Finite-resource teleportation stretching for continuous-variable systems [1]

Riccardo Laurenza, Samuel L. Braunstein, and Stefano Pirandola
Computer Science and York Centre for Quantum Technologies,
University of York, York YO10 5GH, United Kingdom

We investigate the recently developed teleportation stretching technique [2] in the scenario of continuous variable systems assuming that the resource of entanglement for teleportation is a bipartite state with a finite amount of energy. Relying on this, we are then able to derive novel upper bounds on the secret key capacity of phase-insensitive Gaussian channels

The main technique was introduced as a tool to establish the ultimate limits of quantum and private communications determining the secret-key capacity for a wide class of qubit and bosonic channels (see also the extension to multipoint users [4], networks [5] and adaptive parameter estimation [6]). In particular, it completely characterizes the fundamental rate-loss scaling of any repeaterless quantum communication and optical implementation of quantum key distribution. In fact, by optimizing over the most general protocols for key generation over a lossy channel with transmissivity η, Ref. [2] determine its secret-key capacity to be $K(\eta) = -\log_2(1-\eta)$, which is about 1.44η secret bits per channel use at long distances ($\eta \simeq 0$).

In the original approach, the teleportation stretching, which reduces any adaptive (feedback-assisted) quantum protocol over an arbitrary channel into a much simpler block version, is combined with the relative entropy of entanglement suitably extended from quantum states to quantum channels.

The root of teleportation stretching finds its origin into the idea of channel simulation, according to which an arbitrary quantum channel is replaced by completely general local operations and classical communications. For bosonic channels the simulation is tipically asymptotic. This means that we must consider a suitable limit over sequences of resource states as it stems from the fact that the Choi matrices of such channels are asymptotic states. Here [1] we consider a different type of simulation for bosonic Gaussian channels, which is based on finite-energy two-mode Gaussian states as recently introduced in Ref. [3]. We use this particular simulation at the core of teleportation stretching in order to simplify adaptive protocols.

Not only this represents an interesting novel design (with potential other applications beyond this work) but also allows us to derive upper bounds for the secret-key capacities of phase-insensitive Gaussian channels which well approximate the asymptotic results established in Ref. [2].

[1] R. Laurenza, S.L. Braunstein, and S.Pirandola, Preprint arXiv:1706.06065 (2017).

[2] S. Pirandola, R. Laurenza, C. Ottaviani, and L. Banchi, Nature Communications **8**, 15043 (2017). See also arXiv:1510.08863 (2015).

[3] P. Liuzzo-Scorpo, A. Mari, V. Giovannetti, and G. Adesso, Preprint arXiv:1705.03017 (2017).

[4] R. Laurenza, and S. Pirandola, Preprint arxiv:1603.07262 (2016).

[5] S. Pirandola, S. *Capacities of repeater-assisted quantum communications*, arXiv:1601.00966 (2016).

[6] S. Pirandola, and C. Lupo, Phys. Rev. Lett. **118**, 100502 (2017).