V O R T R A G S E I N L A D U N G

im Rahmen des gemeinsamen Berufungsverfahrens
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W1-Professur

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Helmholtz-Zentrum Berlin, Lise Meitner Campus,
Hahn-Meitner-Platz 1, 14109 Berlin Raum PT 104
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„Nuclear state preparation and coherent spin manipulation in III-V semiconductor quantum dots"

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Remarkable achievements have been made towards the ultimate goal of having a functional quantum computer. However, there are still several obstacles that must be overcome. One of these is decoherence induced via the interaction of the qubit (quantum bit, elementary building block to process quantum information) with its environment. Among the possible architectures, the progress made with spin-based qubits confined in III-V semiconductor quantum dots (like GaAs which is often used in experimental implementations) has been the most impressive. One of the major problems of this architecture is the undesirable interaction between the electron spin with the host nuclear spins via the hyper_ne interaction, which leads to decoherence. However, the situation is not as hopeless as it appears, since it is possible to increase coherence times by manipulating nuclear spins.

In electrically defined double quantum dots, it is possible to increase the coherence of a two-spin based qubit by repeatedly tuning the two-electron spin system across a singlet-triplet level-anticrossing with alternating slow and rapid sweeps of an external bias voltage. Using a Landau-Zener-Stückelberg-Majorana (LZSM) model, we find that in addition to a small nuclear polarization that weakly affects the electron spin coherence, the slow sweeps are only partially adiabatic and lead to a weak nuclear spin measurement and a nuclear-state narrowing which prolongs the electron spin coherence [1].

In self-assembled quantum dots, a recent experiment [2] has demonstrated that high nuclear spin polarization can be achieved by exploiting an optically forbidden transition between a heavy hole and a trion state. However, a fully polarized state is not achieved as expected from a classical rate equation. By investigating this problem with the help of a quantum master equation, we demonstrate that a fully polarized state cannot be achieved due to formation of a nuclear dark state. Moreover, we show that the maximal degree of polarization depends on structural properties of the quantum dot [3].

Although nuclear spins are a nuisance for achieving coherent electron spin control in quantum dots, they can, under the right conditions, also be used for exactly that task. Coherent quantum control of a spin singlet S and spin triplet T+ confined in an electrically defined double quantum dot can be achieved through Stückelberg interferometry [4].

By designing a tailored pulse with a detuning dependent level velocity, we show how to overcome limitations set by both nuclear spins and charge environment [5,6].

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[5] H. Ribeiro, G. Burkard, J. R. Petta, H. Lu, and A. C. Gossard, Phys. Rev. Lett. 110, 086804 (2013).
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