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Feature detection and automation in Si MOS quantum dots toward automated qubit tuning

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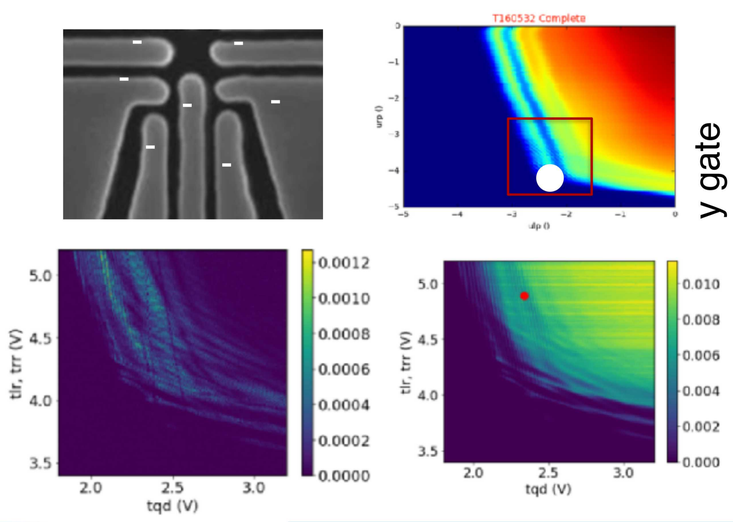
Introduction

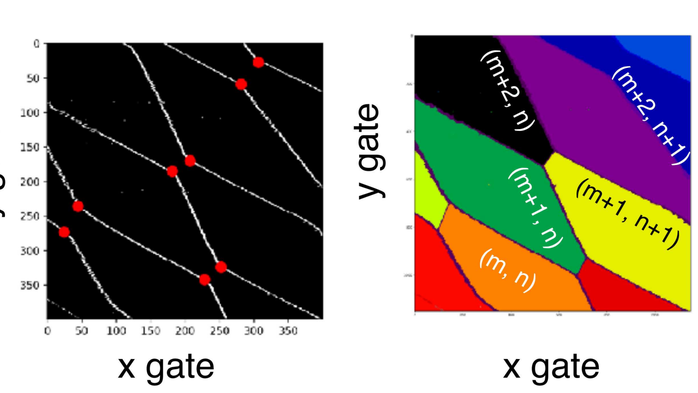
- Challenging tuning conditions and complex devices lead to a need for automated measurements and analysis [1]
- A few groups have shown some automation steps and automated analysis.[2, 3, 4, 5, 6]
- Previously we've shown that
  a. Auto tune from no voltages to working charge sensor
  b. Detect multiple charge offsets and anitcrossings in a large voltage space
- Here we show a feed forward automation protocol starting at an anticrossing to generating pulse sequences toward qubit calibration

