Symmetry games in driven quantum dot circuits

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Quantum dots are central components of semiconductor based electronic quantum circuits. They are being investigated for their potential for quantum information applications and provide a test bed for studying fundamental questions, for instance as local detector embedded in the matrix of a crystal. Laterally defined nanodevices allow the design of symmetry properties. This opens up new perspectives for experiments and can lead to novel ideas for applications. In my talk I will present experiments, in which we purposely break and control symmetries by applying a combination of static and dynamic fields.

In one experiment we realize a Lissajous rocking ratchet by simultaneously driving two tunnel barriers of a single dot and measuring a dc current induced by this driving [1]. It allows to compare and process two different rf signals and their relative phase on a chip.

In a second set of experiments we periodically drive a double quantum dot charge qubit through its avoided crossing thereby performing Landau-Zener-Stückelberg-Majorana spectroscopy [2]. We demonstrate that the extension from monochromatic to bichromatic driving opens up a playground of new possibilities [3]. Interestingly, driving with commensurable frequencies reduces the symmetry of coherence patterns, while incommensurable frequencies generally lead to a full recovery of the symmetry.

Finally, I will introduce an experiment in which an inhomogeneous magnetic field breaks the symmetry in regard to the electron spin [4]. This static symmetry breaking strongly influences the hyperfine interaction between electrons and nuclei and facilitates the dynamic polarization of the ~10^6 nuclear spins in a double quantum dot. It thereby helps us to reveal an unexpected complexity of the many body nuclear spin system which, for instance, gives rise to multistabilities in the driven system.

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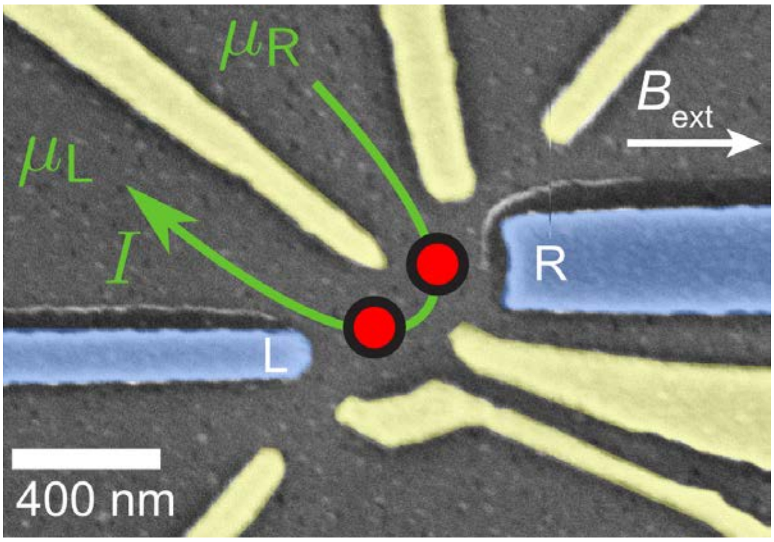
[2] F. Forster, G. Petersen, S. Manus, P. Hänggi, D. Schuh, W. Wegscheider, S. Kohler, and S. Ludwig, "Characterization of Qubit Dephasing by Landau-Zener-Stückelberg-Majorana Interferometry", Phys. Rev. Lett. **112**, 116803 (2014).

[3] F. Forster, M. Mühlbacher, R. Blattmann, D. Schuh, W. Wegscheider, S. Ludwig, and S. Kohler, "Landau-Zener interference at bichromatic driving", Phys. Rev. B 92, 245422 (2015).

[4] F. Forster, M. Mühlbacher, D. Schuh, W. Wegscheider, G. Giedke, and S. Ludwig, "Multistability and spin diffusion enhanced lifetimes in dynamic nuclear polarization in a double quantum dot", Phys. Rev. B 92, 245303 (2015).



The figure displays an SEM image of one of our double quantum dot samples. It contains gold (yellow) and cobalt (blue) gates on the surface of a GaAs/AlGaAs heterostructure with a two-dimensional electron system (2DES) 85 nm beneath the surface. The gates are used to define a double quantum dot (indicated by red circles) in the 2DES by means of the electric field effect. The green arrow depicts a typical transport measurement where a tunnel current flows through the double dot and between two-dimensional leads at chemical potentials μ_L and μ_R. In this device the ferromagnetic cobalt gates constitute single domain nanomagnets and generate a strongly inhomogeneous magnetic field in the region of the double dot.