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 ~10⁶ 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.

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 $\mu_L$ and $\mu_R$. 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.