Quantum Speed Limits in Shortcuts to Adiabaticity

The story of quantum speed limits begins in 1945 when Mandelstam and Tamm first showed that the quantum mechanical state of a system (i.e. its wavefunction) cannot change arbitrarily fast in time [1]. In fact, the time taken to evolve in "state space" is bounded by a term which is inversely proportional to the variance of the Hamiltonian.

However it was later realised that in practice, this does not always give a very useful bound on the evolution time. The next big milestone came in 1998, when Margolus and Levitin proved a different bound which is inversely proportional to the expectation value of the Hamiltonian (i.e. the average energy).

Since then, there has been a plethora of work on the generalisation, application and consequences of quantum speed limits [3]. These limits are of particular significance to the area of Shortcuts to Adiabaticity (STA) [4].

The term Shortcuts to Adiabaticity describes a variety of methods, typically analytical, which are all intended to achieve the same outcome as quantum adiabatic processes in significantly shorter times. Using STA methods one can derive alternative processes which work for much shorter times with perfect fidelity i.e. without final excitations.

The goal of the project is to investigate the trade off between speed and energetic cost of implementing STA protocols in several example systems. This will mainly consist of analytical calculations and possibly some numerical work.

[1] Mandelstam L and Tamm I 1945 J. Phys. 9 249

[2] Margolus N and Levitin L B 1998 Physica D 120 188

[3] Deffner S and Campbell S 2017 J. Phys. A: Math. Theor. 50 453001

[4] Guéry-Odelin D, Ruschhaupt A, Kiely A, Torrontegui E, Martínez-Garaot S, and Muga J G 2019 Rev. Mod. Phys