Effect of source statistics on utilizing photon entanglement in quantum key distribution

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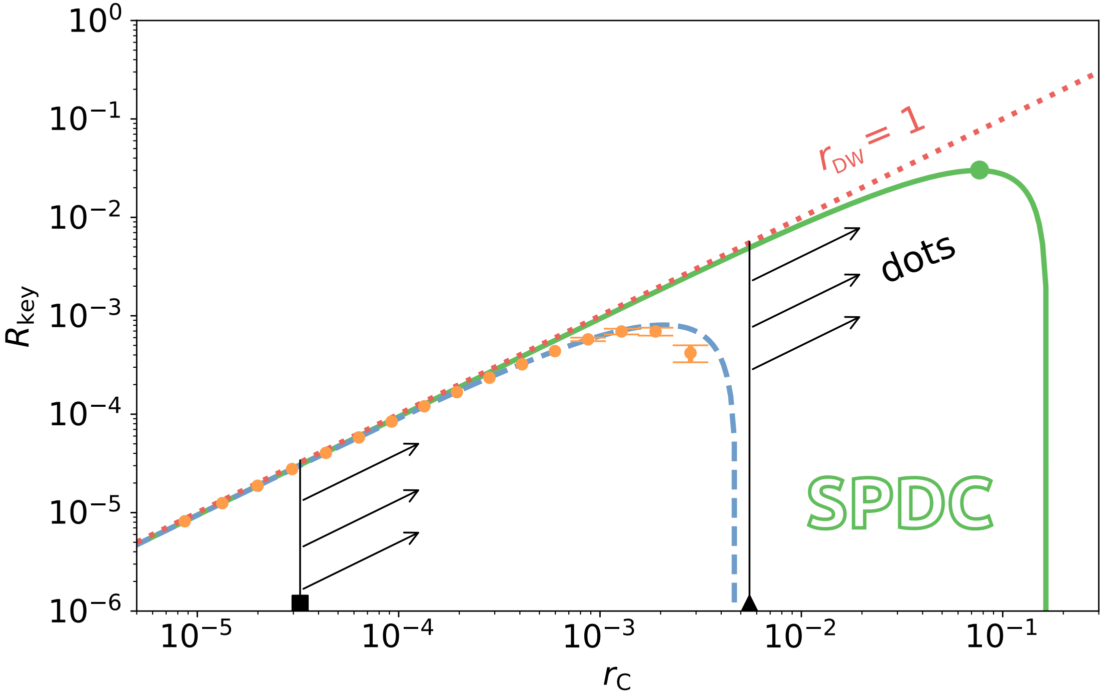
- **The effect of photon-pair generation rate on quantum entanglement is analyzed in the context of device-independent quantum key distribution (QKD).**
- **Comparison of spontaneous parametric down-conversion (SPDC) and quantum dot entanglement sources is made** using reconstructed entangled states.
- **Limits on the secure key rate of down-converted photon pairs,** as well as an optimum gain for SPDC sources **were found.**
- **Predictions were made for performance of quantum dot entanglement sources in QKD** and it is shown that they can surpass SPDC with future advancement of their capabilities.



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Entanglement quality characterization

Standard approaches:

- measurement/witness (Bell inequality)
- tomography and calculation on *density matrix* (concurrence, fidelity, etc.)

We choose an application-oriented approach:

- assess performance of quantum state in a protocol of choice
  - our choice: device-independent QKD (DI-QKD) [1]
- we wish to avoid carrying out the actual protocol, and instead provide a characterization procedure that is easy to carry out, with required data readily available

Our method:

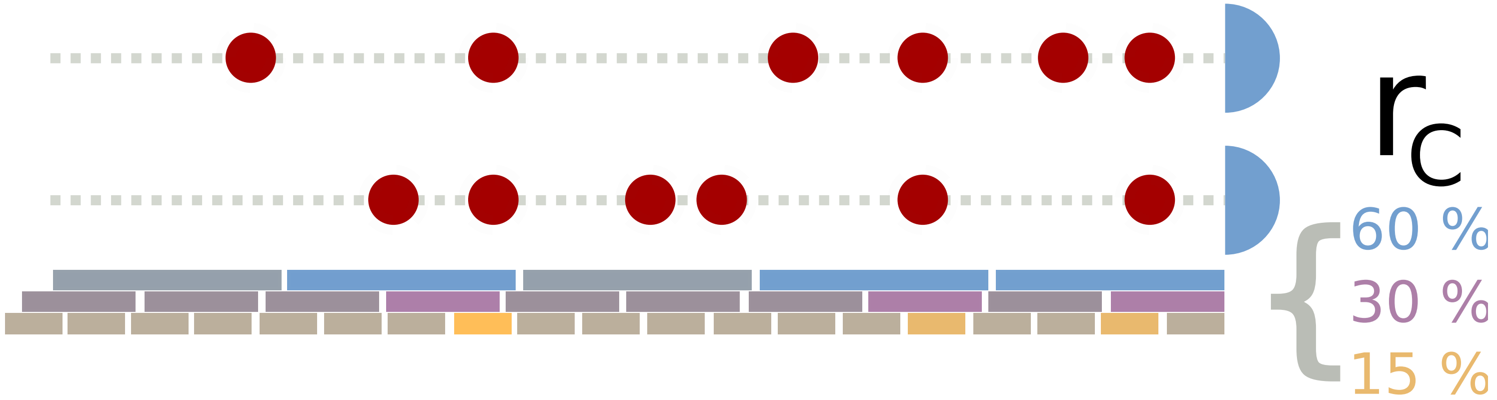
1) obtain a density matrix of an entangled quantum state
2) use the density matrix to calculate QKD secure key rate

[1] A. Acín et al., Phys. Rev. Lett. **98** (2007).

