Higher-order quantum operations of blackbox unitaries

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Abstract: Supermaps are higher-order transformations taking maps as input. Quantum mechanically implementable supermaps are called quantum supermaps and their general properties are formulated by the framework of quantum networks and quantum combs proposed by Chiribella et al. We consider the implementability of supermaps in quantum mechanics when the input maps are unitaries given as blackboxes and the unitary blackboxes can be used multiple but finite times to explore fundamental quantum properties exhibited in higher-order transformations possibly utilized for quantum computation. We regard such direct implementations of supermaps for blackbox quantum operations with multiple uses of the blackboxes as "higher-order quantum operations". We investigate how the causal structure and spacetime symmetry of these unitary blackboxes affects their performance in implementing higher-order quantum operations. We analyze two tasks, inversion of blackbox unitaries and controllization of divisible blackbox unitaries based on controllization of quantum combs.