Single Qubit Clifford Sequences Experiment using

Gate Insertion and Pulse Stretching

Meeting with Professor Schnetzer

September 9, 2020

Reproducing the following figure from Kandala paper

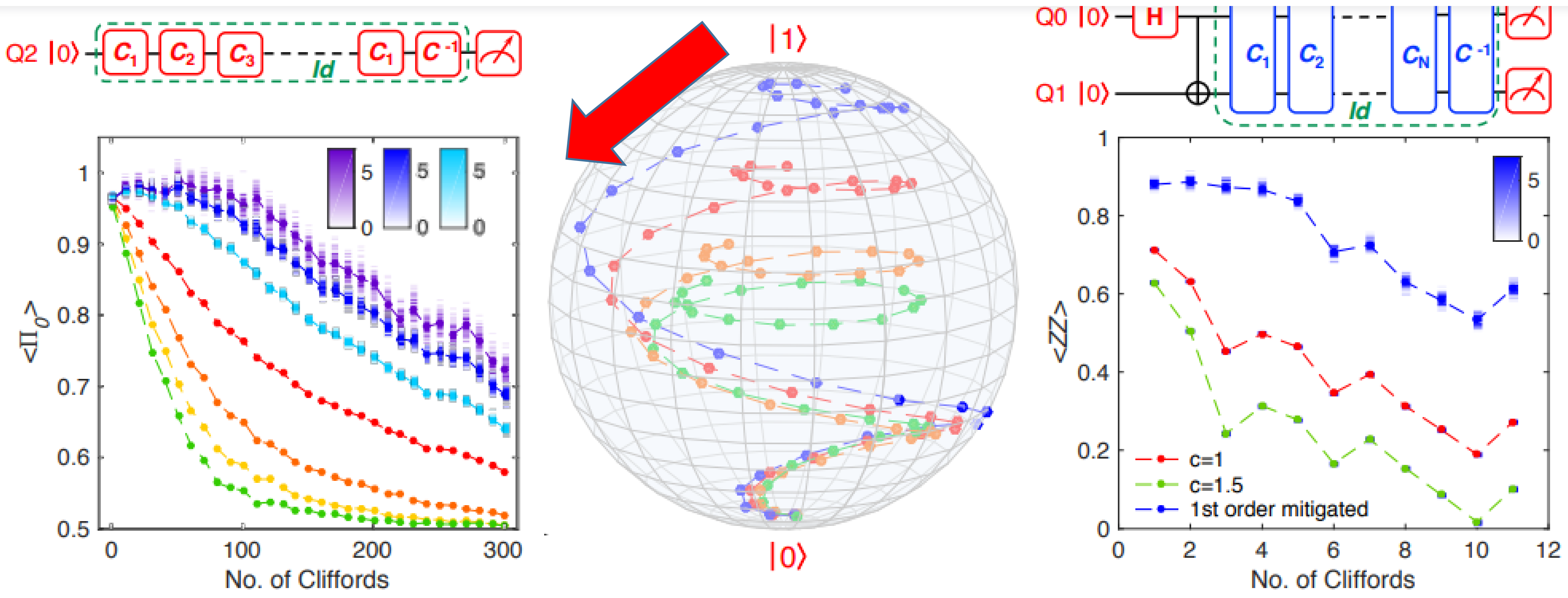
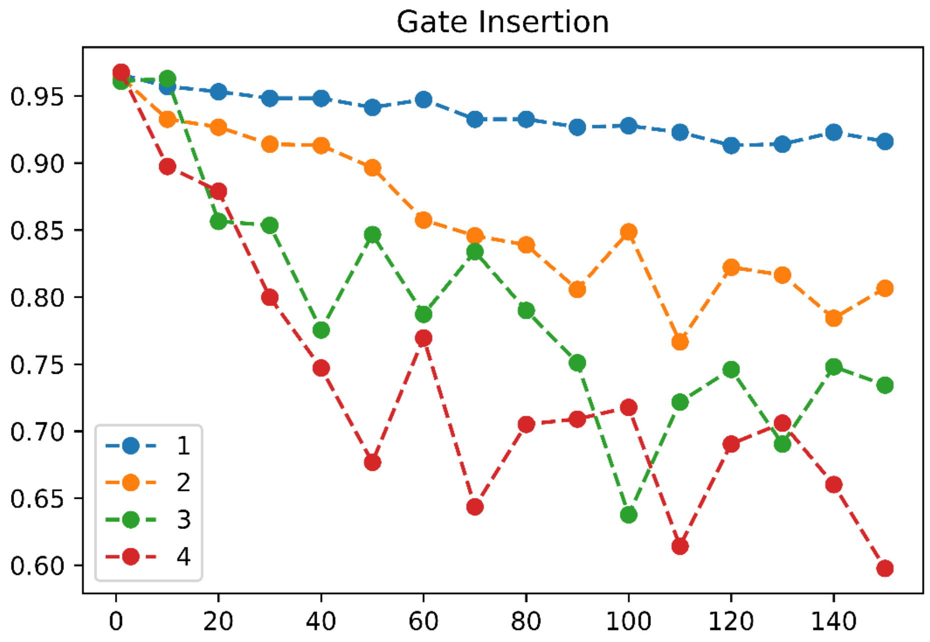


