Approximate counter-diabatic driving protocols for non-integrable quantum systems

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Student's statement providing the context of the contribution

Quantum computers can provide substantial advantage over classical computers in certain tasks like large integer factorization. The "quantum supremacy" is largely due to the quantum algorithms which use bizarre world of quantum physics to their advantage. Many of these algorithms are dependent on adiabatic processes. For example, quantum adiabatic dynamics can be used for solving satisfiability problem [1], quantum search algorithms[2] and holonomic quantum computation [3].

However, quantum adiabatic theorem imposes restriction due to which systems have to be driven sufficiently slow. This makes it difficult to protect their feeble coherence from noise and decoherence caused by the environment.

Counter-diabatic (CD) driving protocols, which are also known as "shortcuts-to-adiabaticity," provide powerful alternatives for controlling a quantum system, doing quantum state transfer and helping in building scalable quantum computers. Within this field of CD driving protocol, there is a problem of zero denominator [4] which prevents us from constructing CD Hamiltonian for non-integrable quantum systems (which are also called quantum chaotic systems). The reason behind this is their exponential sensitivity to perturbations of the Hamiltonian. This makes the quantum control of such systems extremely difficult.

Our approximate CD protocols for these systems avoids this problem. Further, our method has a potential of being used as a diagnostic tool for differentiating between quantum integrable and non-integrable systems. Compared to the conventional method, which uses statistics of nearest neighbor energy spacing distribution, our method should work without worrying about identifying the symmetries of the Hamiltonian.

[1] https://arxiv.org/abs/quant-ph/0001106.

[2]https://arxiv.org/abs/quant-ph/0107015.

[3]Phys. Lett. A 264, 94–99 (1999).

[4]Physics Reports 697 (2017): 1-87.