The Qube: a lattice of vertically and laterally coupled quantum dots

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Quantum dots defined in quantum wells in semiconductor heterostructures are a promising platform for realizing quantum computers. To explore what more the platform has to offer, we investigate the properties when electrostatic top gating is used to define quantum dots on bilayer quantum wells [1]. In doing so, we realize a vertically coupled double quantum dot, measured both in transport across a single hole transistor, then in charge sensing. We tune up to the single hole regime under a single plunger and find the (1,1) charge filling. We demonstrate virtualization of the double dot using surrounding barrier gates and find good evidence for the dots being vertically coupled by triangulation of the coupling to the surrounding gates, and electrostatic simulations.

We demonstrate a vertical 2 x 2 array of quantum dots by accumulating under a second plunger, tuning to the (1,1,1,1) regime. By extending this to a four-plunger gate design, we form four vertically coupled double quantum dots. We obtain charge stability diagrams of four dots through the variation of two top plunger gates at a time, on both sides of the device at the same voltage point, resulting in a 2x2x2 quantum dot lattice. This is an exciting opportunity to extend the framework of gate-defined semiconductor quantum dots beyond planar implementations, for the development of quantum computation and simulation.

References

[1] 1] A High-Mobility Hole Bilayer in a Germanium Double Quantum Well, A. Tosato, B. Ferrari, G. Scappucci et al Advanced Quantum Technologies, 2022.

Figures

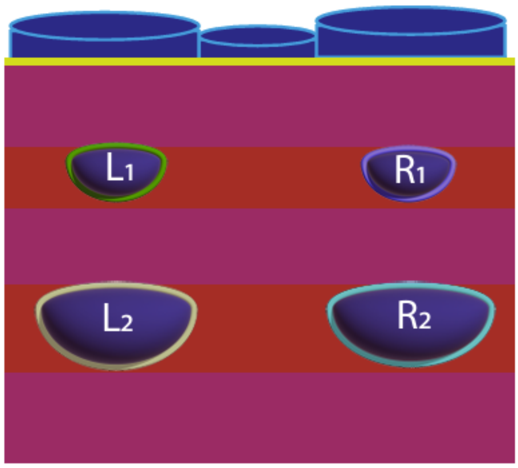

Figure 1: Schematic of a heterostructure with two quantum wells, with two plunger gates. Beneath each plunger gate there is a vertically coupled double quantum dot accumulated.