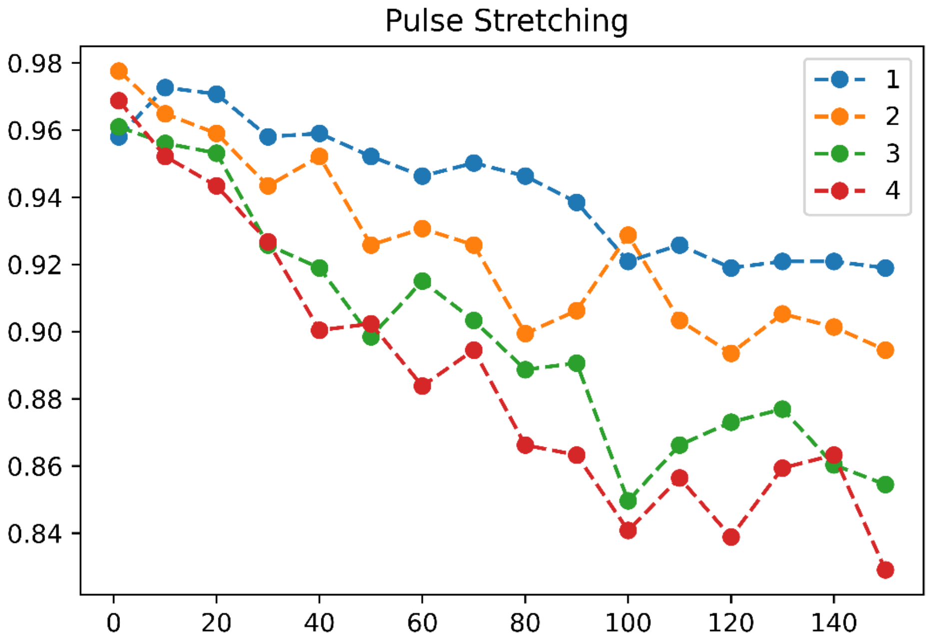
FIG. 2. **Error mitigation of random single-qubit and two-qubit circuits a** Expectation value of the ground state projector for identity equivalent single-qubit Clifford sequences for stretch factors $c = 1$ (red), 2 (orange), 3 (yellow), 4 (green) and the corresponding Richardson extrapolations to first (light blue), second (dark blue) and third order (violet). **b** Experimental implementation of trajectories described by Eq. 3, represented on a Bloch sphere for stretch factors $c = 1$ (red), 2 (orange), 3 (green) and the and the corresponding first-order Richardson extrapolation (blue). The ideal theoretical trajectory is one that takes the qubit from its ground state to its excited state along the surface of the Bloch sphere. **c** Expectation value of the ZZ parity for identity equivalent two-qubit Clifford sequences applied on a Bell State for stretch factors $c = 1$ (red), 1.5 (green) and the corresponding 1st order Richardson extrapolations (dark blue). The color density plots of **a, c** represent histograms of outcomes of 100 numerical experiments obtained by bootstrapping of each experimental data point.

