Public discussion in Quantum Cryptography

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Outline

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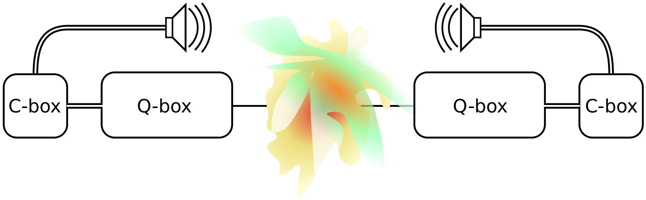
Two phases of quantum key distribution

1. *Quantum* apparatus to generate *classical* data
2. Post-processing of the data, including *public* communication

If the data is found to be good enough, this will lead to a secret key



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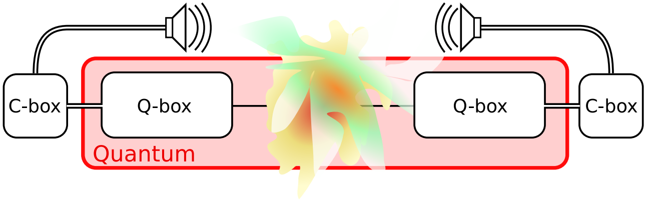

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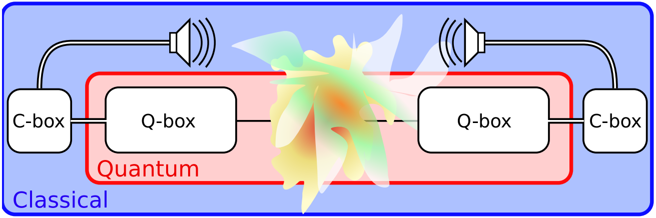
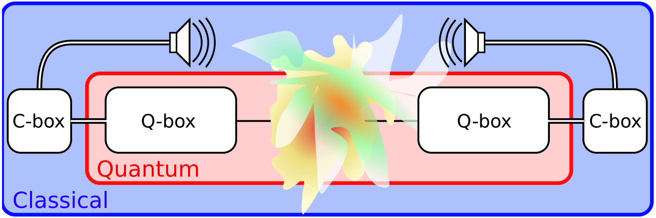


Replacement

- For the analysis, we can replace a box with another box that behaves the same way externally.
- Prepare & Measure $\leftrightarrow$ Entanglement based



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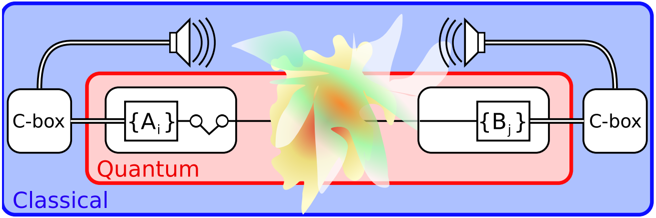

Threshold and upper bound for key rate

- General bound and threshold
  - If you cannot prove entanglement from your data, no secret key (Marcos Curty)
  - Specific attack: Eve splits the state into separable and entangled part
    $\Rightarrow$ Upper bound (Tobias Moroder)
- One way bound and threshold
  - If you cannot rule out a symmetric extension of the state, no secret key from one way communication
  - Eve can split into parts with and without symmetric extension
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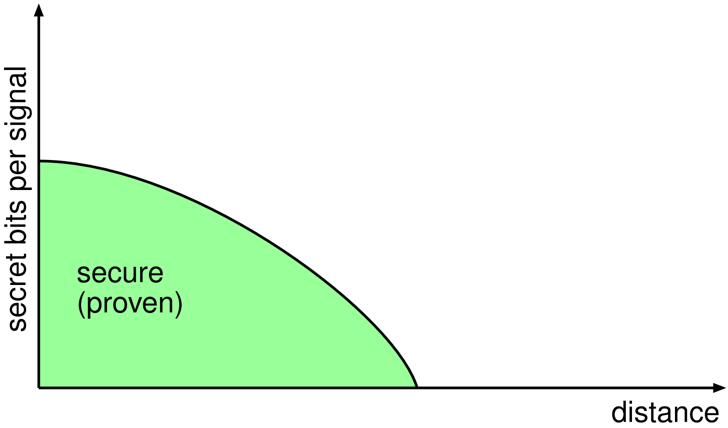

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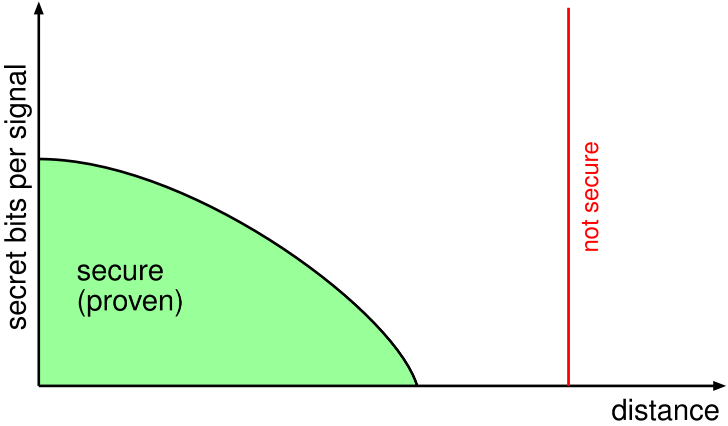

