Filter Functions for Quantum Processes under Correlated Noise

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While the quantum operations formalism provides a natural framework for describing the concatenation of quantum processes, it is of limited use when describing the effect of non-Markovian noise. In my talk I will address this issue with an extension of the filter-function formalism, which so far has mostly been used to model gate fidelities and the effects of dynamical decoupling sequences. Our extension allows the efficient, perturbative calculation of full quantum processes in the presence of correlated noise, e.g., the $1/f$-like noise found in many solid-state qubit systems [1, 2]. I will then show that a simple composition rule arises for the filter functions of gate sequences. This enables the investigation of quantum algorithms in the presence of correlated noise with moderate computational resources. Moreover, it allows for singling out correlation terms between different gates in a sequence, capturing for instance the dynamical error suppression of spin echos (Figure 1). Lastly, I present a fast and easy-to-use open-source software framework [3] which facilitates the calculation of quantum processes and fidelities for arbitrary system dimensions using filter functions. Other features include the efficient concatenation of several operations, an optimized treatment of periodic Hamiltonians, as well as integration with qopt, a software package for quantum robust control [4, 5].

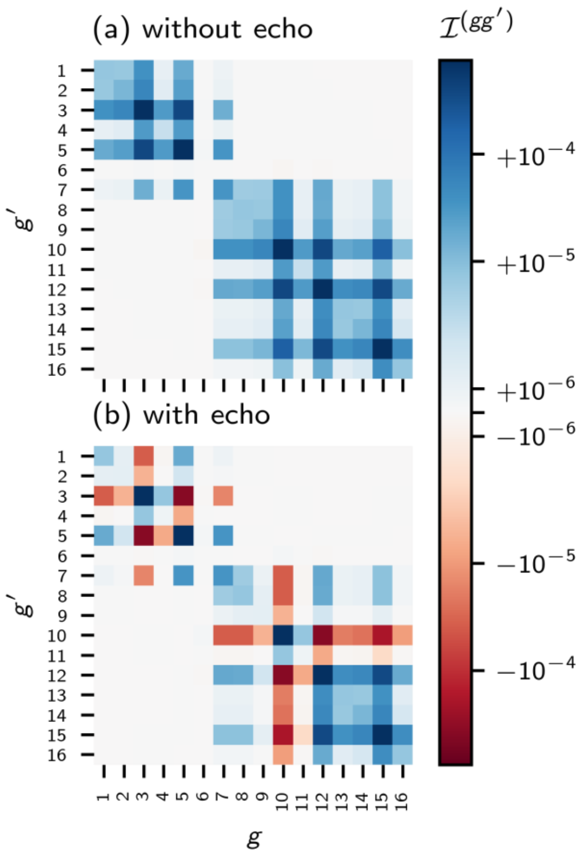

Figure 1: 'Pulse correlation infidelities' between pairs of gates executed at positions g and g' in a four-qubit Quantum Fourier Transform circuit for $1/f$ noise, once without (a) and with (b) interleaved echo pulses. The echos' effect manifests itself in negative correlation infidelity contributions, leading to a reduced overall infidelity.

References

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[3] github.com/qutech/filter_functions
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