Open quantum system description of singlet-triplet qubits in quantum dots

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arXiv:1503.08673 [quant-ph]

We develop a theoretical model to describe the dissipative dynamics of singlet-triplet (S-T_0) qubits in GaAs quantum dots. Using the concurrence experimentally obtained as a guide, we show that each logical qubit is coupled to its own environment because the decoherence effect can be described by independent dephasing channels. Given the correct description of the environment, we study the dynamics of concurrence as a function of the temperature, the constant coupling between the system and the environment, the preparation time, and the exchange coupling. Although the reduction of the environment coupling constant modifies the entanglement dynamics, we demonstrate that temperature emerges as a crucial variable and a variation of millikelvins significantly modifies the generation of entangled states. Furthermore, we show that the exchange coupling together with the preparation time strongly affects the entanglement dissipative dynamics.

Optically loaded semiconductor quantum memory register

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arXiv:1505.01540 [quant-ph]

We propose and analyze an optically loaded quantum memory exploiting capacitive coupling between self-assembled quantum dot molecules and electrically gated quantum dot molecules. The self-assembled dots are used for spin-photon entanglement, which is transferred to the gated dots for long-term storage or processing via a teleportation process heralded by single-photon detection. We illustrate a device architecture enabling this interaction and we outline its operation and fabrication. We provide self-consistent Poisson-Schroedinger simulations to establish the design viability and refine the design, and to estimate the physical coupling parameters and their sensitivities to dot placement. The device we propose generates heralded copies of an entangled state between a photonic qubit and a solid-state qubit with a rapid reset time upon failure. The resulting fast rate of entanglement generation is of high utility for heralded quantum networking scenarios involving lossy optical channels.

Spintronics and magnon Bose-Einstein condensation

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arXiv:1505.01329 [cond-mat.mes-hall]

Spintronics is the science and technology of electric control over spin currents in solid-state-based devices. Recent advances have demonstrated a coupling between electronic spin currents in non-magnetic metals and magnons in magnetic insulators. The coupling is due to spin transfer and spin pumping at interfaces between the normal metals and magnetic insulators. In this Chapter, we review these developments and the prospects they raise for electric control of quasi-equilibrium magnon Bose-Einstein condensates and spin superfluidity.

Genuine multipartite entanglement without multipartite correlations

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Phys. Rev. Lett. **114**, 180501 (2015)

Nonclassical correlations between measurement results make entanglement the essence of quantum physics and the main resource for quantum information applications. Surprisingly, there are *n*-particle states which do not exhibit *n*-partite correlations at all but still are genuinely *n*-partite entangled. We introduce a general construction principle for such states, implement them in a multiphoton experiment and analyze their properties in detail. Remarkably, even without multipartite correlations, these states do violate Bell inequalities showing that there is no classical, i.e., local realistic model describing their properties.

Transport through an impurity tunnel coupled to a Si/SiGe quantum dot
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arXiv:1505.02132 [cond-mat.mes-hall]

Achieving controllable coupling of dopants in silicon is crucial for operating donor-based qubit devices, but it is difficult because of the small size of donor-bound electron wavefunctions. Here we report the characterization of a quantum dot coupled to a localized electronic state, and we present evidence of controllable coupling between the quantum dot and the localized state. A set of measurements of transport through this device enable the determination of the most likely location of the localized state, consistent with an electronically active impurity in the quantum well near the edge of the quantum dot. The experiments we report are consistent with a gate-voltage controllable tunnel coupling, which is an important building block for hybrid donor and gate-defined quantum dot devices.

^{29}Si nuclear spins as a resource for donor spin qubits in silicon
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arXiv:1505.02057 [quant-ph]

Nuclear spin registers in the vicinity of electron spins in solid state systems offer a powerful resource to address the challenge of scalability in quantum architectures. We investigate here the properties of ^{29}Si nuclear spins surrounding donor atoms in silicon, and consider the use of such spins, combined with the donor nuclear spin, as a quantum register coupled to the donor electron spin. We find the coherence of the nearby ^{29}Si nuclear spins is effectively protected by the presence of the donor electron spin, leading to coherence times in the second timescale - over two orders of magnitude greater than the coherence times in bulk silicon. We theoretically investigate the use of such a register for quantum error correction, including methods to protect nuclear spins from the ionisation/neutralisation of the donor, which is necessary for the re-initialisation of the ancillae qubits. This provides a route for multi-round quantum error correction using donors in silicon.

Large superconducting gap in semiconductor Majorana nanowires: Too much of a good thing?
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arXiv:1505.01482 [cond-mat.supr-con]

With the recent achievement of extremely high-quality epitaxial interfaces between InAs nanowires and superconducting Al shells with strong superconductor-semiconductor tunnel coupling, a new regime of proximity-induced superconductivity in semiconductors can be explored where the induced gap is similar to the bulk Al gap (large gap) with negligible subgap conductance (hard gap). We propose several experimentally relevant consequences of this large-gap strong-coupling regime for tunneling experiments, and we comment on the prospects of this regime for topological superconductivity. In particular, we find that the advantages of having a strong spin-orbit coupling and a large spin g-factor in the semiconductor nanowire may both be compromised in this strongly coupled limit, and somewhat weaker interface tunneling may be necessary for achieving optimal proximity superconductivity in the semiconductor nanowire. We derive a theory for the strong-coupling hard-gap regime obtaining excellent agreement with experiment and pointing out future directions necessary for further progress toward Majorana nanowires in hybrid semiconductor-superconductor structures.

Double pendulum model for tennis stroke including a collision process
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arXiv:1505.01916 [physics.class-ph]

By means of adding a collision process between the ball and racket in double pendulum model, we analyzed the tennis stroke. It is possible that the speed of the rebound ball does not simply depend on the angular velocity of the racket, and higher angular velocity sometimes gives lower ball speed. We numerically showed that the proper time lagged racket rotation increases the speed of the rebound ball by 20%. We also showed that the elbow should move in order to add the angular velocity of the racket.