SPDC and its multi-photon nature

SPDC is not a perfect single-pair photon source

- multi-photon nature is more prominent with increasing *gain*
  - analogously to varying gain, varying *coincidence window length* also has the same effect



r_C: coincidence rate

- probability of detecting a coincidence, per coincidence window

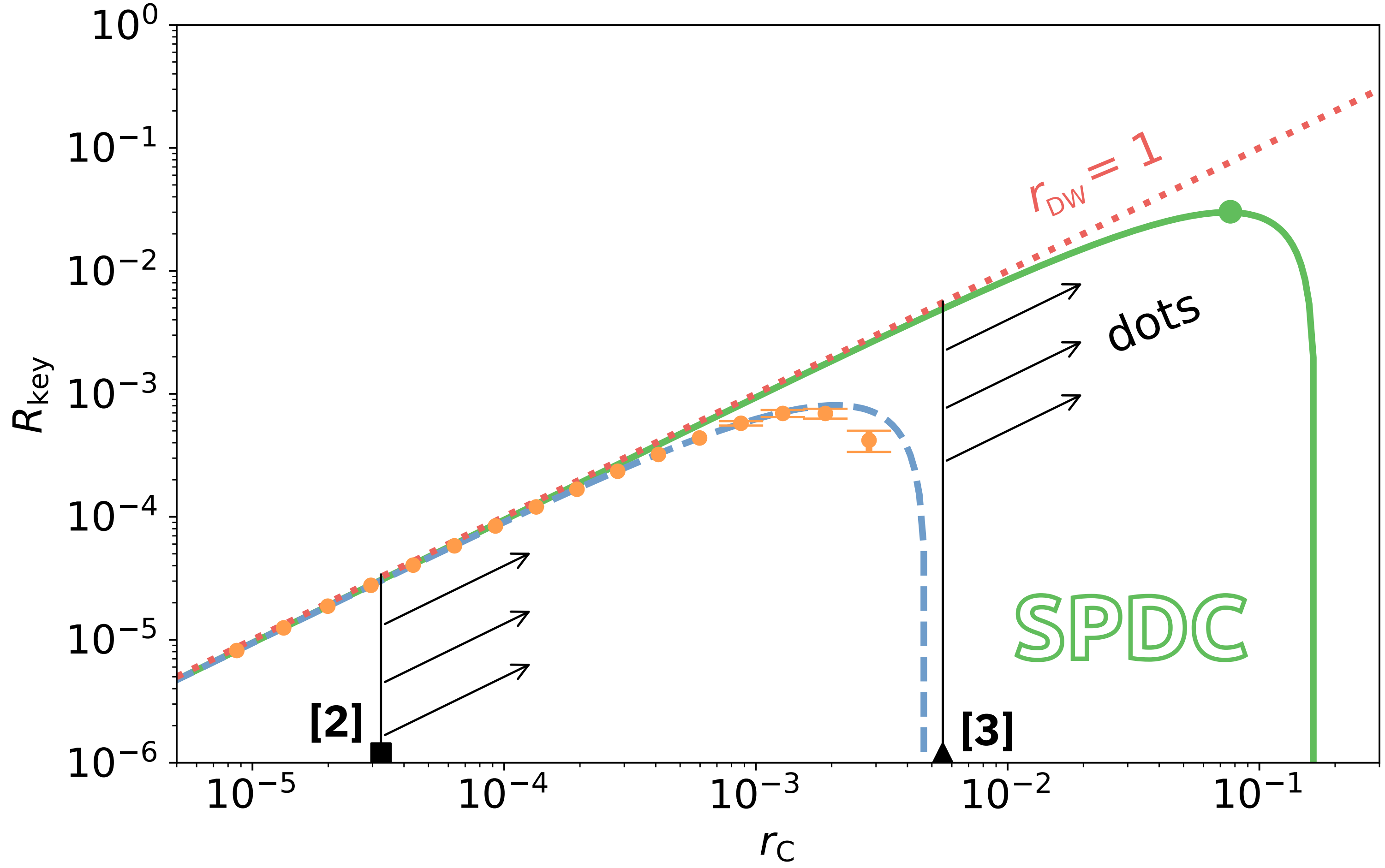
r_{DW}: Devetak-Winter rate

- lower bound on secure key information (bits) we can extract from a quantum state in the QKD protocol

$R_{key} = r_C \times r_{DW}$: key rate

- secure key information extracted per coincidence window

SPDC entanglement quality-quantity trade-off and quantum dot predictions



[2] F. B. Basset et al., Phys. Rev.Lett. 123, 160501 (2019).

[3] H. Wang et al., Phys. Rev. Lett. 122, 113602 (2019).

Want to know more? Get in touch!

Check out the preprint!
R. Hošák et al., arXiv 2008.07501 (2020).

Reach out to us on Twitter:

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Thank you for your attention!