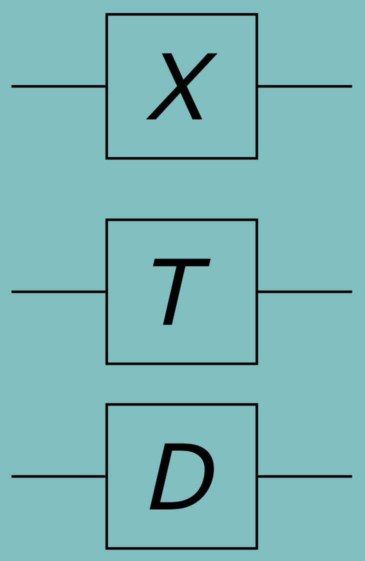
Randomised Benchmarking of universal qutrit gates

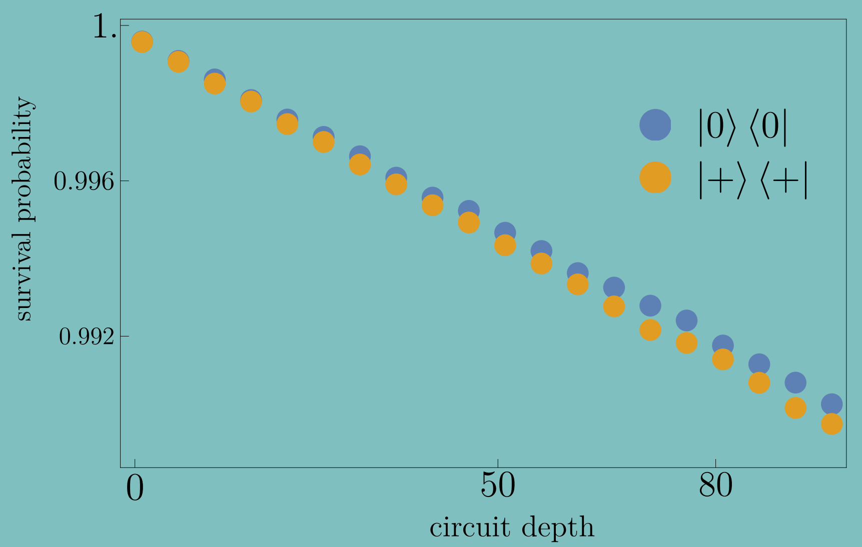
We characterise a set of generators of universal qutrit gates, including the T gate, via an extension of the Randomised Benchmarking scheme.



$$X:\ \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

$$T:\ \begin{bmatrix} 1 & 0 & 0 \\ 0 & e^{2\pi i/9} & 0 \\ 0 & 0 & (e^{2\pi i/9})^2 \end{bmatrix}$$

$$D:\ \begin{bmatrix} e^{2\pi i/9} & 0 & 0 \\ 0 & e^{2\pi i/9} & 0 \\ 0 & 0 & e^{2\pi i/9} \end{bmatrix}$$



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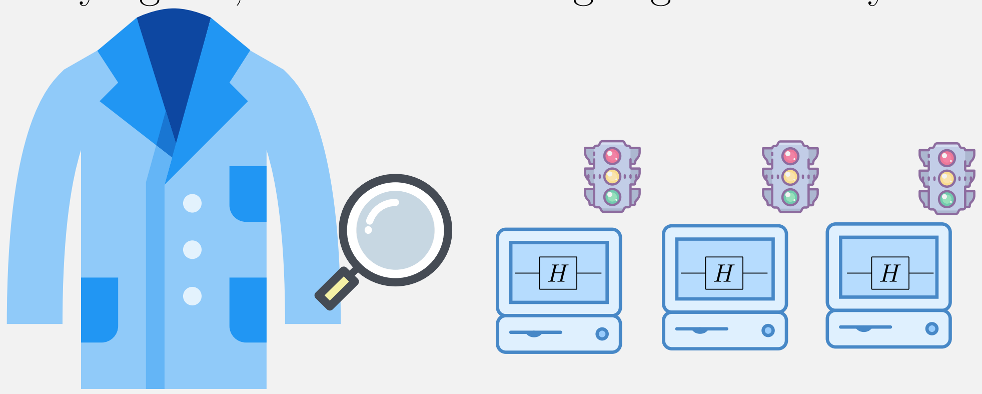
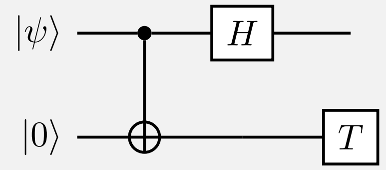
Background

Randomized Benchmarking estimates quantum gate quality comparing the behaviour of ideal and noisy gates, via the average gate fidelity F.



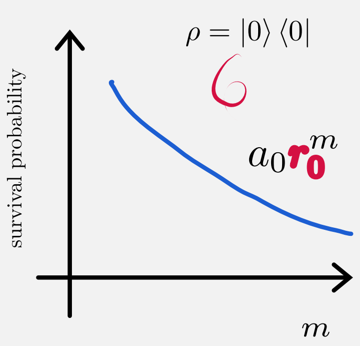
RB is used to characterize Clifford gates, T gates require an extension for their characterization.

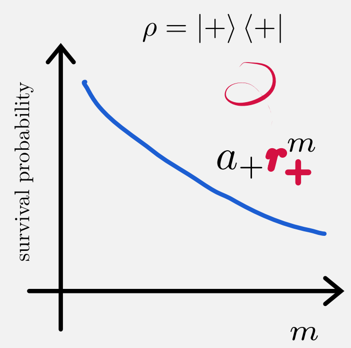


A **qutrit** is a three-level quantum system that offers advantages over qubits and is widely implemented in different quantum information implementations.

Results

RB assumes gates correspond to a physical group; we introduce the HyperDihedral group to characterise a T gate. The HyperDihedral group is generated by:





$$F = \frac{(1 + 2r_0 + 6r_+)/3 + 1}{4}$$

We obtained the expression for the average gate fidelity for the HyperDihedral group; it has two parameters, accessible by using two different initial states. Our expression is valid for state imperfections and gate-dependent errors.