Computational Advantage from the Quantum Switch

Jorge Escandón-Monardes*, Aldo Delgado†, Stephen P. Walborn**
Millennium Institute for Research in Optics and Physics Department, Universidad de Concepción, 160-C Concepción.
∗jescandon@udec.cl, †aldelgado@udec.cl,∗∗swalborn@udec.cl

Introducción

The quantum switch[1] is a quantum computational primitive that applies a set of quantum operations in a superposition of orders. In this contribution, we show that the quantum switch provides computational advantage in a number of tasks. In particular, it demands less gate uses than any fixed-order circuit to discriminate between commuting and anticommuting gates. We present and discuss two generalizations of this task: the Fourier Promise Problem (FPP)[2] and the Hadamard Promise Problem (HPP)[3]. Recently, the authors have introduced the broader Complex Hadamard Promise Problem (CHPP)[4], which reduces to the FPP and HPP as limiting cases. We highlight some features of this task and show that the quantum switch requires less gate uses than other strategies to solve the problem, thus providing query advantage in the entire family of CHPPs. Finally, we mention applications of the quantum switch in quantum communication and quantum metrology.

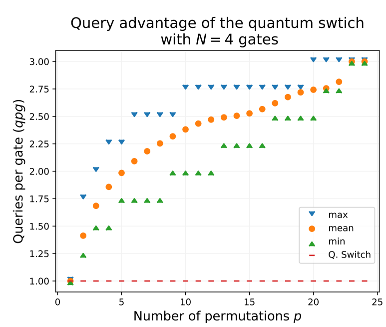
Desarrollo

Let M be a $CH(p)$ matrix in its dephased form and consider a set of N unknown unitary gates $U_0, ..., U_{N-1}$. We define the product $\Pi_0 = U_{N-1}U_{N-2}...U_0$ and denote different permutations of the same gates by $\Pi_1, ..., \Pi_{p-1}$. The Complex Hadamard Promise states that the set of unitaries satisfies the following property for one of the columns k of M:

$$\forall j \in \{0, ...p-1\} : \Pi_j = M_{jk} \cdot \Pi_0. \tag{1}$$

The problem is to find the value of the column k.

The graph shows the computational advantage of the quantum switch in terms of the *queries per gate* (*qpg*) parameter against a fixed-order simulation of an (N, p)-`switch`, for $N = 4$ and varying p.



Agradecimientos: Fondo Nacional de Desarrollo Científico y Tecnológico (ANID) (1200266), ANID – Millennium Science Initiative Program – ICN17_012, and ANID-Subdirección de Capital Humano Avanzado/Doctorado Nacional/2021-21211347.

Referencias

[1] G. Chiribella, G. D'Ariano, P. Perinotti and B. Valiron. Phys. Rev. A, 88:022318 (2013)
[2] M. Araújo, F. Costa and Č. Brukner. Phys. Rev. Lett., 113:250402 (2014)
[3] M. Taddei et al. PRX Quantum, 2:010320 (2021)
[4] J. Escandón-Monardes, A. Delgado and S. P. Walborn. arXiv:2207.12997 (2022)