Previous work

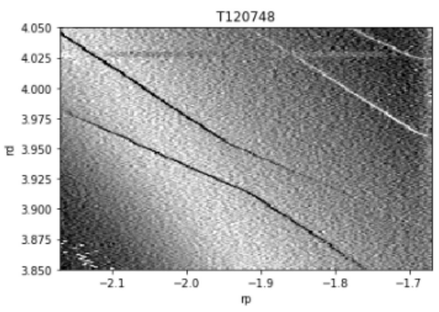
(a) Zero to charge sensor



(b) Finding anticrossings



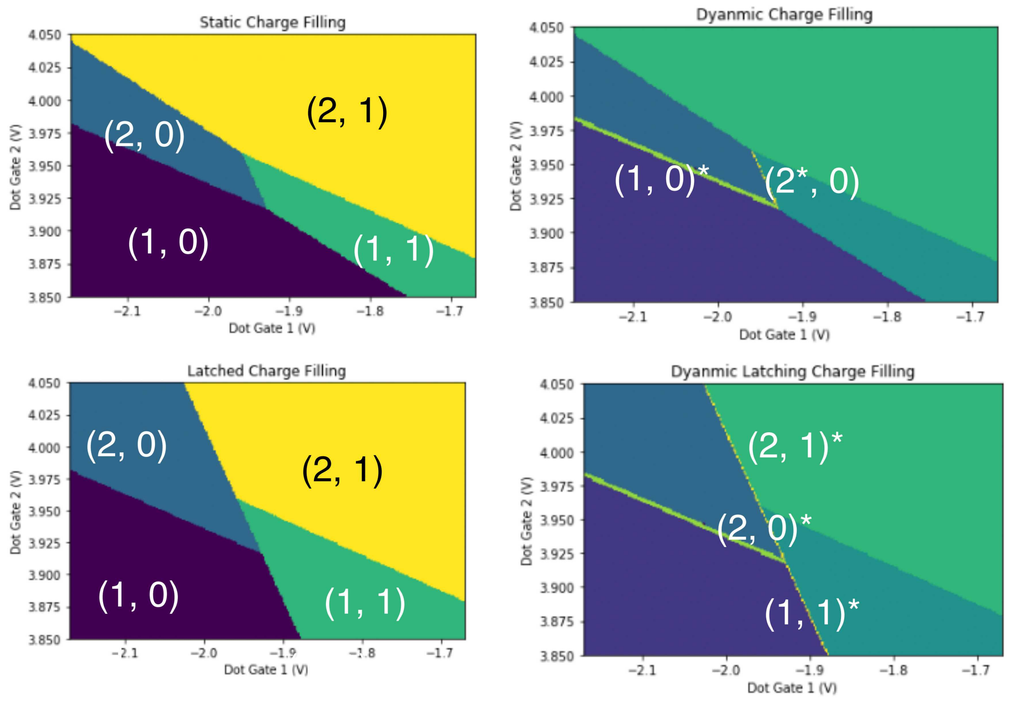
Quantify Anticrossing Parameters



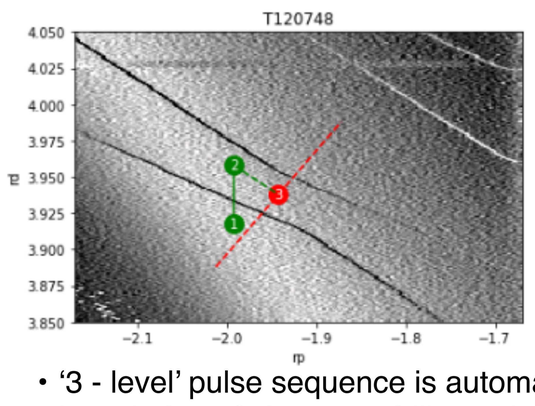
- Identify charge offsets and triple points in anticrossing stability diagram:
  1. Hough transform to find lines
  2. Gen. Hough Transform with angle template to find triple points
  3. Optimize location triple points and angles

- Auto-Identify Stability Regions
  1. Use output from anticrossing analysis
  2. Simple greater than/less than rules apply for static and latching charge filling
  3. Dynamic (excited states) can be filled in by knowledge of valley splitting

Auto-Identify Stability Regions



Auto-Generate Pulse Sequence



n	ramp	wait
1	100 ns	10 us
2	500 ns	1 us
3	500 ns	100 us

- '3 - level' pulse sequence is automatically generate from knowledge of charge stability regions
  1. Initialize state in the (1, 0) region away from latch line
  2. Load mixture of singlets and triplets in the (2, 0) region, beyond the (1, 0)* exited state
  3. Raster the readout point to observe potential readout window via Pauli Blockade or Latch Readout
- Other pulse sequences easily generated using similar logic

Conclusions

Starting from a single anticrossing of interest (potential donor or double quantum dot qubit) we show we can:

1. Analyze the stability diagram for triple point location and charge transition slopes
2. Determine the charge filling for both the static and dynamic charge filling
3. Automatically formulate a pulse sequence to begin calibrating our qubit

Future Steps:

- Analysis modules for different pulse sequence results
- Mulit-qubit stability diagram navigation

[1] Hensgens et al., Nature 548, 70 (2017).
[2] Baart et al, APL 108, 213104 (2016).
[3] Diepen, et al, arXiv:1803.10352v1 (2018).
[4] Kalantre et al, arXiv:1712.04914 (2018).
[5] Botzem et al. arXiv:1801.03755 (2018).
[6] Lapointe-Major, Masters Thesis (2017)

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