Dispersive Readout and Coherent Manipulation in an Isolated 2x2 Quantum Dot Array in ^{28}Si

P. Hamonic[1], M. Nurizzo[1], J. Nath[3], M. C. Dartiailh[3], B. Bertrand[2], H. Niebojewski[2], P. Julliard[3], B. Cardoso-Paz[3], M. Vinet[3], T. Meunier[1,3] and M. Urdampilleta[1]
[1]*Néel Institute, CNRS Grenoble, France*
[2]*CEA-LETI Grenoble, France*
[3]*Quobly Grenoble, France*
pierre.hamonic@neel.cnrs.fr

Spin-qubits based on semiconductors quantum dots is a promising approach to quantum computing as demonstrated by recent implementations of quantum algorithms [1]. However, the size of the quantum dot array is often limited by the sensitivity and footprint of the charge sensors used for readout . Therefore, scaling up an architecture based on quantum dots requires a paradigm shift in terms of readout and control of single charges.

In this presentation, we demonstrate dispersive readout of electrons in a CMOS quantum dot array free of charge detector. For this purpose, we combine two methods: first, we load a controlled number of electrons in the QD array which is subsequently isolated from reservoirs and operated out of equilibrium. This drastically simplifies the stability diagram via the reduction of the available charge states by the system. Second, we use gate-based reflectometry technique to probe electron tunneling between quantum dots which allows to discard the use of external charge sensors [2].

Using virtual gates, we demonstrate single occupancy in each dot in double, triple and quadruple quantum dot configuration. Single electron occupancies are further confirmed by magneto-spectroscopy and single shot spin readout.

We utilize this dispersive readout to probe and tune the exchange interaction between two electrons using the confinement potential and demonstrate coherent manipulations between the different spin states. This includes S-T$^-$ oscillations and exchange oscillations.

We believe that the combination of dispersive readout and the operation of the array decoupled from the reservoirs, greatly facilitates an easy initialization and manipulation of the system, and is a scalable approach.

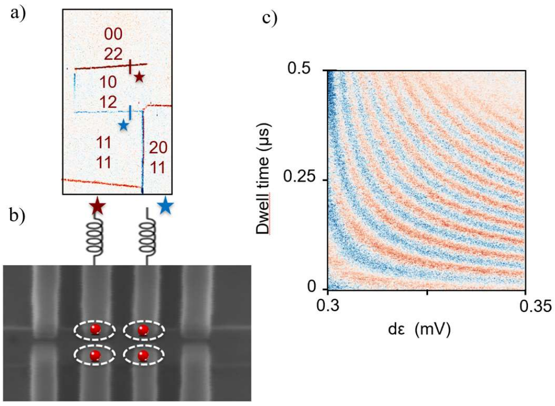

Fig.1. a) Single occupancy state of the quadruple quantum dot. blue transitions are sensed through the top right gate of the array and red transitions are sensed through the top left gate of the array. b) SEM micrograph of the device comprising 4 split gates. The rightmost and leftmost gates are closed to isolate the 2x2 array from reservoirs. The device is fabricated in the CEA-LETI foundry using FDSOI (fully depleted silicon on insulator) technology. c) S-T$^-$ oscillations observed at the 11-20 transition of the left double quantum dot.

References

[1] N. Hendrickx et al, Nature **591**, 580 (2021).
[2] F. Vigneau et al, Applied Physics Review **10**, 021305 (2023).