The power of one qubit in quantum simulation algorithms

Polla, S.

Curriculum Vitæ

I was born on the 26th of January 1994 in Bergamo, Italy. From a young age I was fascinated by magnets, gyroscopes and symbolic languages. While attending secondary education at LSS Filippo Lussana, I developed an interest for electronics, music and philosophy.

Guided by my passions, I began my Bachelor's studies in Physics at Università degli Studi di Milano in 2013 and graduated *cum laude* in 2016. During bachelor thesis, I engaged in an internship at LENS in Florence, bridging the research of M. Bellini's experimental quantum optics group and M. G. A. Paris's quantum information theory group in Milan. Throughout my studies, I played an active role in the Italian Association of Physics Students (AISF), organizing physics events at local, national, and international levels.

I got to know Leiden through a LION summer school, and decided to move there to pursue a Master's in physics in 2017. Admitted to the Casimir Master Track, I had the opportunity to work on short research projects in experimental quantum optics (Löffler group) and spin qubits (Vandersypen group in TU Delft). My final thesis on quantum digital cooling under the supervision of T. E. O'Brien and Y. Herasymenko, led to my graduation *summa cum laude* in 2019. During this period, I received the Casimir prize for academic performance and the Lorentz prize for the best master thesis in theoretical physics in the Netherlands. As part of the Casimir track, I composed a research proposal on *Non-Unitary Algorithms for Near-Term Quantum Computing*, which was awarded with funding for a Ph.D. position and forms the base of this thesis.

Supervised by T. E. O'Brien and C. W. J. Beenakker, my doctoral research centered on advancing quantum algorithms for the simulation of complex quantum systems. During my time at Leiden, I found great satisfaction in contributing to the instruction of Master courses in condensed matter physics and applied quantum algorithms. I actively contributed to the development of course content for the latter, taking charge of sections covering numerics for quantum simulation algorithms and applications to quantum chemistry.

In the final two years of my doctoral program, I concurrently held a part-time student researcher role with the Google Quantum AI team, which allowed me to absorb invaluable knowledge and a perspective on research oriented to ambitious goals.

During my doctoral studies, I witnessed the birth and growth of the Applied Quantum Algorithms Leiden $\langle \mathrm{aQa}^{\mathrm{L}} \rangle$ group, actively contributing by fostering collaborations both within and outside Leiden University. In 2022, I authored a research proposal on quantum algorithms for quantum chemistry, securing continued funding from Shell to support the research in collaboration with L. Visscher's Theoretical Chemistry group at VU Amsterdam. This funding facilitated the hiring of two postdoctoral researchers, kicking off the QC^2 (quantum computational quantum chemistry) project. In the upcoming period, I am dedicated to continuing this research initiative in Leiden. As a part of this, I am co-organizing a Lorentz Center workshop, which will bring together world-class experts in the simulation of quantum systems in Leiden.

List of publications

[255] S. Polla, Y. Herasymenko & T. E. O'Brien. Quantum digital cooling. *Physical Review A*, **104**, 012414 (2021).
[Chapter 2 is based on this publication.]

[156] T. E. O'Brien, S. Polla, N. C. Rubin, W. J. Huggins, S. McArdle, S. Boixo, J. R. McClean & R. Babbush. Error Mitigation via Verified Phase Estimation. *PRX Quantum*, **2**, 020317 (2021).
[Chapter 3 is based on this publication.]

[196] S. Polla, G.-L. R. Anselmetti & T. E. O'Brien. Optimizing the information extracted by a single qubit measurement. *Physical Review A*, **108**, 012403 (2023).
[Chapter 4 is based on this publication.]

[257] B. F. Schiffer, D. van Vreumingen, J. Tura & S. Polla. Virtual mitigation of coherent non-adiabatic transitions by echo verification, arXiv:2307.10358 (2023).
[Chapter 5 is based on this preprint.]

[256] E. Koridon, J. Fraxanet, A. Dauphin, L. Visscher, T. E. O'Brien & S. Polla. A hybrid quantum algorithm to detect conical intersections, arXiv:2304.06070 (2023).
[Chapter 6 is based on this preprint.]

[258] P. Steindl, H. Snijders, G. Westra, E. Hissink, K. Iakovlev, S. Polla, J. A. Frey, J. Norman, A. C. Gossard, J. E. Bowers, D. Bouwmeester, and W. Löffler Artificial Coherent States of Light by Multiphoton Interference in a Single-Photon Stream. *Physical Review Letters*, **126**, 143601 (2021).

[69] T. E. O'Brien, G. Anselmetti, F. Gkritsis, V. E. Elfving, S. Polla, W. J. Huggins et al. Purification-based quantum error mitigation of pair-correlated electron simulations. *Nature Physics*, **19**, 1787–1792 (2023).

[259] L. A. Markovich, S. Malikis, S. Polla & J. T. Brugués. Phase shift rule with the optimal parameter selection, arXiv:2309.07655 (2023).