Teleportation Simulation of non-Pauli Channels[1]

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I. EXTENDED ABSTRACT

Teleportation[2] is one of the most captivating ideas of quantum information. It exploits the resource of quantum entanglement to allow us to perfectly transfer a state from one system to another, using only **L**ocal **O**perations and **C**lassical **C**ommunication (LOCC). We can interpret this protocol as the simulation of a noiseless quantum channel or transfer operator, and ask if we can alter the protocol to simulate other, noisy channels.

To begin with, we review the motivation behind simulating quantum channels using pre-shared entanglement, and (arbitary) LOCCs. In fact, this simulation allows one to upper bound the ultimate, two-way capacities for quantum communication, entanglement distribution, and secret key generation by just computing the **R**elative **E**ntropy of **E**ntanglement (REE) of the resource state. This work was done by Stefano Pirandola, Riccardo Laurenza, Carlo Ottaviani and Leonardo Banchi in Ref. [3].

Then, we look at the simplest generalization of the teleportation simulation argument of Ref. [4], which was based on the perfect use of Pauli corrections, and therefore limited to the simulation of Pauli channels, as proven in Ref. [5]. In fact, we show how we may generalize this idea much further by replacing the hitherto assumed perfect classical communication of Alice by a noisy classical channel, so that the Pauli corrections are stochastically implemented. In this stochastic version of teleportation, we may simulate a much more general class of quantum channels, and for qubits we also provide an explicit formula for the channel simulated, given a resource state and noisy classical channel.

Furthermore, we characterise all possible channels simulatable using the Choi Matrix of an amplitude damping channel and a noisy classical channel. In particular, this approach allows us to define a new class of quantum channels that we call "Pauli-damping" channels, because of the peculiar decomposition into a Pauli and a damping part. For this class, we compute their minimum trace-norm and diamond-norm distance from the set of Pauli channels. Most importantly, we show a single-letter REE-based upper bound for their two-way quantum and secret-key capacities.

Finally, we conclude with an explanation of the logical next steps which this work will take, along with some intuitive ideas about what we may find.

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