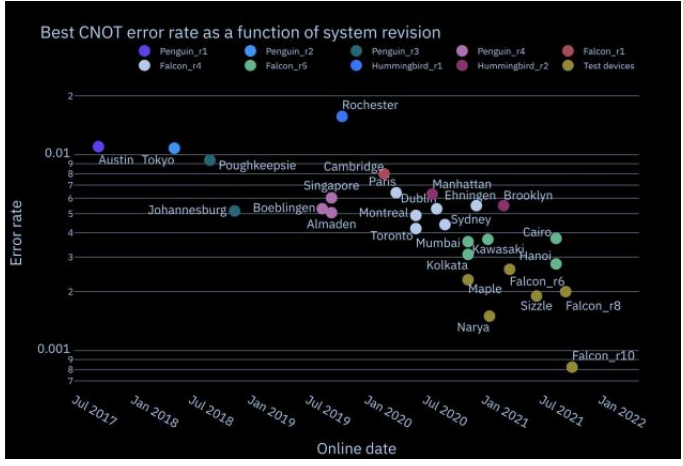
Improving Quantum Gates with Optimal Quantum Control

L. Pereira, R. González, M. Á. Palomo, A. Bravo, R. Romero

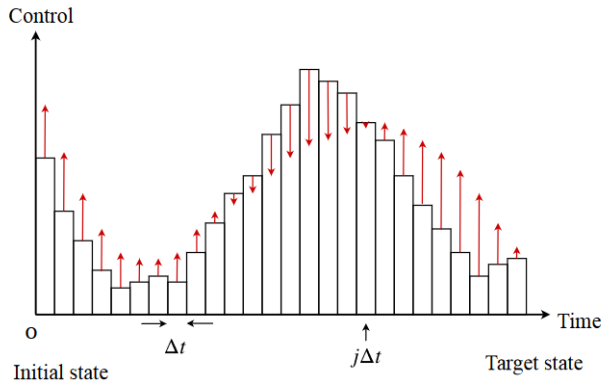
It is necessary to improve the fidelity of quantum gates to achieve computational advantage with quantum computers.



https://twitter.com/jaygambetta/status/1445115380616335373

An alternative is use optimal quantum control.

$\rightarrow$ Gradient Ascent Pulse Engineering (GRAPE) Pulses.



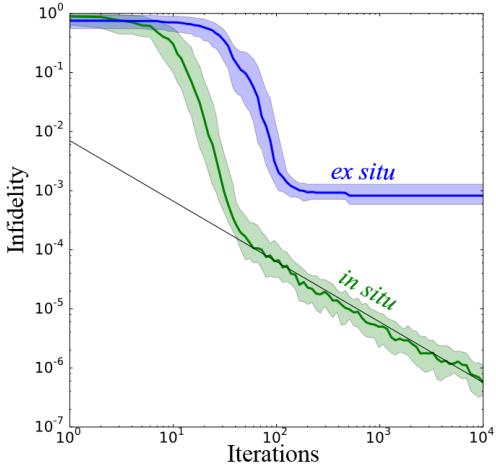
Y. Shi *et al.*, "Optimized Compilation of Aggregated Instructions for Realistic Quantum Computers".

We optimize the GRAPE pulse maximizing the Fidelity.

$$f(\vec{w}) = \frac{1}{d^2} |\, Tr(V^\dagger U(\vec{w}))|^2.$$

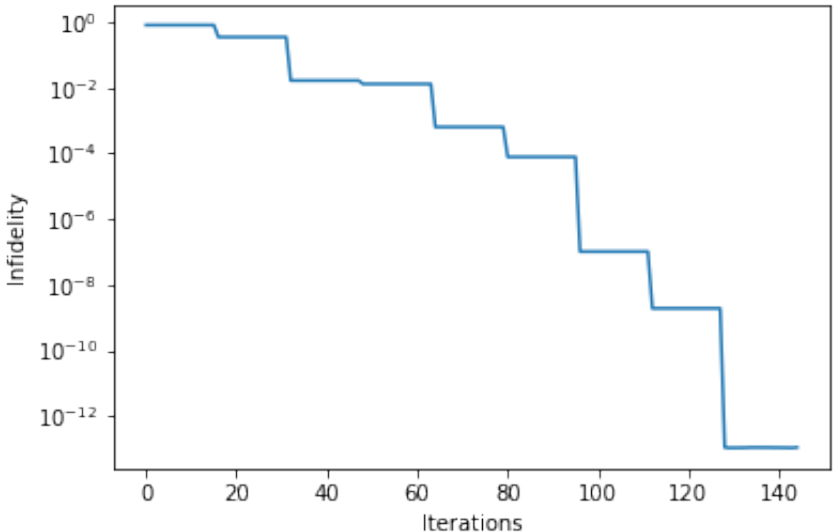
This can be evaluated:

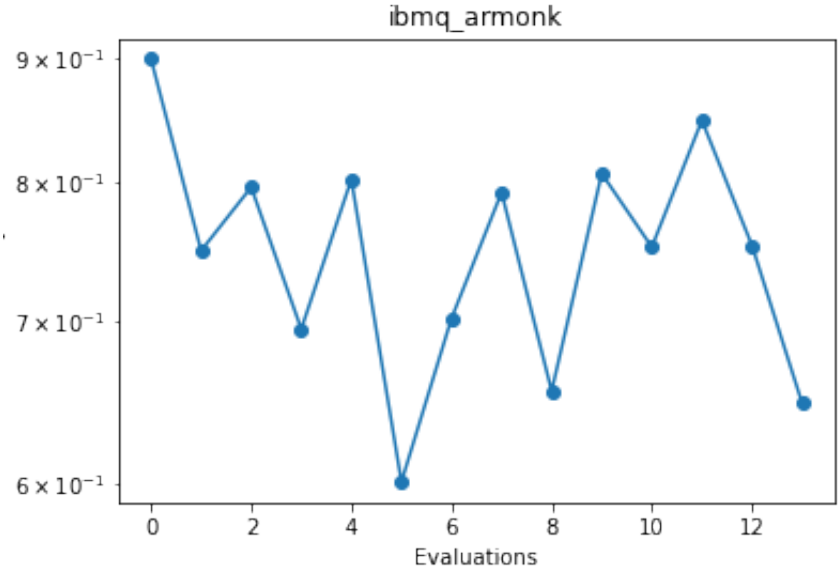
- Numerically, proposing a model for the system.
- Experimentally. S. T. Flammia and Y.-K. Liu, "Direct Fidelity Estimation from Few Pauli Measurements".



C. Ferrie and O. Moussa, "Robust and efficient in situ quantum control".

- We build a Qiskit library to perform the ex-situ and in-situ quantum control with GRAPE.
- We implement GRAPE pulses with Qiskit Pulse.
- We implement Direct Fidelity Estimation for unitary gates.
- We propose a mixed protocol, where first the ex-situ quantum control is carried out, to then refine the result with in-situ quantum control.
- We implement the not-gate with ex-situ and in-situ quantum control.


Infidelity
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
20
40
60
80
100
120
140
Iterations


ibmq_armonk
9×10^{-1}
8×10^{-1}
7×10^{-1}
6×10^{-1}
0
2
4
6
8
10
12
Evaluations