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Project acronym: **Q-ESSENCE**

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# DELIVERABLE REPORT

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| Deliverable no.: | **D2.3.1** |
| Deliverable name: | **Proposal for deterministic entangled "digital" continuous variable QM states** |
| Workpackage no. | **WP2.3** |
| Lead beneficiary | **UCPH** |
| Nature | **R = Report** |
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There are a variety of quantum information protocols for both continuous and discrete variables. Both of these approaches have their own advantages and disadvantages depending on the task at hand. The high efficiency of homodyne detectors has enabled unconditional teleportation of light for CV systems. However for some protocols, e.g., quantum computation, it is desirable to have “digital states”, where a system is in a superposition of only two different states forming a qubit. Such digital states may be realised for continuous variables by using superpositions of two coherent states $|\alpha\rangle$ and $|-\alpha\rangle$. While these states can be processed by continuous variable techniques, certain operations such as the generation of superpositions of the states are hard to perform. UCPH has developed a hybrid continuous-discrete variable protocol for quantum communication based on these digital continuous variable states. In essence, the protocol exploits the distinct advantages of the discrete and continuous variables: non-local entanglement is generated in a manner, which is robust to transmission losses, by conditioning on the detection of a photon, whereas the subsequent local processing of the entanglement is achieved by efficient homodyne detection. For long distance quantum communication a deterministic entanglement swapping procedure for digital continuous variable states is developed, which only uses linear optical elements. The combination of efficient homodyne detection for deterministic entanglement swapping provides an interesting first demonstration for the potential benefits in combining discrete and CV approaches for quantum repeater architectures and protocols.

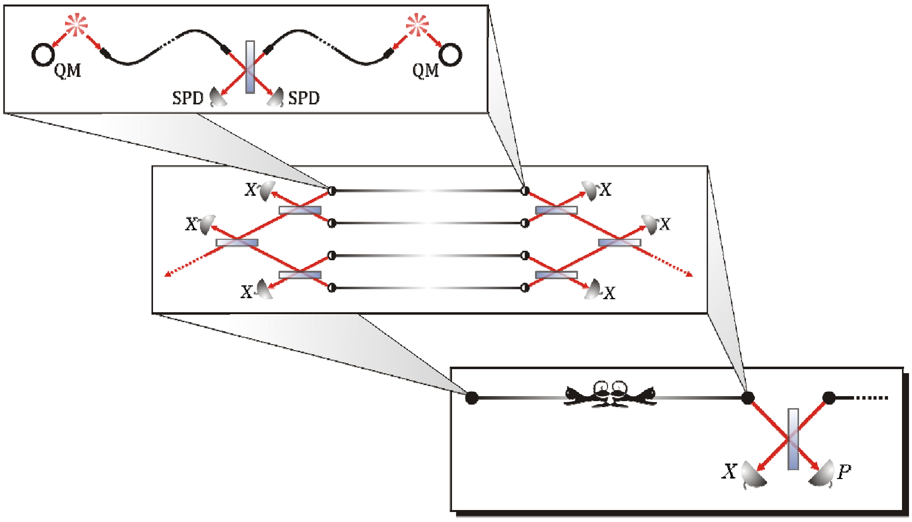


*Figure 7: Elements of the repeater protocol. Discrete variable entanglement is first generated non-locally by conditioning on the detection of a photon. This entanglement is then grown using homodyne detection into large “digital” continuous variable states, also know as “cat-states”. Finally entanglement swapping between the cat states is performed by homodyne measurement.*

**References:**

[BRP1-10] Jonatan B. Brask, Ioannes Rigas, Eugene S. Polzik, Ulrik L. Andersen, and Anders S. Sørensen, *A Hybrid Long-Distance Entanglement Distribution Protocol,* Phys. *Rev. Lett.* ***105****, 160501 (2010)*.