Multipartite measurement-device independent quantum cryptography: Conferencing and secret sharing [1]

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Today, much of the effort in quantum key distribution (QKD) protocols is devoted in developing solutions to increase the key rate. At the same time, it is desirable to move towards a full end-to-end network scenario. Continuous variable (CV) systems can offer a solution to both these problems: Using bright coherent states and efficient homodyne detection, one can increase the key rate; then, adopting the configuration of measurement-device independent (MDI) QKD, one can make the first step towards the end-to-end principle. For this reason, CV-MDI-QKD protocols [2, 3] are appealing for quantum networks, especially at the metropolitan distances [4].

In this work we extend CV-MDI-QKD to a multipartite symmetric configuration (star network), where N Bobs send N modulated coherent states to an untrusted relay which performs a multipartite Bell detection. The outcomes γ's are broadcast to the parties. The resulting post-relay N-partite state can then be exploited for private communication, with the trusted parties extracting N keys, that are used to distill a single conference key.

In the fully symmetric configuration the parties are equidistant from the relay and the action of the eavesdropper (Eve) is described by a memory-less thermal channel. The performances of the scheme are quantified in terms of achievable key-rate and distances for fixed number of parties. We perform the security analysis in the entanglement-based representation. Using the Devetak-Winter security criterion, we bound Eve's information by the Holevo function

$$\chi = 2h(\nu) - h(\nu_N), \tag{1}$$

where $\nu = [\mu\,[\eta + \omega\mu(1-\eta)]\,/\,(\eta\mu + (1-\eta)\omega)]$,

$$h(x) = \frac{x+1}{2}\log_2\frac{x+1}{2} - \frac{x-1}{2}\log_2\frac{x-1}{2}, \tag{2}$$

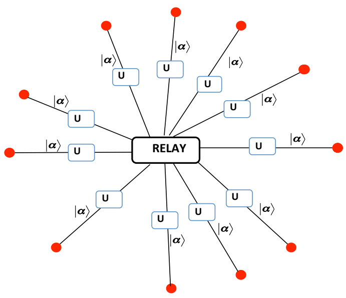
and ν_N is a symplectic eigenvalue depending on the number of users N.

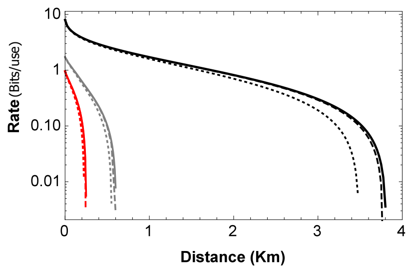
From the post-relay CM $\mathbf{V}_{i|\gamma}$, associated with the ith Bob, and from the conditional CM $\mathbf{V}_{i|\gamma\beta_j}$, after heterodyne detection by jth, we obtain the mutual information between two arbitrary Bobs $I_{B_iB_j} = \frac{1}{2}\log\Sigma$, where Σ depends on $\mathbf{V}_{i|\gamma}$ and $\mathbf{V}_{i|\gamma\beta_j}$. We finally get key conference key rate

$$R = \frac{1}{2}\log\Sigma - 2h(\nu) + h(\nu_N). \tag{3}$$

The figure shows the optimal rate for $N = 2$ (black), 10 (gray), 100 (red) users, assuming no thermal noise (solid lines), 0.01 thermal noise (dashed lines), and 0.1 thermal noise (dotted lines).

In summary we found that high-rate quantum conference-key-agreement is possible over distances between hundreds of meters and a few kilometers, with a large number of users.





[1] C. Ottaviani, C. Lupo, S. Pirandola, *in preparation.*
[2] S. Pirandola *et al.,* Nature Photon. **9**, 397 (2015).
[3] C. Ottaviani *et al.,* Phys. Rev. A **91**, 022320 (2015).
[4] Pirandola S. *et. al.*, Nature Photonics **9**, 773 (2015).