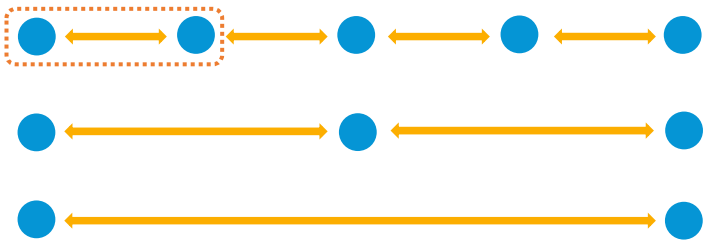
ANALYSING THE EFFECT OF ASYMMETRY ON THE PERFORMANCE OF ATOMIC ENSEMBLES BASED REPEATER PROTOCOLS

Hana Jirovská (h.jirovska@student.tudelft.nl), David Maier, Stephanie Wehner

QuTech

TUDelft

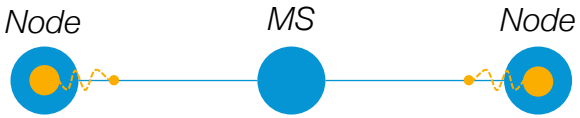
Quantum Repeater Protocols



- Two nodes can exchange quantum information by sharing entanglement over elementary link
- Figure of merit used for analysing performance: secret key rate which takes into account quality of created state and entanglement generation rate

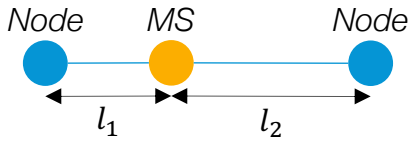
Atomic Ensembles

Generating entanglement:
1. Nodes send a photon to the midpoint station
2. Bell-state measurement is performed



- Probabilistic photon pair sources emit photons and can be described by mean photon pair number μ
- Higher μ increases entanglement generation rate but introduces multi-photon emission errors

Midpoint Asymmetry



$$A = \frac{|l_1 - l_2|}{l_1 + l_2}$$

- Motivation: Existing fibre networks are asymmetric
- Asymmetry can have a significant effect on the optimal parameters [1]
- Probability of photon arriving at MS:

$$p = \mu \cdot 10^{-\alpha L/10}$$

where α is fibre attenuation and L is length

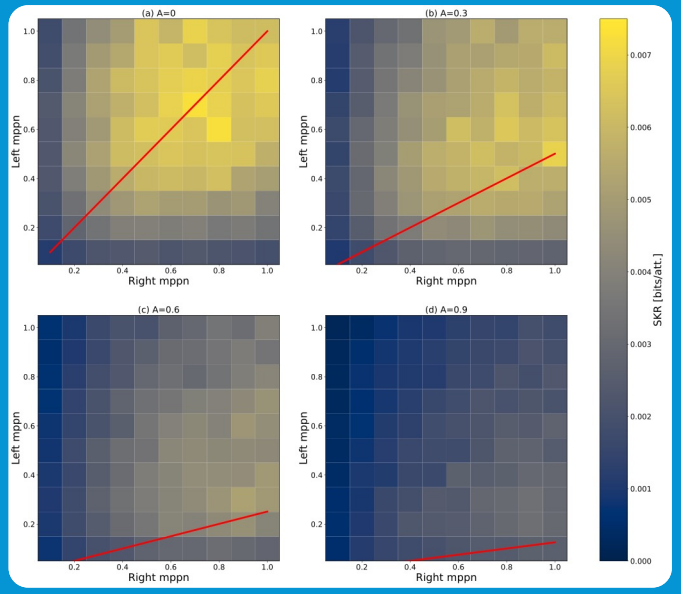
Simulations

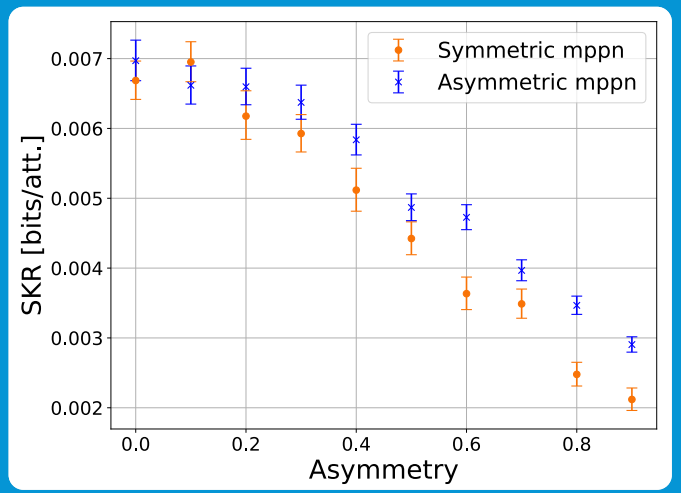
- Motivation: errors from multi-photon emission are hard to treat analytically [2]
- NetSquid [3] is used to simulate all components in the elementary link

Contributions

1. Extension of existing framework for AE simulations to allow for midpoint asymmetry
2. Midpoint asymmetry has significant effect on performance of elementary links
3. Individual optimisation of sources helps to mitigate the effects of asymmetry

Simulation Results





Sources: [1] Avis, Maier, Silva et al., In preparation, 2021. [2] S. Guha et al., "Rate-loss analysis of an efficient quantum repeater architecture", 2015. [3] T. Coopmans et al., "NetSquid, a discrete-event simulation platform for quantum networks", 2020.