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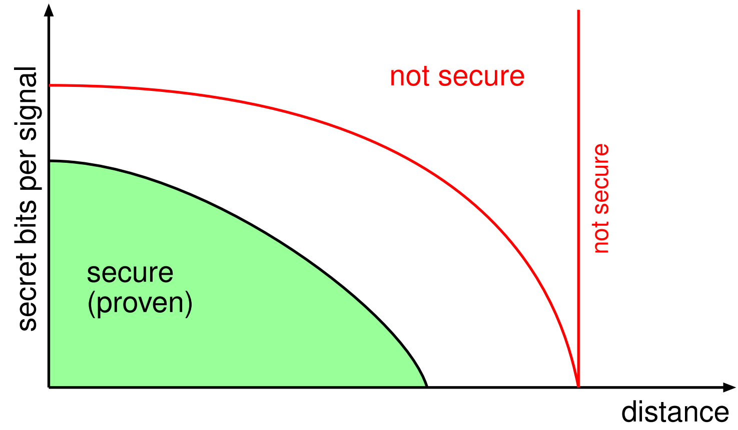

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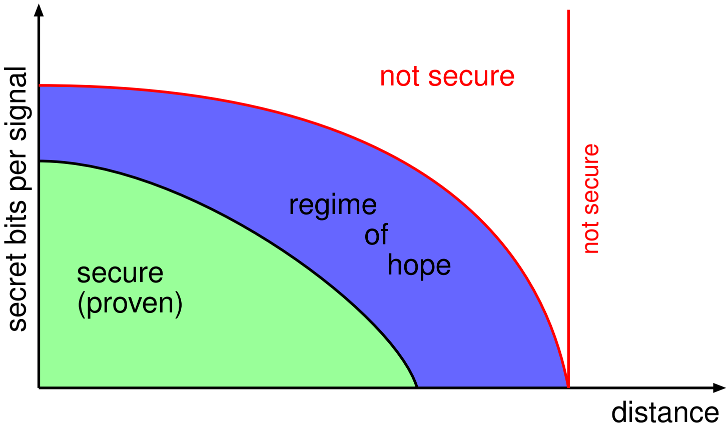

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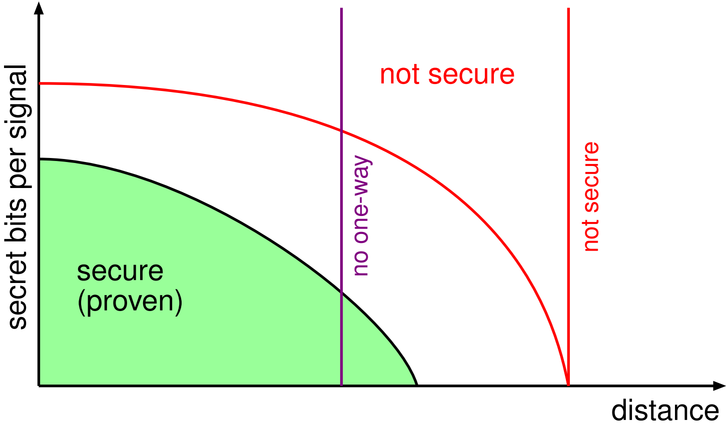

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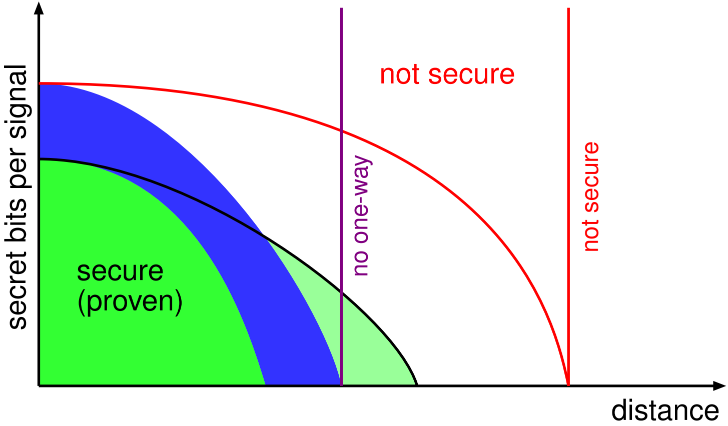

How to get rid of symmetric extensions?

