Tensor Networks for Quantum Simulation and Quantum Software

UCL Lead department: London Centre for nanotechnology

Lead Supervisor: Prof Andrew G Green

Project Summary: Tensor networks provide some of the most efficient algorithms for classical simulation of many-body quantum systems[1]. Their algebraic structure also permits them to be used for a range of classical computational tasks such as machine learning[2] and computational fluid dynamics [3]. One of the most interesting properties for tensor network methods is the ease with which they can be transferred to quantum computers [4,5,6,7]. This project will combine the development of new algorithms for both classical and quantum tasks and where possible, run these algorithms on state of the art quantum computers.

I can offer projects in this general area tailored the interests of the PhD student. These range from analytical and numerical investigations of fundamental aspects of many-body quantum dynamics (with an eye to implementing the insights obtained in future classical and quantum algorithms) to the direct implementation of algorithms to run on current quantum computers.

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arXiv:1605.05775 (2016).
[3] Gourianov et al Nature Comp Sci 2, 30-37 (2022)
[4] Huggins et al “Towards quantum machine learning with tensor networks. Quantum Sci.
Technol. 4, 024001 (2019).
[5] Barratt et al. “Parallel quantum simulation of large systems on small NISQ computers”
npj Quantum Information 7, 1–7 (2021).
[6] Lin et al “Real- and imaginary-time evolution with compressed quantum circuits”. PRX
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[7] Dborin et al “Simulating groundstate and dynamical quantum phase transitions on a
superconducting quantum computer”, Nat Comms. 13, 5977 (2022)