dimensional array of tunnel coupled quantum dots

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Controlling nanocircuits at the single electron spin level in quantum dot arrays is at the heart of any scalable spin-based quantum information platform. The cumulated efforts to finely control individual electron spins in linear arrays of tunnel coupled quantum dots have permitted the recent coherent control of multi-electron spins and the realization of quantum simulators. However, the two-dimensional scaling of such control is a crucial requirement for simulating complex quantum matter and for efficient quantum information processing, and remains up to now a challenge.

Here we demonstrate such two-dimensional coherent control using individual electron spins in arrays up to 9 tunnel-coupled lateral quantum dots. The demonstrated charge control with one and two electrons loaded in the dot arrays permits to explore coherent spin control and displacement. To realize this, two electrons are prepared in the coherent singlet state, and separately displaced within the quantum dot arrays. We show that the electron spin coherence can be maintained over 5 micrometers and 80 ns, and that the motion of the electrons is not detrimental for their spin coherence properties. Actually, the fast control of the potential landscape induces moving quantum dots, in which the electron spins, through a motional narrowing process, are effectively decoupled from the substrate nuclear spins. This work demonstrates key quantum functionalities, crucial for using two-dimensional quantum dot arrays for quantum simulation and computation.

References:

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