Broadcast-based nonlocality activation for noisy quantum states

Luis Villegas-Aguilar[a], K. Laverick[b], S. Slussarenko[a], N. Tischler[a], E. Cavalcanti[b] and G. J. Pryde[a]

[a]*Centre for Quantum Dynamics and Centre for Quantum Computation and Communication Technology, Griffith University, Brisbane, Queensland 4111, Australia.*

[b]*Centre for Quantum Dynamics, Griffith University, Gold Coast, Queensland 4222, Australia.*

Bell nonlocality has been shown to be a paramount resource for a number of quantum communication protocols [1]. However, entanglement alone is not enough to show Bell nonlocal correlations, since there exist certain mixed entangled states that admit a local hidden-variable model [2]. Nevertheless, some quantum states that are incapable of exhibiting nonclassical behaviour in the standard Bell scenario can have their nonlocality revealed by subjecting them to a more complex measurement procedure. This phenomenon is now known as nonlocality activation, and it typically involves a large resource overhead in the form of multiple copies of the state and the need for joint measurements [3].

The objective of this work is to experimentally demonstrate single-copy nonlocality activation for the two-qubit Werner [2] state, using only local measurements and a quantum broadcasting channel (see Figure 1.a). We have built a source of high-quality optical Werner states with average fidelities of 0.9958, which also allows full tunability of the amount of noise present in the system (see Figure 1.b).

In the final phase of this ongoing experiment, nonlocality activation will be achieved by broadcasting half of the original state to two additional parties in a network structure [4]. This operation will be implemented via an optical controlled-NOT gate plus local unitary operations, after which we will perform a three-party Bell test tailored to the broadcast scenario. This experiment enables loss-tolerant Bell nonlocality tests, and represents an important step towards understanding the relationship between entanglement and nonlocality, all within the context of quantum networks.

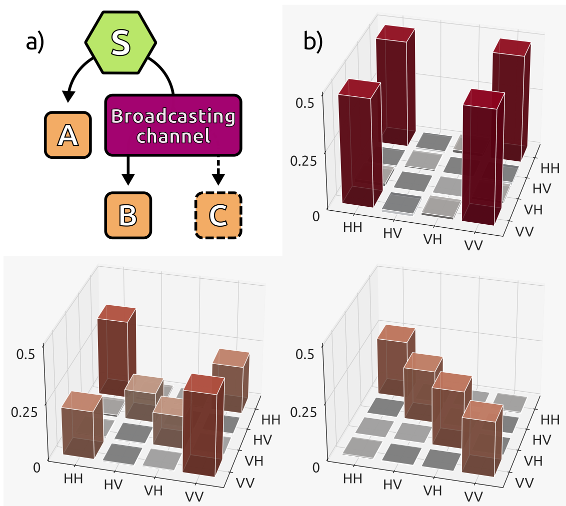

Figure 1: **a)** Causal structure for the broadcast scenario. **b)** Real part of the reconstructed density matrix of the Werner state for three different experimental conditions: maximally entangled, half-mixed and fully mixed.

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