Coherent control of three-spin states in a triple quantum dot

L. Gaudreau, G. Granger, A. Kam, G. C. Aers, S. A. Studenikin, P. Zawadzki, M. Pioro-Ladrière, Z. R. Wasilewski, and A. S. Sachrajda
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Spin qubits involving individual spins in single quantum dots or coupled spins in double quantum dots have emerged as potential building blocks for quantum information processing applications. It has been suggested that triple quantum dots may provide additional tools and functionalities. These include encoding information either to obtain protection from decoherence or to permit all-electrical operation, efficient spin busing across a quantum circuit, and to enable quantum error correction using the three-spin Greenberger-Horn-Zeilinger quantum state. Towards these goals we demonstrate coherent manipulation of two interacting three-spin states. We employ the Landau–Zener–Stückelberg approach for creating and manipulating coherent superpositions of quantum states. We confirm that we are able to maintain coherence when decreasing the exchange coupling of one spin with another while simultaneously increasing its coupling with the third. Such control of pairwise exchange is a requirement of most spin qubit architectures, but has not been previously demonstrated.

NMR probing of the spin polarization of the ν = 5/2 quantum Hall state

M. Stern, B. A. Piot, Y. Vardi, V. Umansky, P. Plochocka, D. K. Maude, and I. Bar-Joseph
arXiv:1201.3488v1 [cond-mat.str-el]

Resistively detected nuclear magnetic resonance is used to measure the Knight shift of the As nuclei and determine the electron spin polarization of the fractional quantum Hall states of the second Landau level. We show that the 5/2 state is fully polarized within experimental error, thus confirming a fundamental assumption of the Moore-Read theory. We measure the electron heating under radio frequency excitation, and show that we are able to detect NMR at electron temperatures down to 30 mK.

Unraveling the spin polarization of the ν = 5/2 fractional quantum Hall state

L. Tiemann, G. Gamez, N. Kumada, and K. Muraki
arXiv:1201.3737v1 [cond-mat.mes-hall]

The fractional quantum Hall (FQH) effect at filling factor ν = 5/2 has recently come under close scrutiny, as it may possess quasi-particle excitations obeying nonabelian statistics, a property sought for topologically protected quantum operations. Yet, its microscopic origin remains unidentified, and candidate model wave functions include those with undesirable abelian statistics. Here we report direct measurements of the electron spin polarization of the ν = 5/2 FQH state using resistively detected nuclear magnetic resonance (NMR). We find the system to be fully polarized, which unambiguously rules out the most-likely abelian contender and thus lends strong support for the ν = 5/2 state being nonabelian. Our measurements reveal an intrinsically different nature of interaction in the first-excited Landau level underlying the physics at ν = 5/2.

Spectroscopy of spin-orbit quantum bits in indium antimonide nanowires

S. Nadj-Perge, V. S. Pribiag, J. W. G. van den Berg, K. Zuo, S. R. Plissard, E. P. A. M. Bakkers, S. M. Frolov, and L. P. Kouwenhoven

arXiv:1201.3707v1 [cond-mat.mes-hall]

Double quantum dot in the few-electron regime is achieved using local gating in an InSb nanowire. The spectrum of two-electron eigenstates is investigated using electric dipole spin resonance. Singlet-triplet level repulsion caused by spin-orbit interaction is observed. The size and the anisotropy of singlet-triplet repulsion are used to determine the magnitude and the orientation of the spin-orbit effective field in an InSb nanowire double dot. The obtained results are confirmed using spin blockade leakage current anisotropy and transport spectroscopy of individual quantum dots.

Observation of Quantum Motion of a Nanomechanical Resonator

A. H. Safavi-Naeini, J. Chan, J. T. Hill, T. P. Mayer Alegre, A. Krause, and O. Painter

Phys. Rev. Lett. **108**, 033602 (2012)

In this Letter we use resolved sideband laser cooling to cool a mesoscopic mechanical resonator to near its quantum ground state (phonon occupancy 2.6±0.2), and observe the motional sidebands generated on a second probe laser. Asymmetry in the sideband amplitudes provides a direct measure of the displacement noise power associated with quantum zero-point fluctuations of the nanomechanical resonator, and allows for an intrinsic calibration of the phonon occupation number.

Measurement-based quantum computing with a spin ensemble coupled to a stripline cavity

Y. Ping, E. M. Gauger, and S. C. Benjamin

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Recently, a new form of quantum memory was proposed. The storage medium is an ensemble of electron spins, coupled to a stripline cavity and an ancillary readout system. Theoretical studies suggest that the system should be capable of storing numerous qubits within the ensemble, and an experimental proof-of-concept has already been performed. Here, we show that this minimal architecture is not limited to storage but is in fact capable of full quantum processing by employing measurement-based entanglement. The technique appears to be remarkably robust against the anticipated dominant error types. The key enabling component, namely a readout technology that non-destructively determines 'are there n photons in the cavity?', has already been realized experimentally.

Relaxation and readout visibility of a singlet-triplet qubit in an Overhauser field gradient

C. Barthel, J. Medford, H. Bluhm, A. Yacoby, C. M. Marcus, M. P. Hanson, and A. C. Gossard

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Using single-shot charge detection in a GaAs double quantum dot, we investigate spin relaxation time (T_1) and readout visibility of a two-electron singlet-triplet qubit following single-electron dynamic nuclear polarization (DNP). For magnetic fields up to 2 T, the DNP cycle is in all cases found to increase Overhauser field gradients, which in turn decrease T_1 and, consequently, reduce readout visibility. This effect was previously attributed to a suppression of singlet-triplet dephasing under a similar DNP cycle. A model describing relaxation after singlet-triplet mixing agrees well with experiment. Effects of pulse bandwidth on visibility are also investigated.