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# Quantum Frequential Computing: a quadratic run time advantage for all algorithms

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Quantum control is the research field focused on designing control fields that manipulate quantum systems. In traditional approaches, these control fields are treated classically. Quantum computers are a notable example where quantum control is employed to implement quantum logic gates. In this work, we explore quantum-quantum control, where both the system to be controlled and the controlling field are quantum. We prove that non-classical states of the control field are required to achieve the maximum speed at which sequential gates can be applied. Additionally, we show that the optimal rate is quadratically faster (for the same power and interaction strength) compared to what is possible in an optimal semi-classical control scenario. Quantum computers are currently projected to not provide a real-world quantum advantage for algorithms with quadratic or cubic speedups due to very slow gate speeds, at least for the next 30 years. This work opens up the possibility of drastically improving gate speeds without increasing power consumption, energy dissipation, or the required interaction strengths.

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