Causal Process Tomography of a Fiber-Based Quantum SWITCH

Michael Antesberger[*1], **Lee Rozema**[1], **Philip Walther** [1]
1. Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria

The field of indefinite causal order in quantum mechanics has seen more and more interest in the past years, both theoretically [1] and experimentally [2]. In such processes, different parties act in a superposition of different orders. Since the first experimental realization of a process with an indefinite causal order, the quantum SWITCH, several protocols taking advantage of this new resource have emerged. In previous experiments, the causal non-separability of two parties has been verified by measuring a so-called 'causal witness' [3]. Nevertheless, the corresponding process matrix has only been evaluated theoretically. Here, we experimentally reconstruct the process matrix of a new passively-stable fiber-based architecture for the quantum SWITCH based on time-bin encoded qubits, which can readily be scaled to more parties. We perform a full characterization of this new type of quantum SWITCH by implementing causal process tomography for the first time. We then compare the tomography results to those obtained by directly measuring several different causal witnesses. Finally, we present the first measurement of the fidelity of our experimental quantum SWITCH to the ideal quantum SWITCH.

References

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[*]Corresponding author: michael.antesberger@univie.ac.at