- To get key from states above one-way threshold we have to get rid of the symmetric extension
- If there is a symmetric extension from Bob, he can get rid of it by talking to Alice
- Gottesman-Lo trick (B-step):

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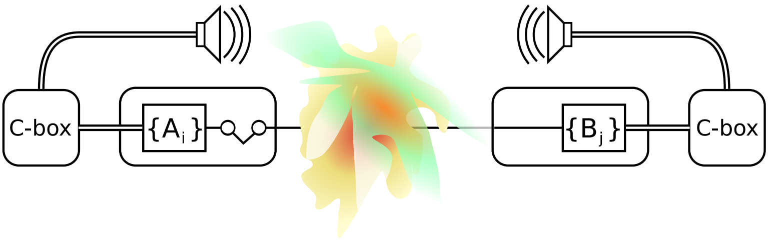
Another replacement

- What really happens: Measure a POVM, announce a function of the result
- Replacement: Do measurement in two steps
  1. An incomplete measurement to measure what is to be announced
     → check entanglement and symmetric extension
  2. Complete the measurement to get a partially secret bit



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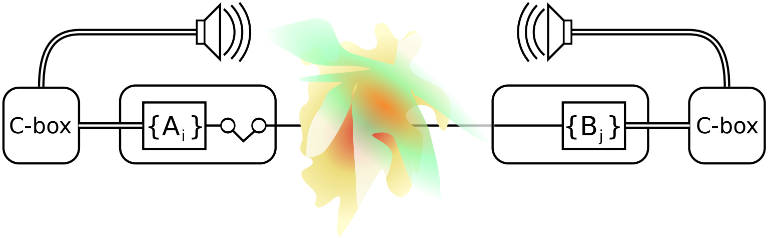

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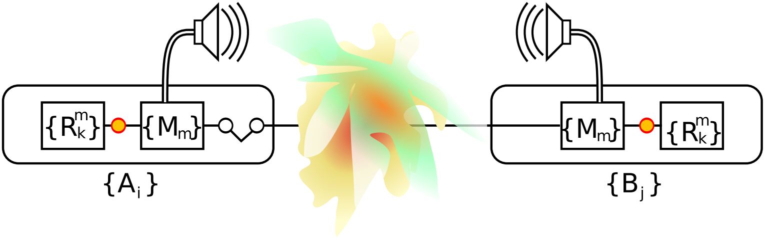

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QKD, thresholds and upper bounds

Announcement measurements

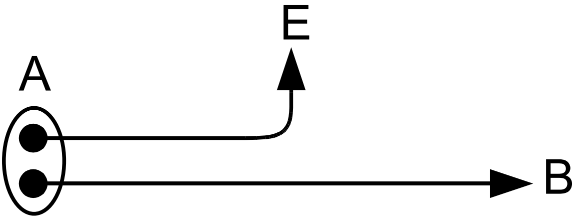
Examples

Wrapping up...

BB84 apparatus – different siftings

- Real POVM elements: $\{|0\rangle\langle 0|, \quad |+\rangle\langle +|, \quad |1\rangle\langle 1|, \quad |-\rangle\langle -|\}$
- BB84-announcement:
  $\{|0\rangle\langle 0| + |1\rangle\langle 1|, \quad |+\rangle\langle +| + |-\rangle\langle -|\} = \{I, I\}$
- SARG-announcement:
  - Alice: $\{|0\rangle\langle 0| + |+\rangle\langle +|, \quad |+\rangle\langle +| + |1\rangle\langle 1|, \quad \ldots\}$
  - Bob (corresponding to Alice's first outcome):
    $\{|1\rangle\langle 1| + |-\rangle\langle -|, \quad |0\rangle\langle 0| + |+\rangle\langle +|\}$

BB84/SARG with two photons



- BB84-announcement:
  $\rho^{\text{out}} = U\sqrt{F}\rho^{\text{in}}\sqrt{F}U^{\dagger} = \frac{1}{2}(|00\rangle\langle 00| + |11\rangle\langle 11|)$
- SARG-announcement:
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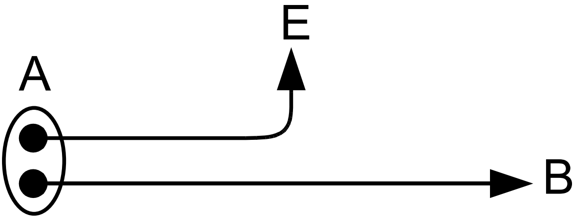

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Chau scheme

Postprocessing scheme with highest known threshold

- Procedure:
  - Take two bits
  - Announce their parity
  - Keep one bit if equal parity for A and B
- Result:
  - Low enough noise: Destroys symmetric extension
  - Higher noise: Keeps symmetric extension, but does not destroy (all) entanglement

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Further complications

- What if we don't know the complete effective state?
- Can find entanglement witnesses to still verify entanglement
- Can restrict those witnesses to those that will witness entanglement *after* a particular announcement

Summary

- By a replacement we can analyze the effective quantum states after announcement
- A useful announcement is one that gets rid of symmetric extension
- We haven't found any new ones yet...