Noise Stretch Factors: 1,2,3,4

Gate Insertion

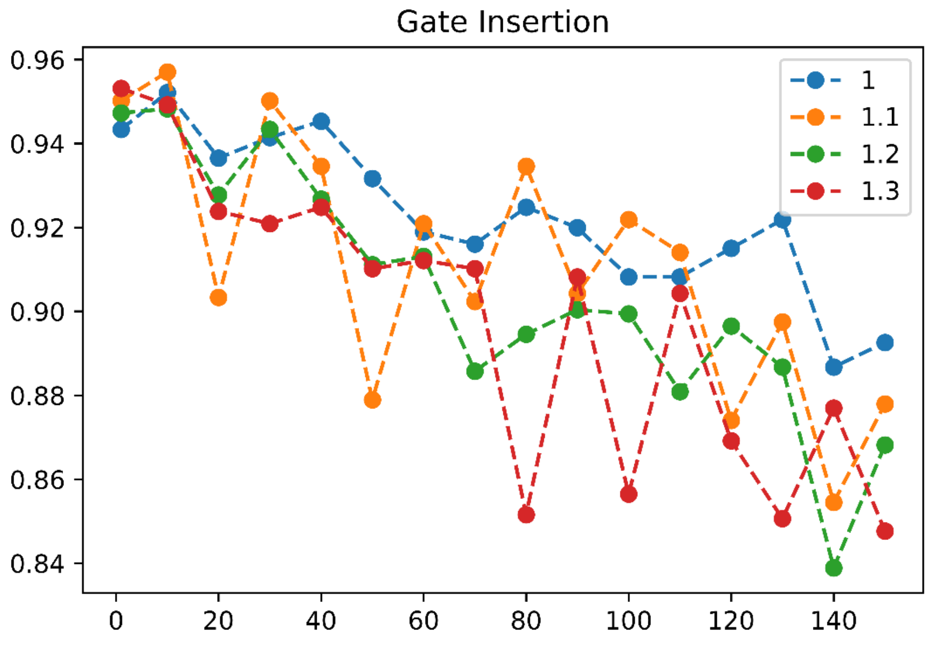


Pulse Stretching

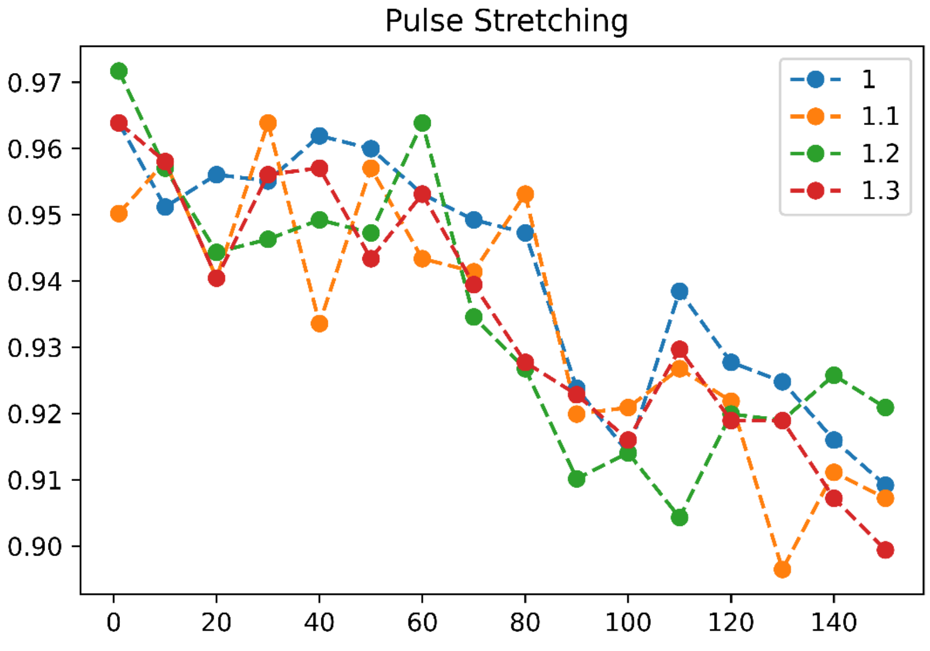


Noise Stretch Factors: 1, 1.1, 1.2, 1.3

Gate Insertion



Pulse Stretching



Methods

Gate Insertion

- For a given gate length x:
  - Generate x Clifford gates adding up to an identity
  - For a given scale factor c:
    - Use Random Identity Insertion Method (after every gate in the circuit, add x identities where x is sampled from a Poisson distribution with mean (c-1)/2

Pulse Stretching

- For a given gate length x:
  - Generate x Clifford gates adding up to an identity
  - For a given scale factor c:
    - Each U3 gate in the circuit has some associated DRAG pulse (Derivative Removal by Adiabatic Gate)
    - Thus pulse is a function of duration, amplitude and sigma (width of Gaussian)
    - To stretch the pulse,
      - New Duration = c*duration
      - New amp = amplitude/c
      - New sigma = c*sigma

$$Gaussian(x, amp, sigma) = amp * e^{-(1/2)*(x-duration/2)^2/sigma^2)}$$