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Quantum theory of dynamic nuclear polarization in quantum dots

SOPHIA ECONOMOU, Naval Research Laboratory, EDWIN BARNES, Condensed Matter Theory Center, University of Maryland — Nuclear spins play a major role in the dynamics of spin qubits in III-V semiconductor quantum dots. Although the hyperfine interaction between nuclear and electron (or hole) spins is typically viewed as the leading source of decoherence in these qubits, understanding how to experimentally control the nuclear spin polarization can not only ameliorate this problem, but in fact turn the nuclear spins into a valuable resource for quantum computing. Beyond extending decoherence times, control of this polarization can enable universal quantum computation as shown in singlet-triplet qubits and, in addition, offers the possibility of repurposing the nuclear spins into a robust quantum memory. In [1], we took a first step toward taking advantage of this resource by developing a general, fully quantum theory of non-unitary electron-nuclear spin dynamics with a periodic train of delta-function pulses as the external control driving the electron spin. Here, we extend this approach to other types of controls and further expand on the predictions and physical insights that emerge from the theory. [1] Edwin Barnes and Sophia E. Economou, Phys. Rev. Lett. 107, 047601 (2011)

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