A novel notation for quantum cryptography

Applications to some recent quantum cryptographic protocols and their equivalences

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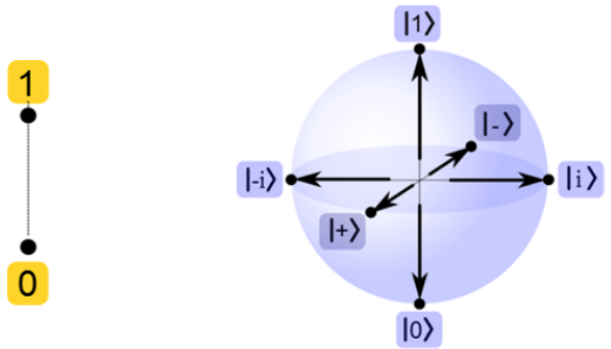
Outline

Introduction

Quantum Information

- The classical bit vs. the qubit

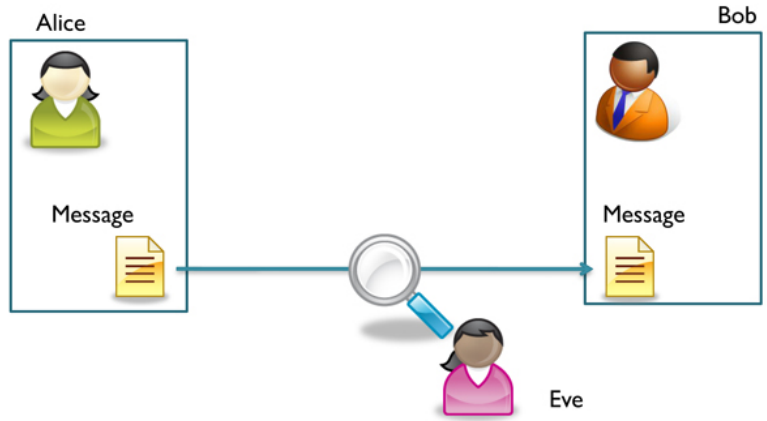


Representation of a classical bit (Left) and a qubit (right) [5].

- Encoding and decoding

Quantum Cryptography

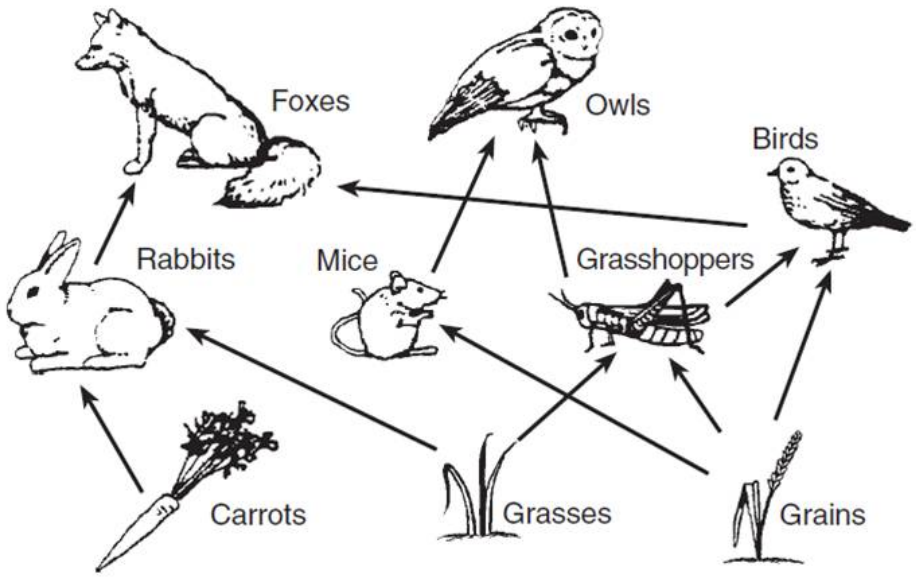
- Quantum cryptographic protocols: Sending a message securely using quantum mechanics



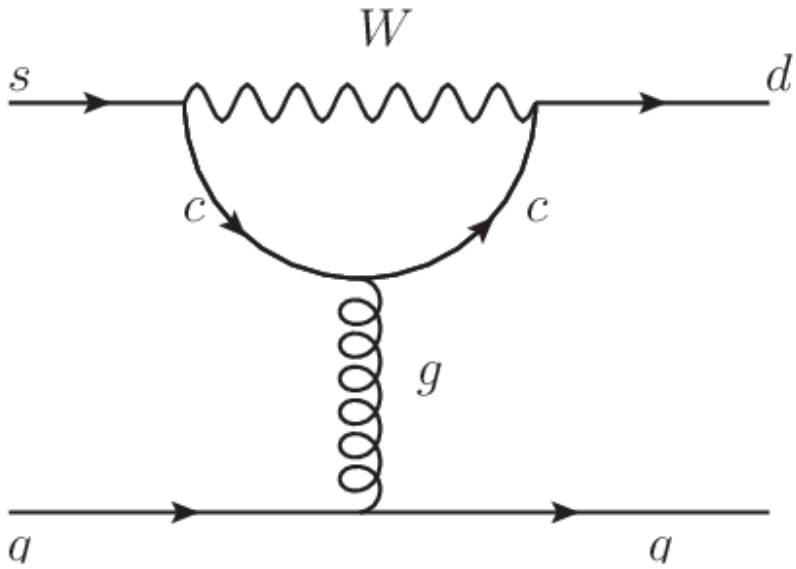
Alice, Bob, and Eve's roles in (quantum) cryptographic protocols [2].

- Dirac notation is not very intuitive

The Diagrammatic Notation



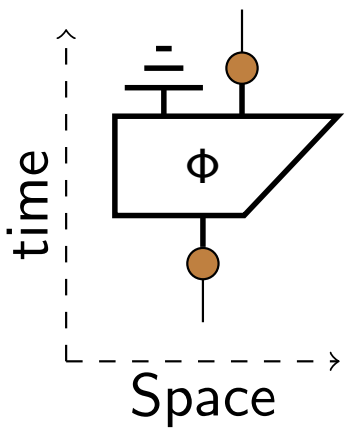
Diagrams in ecology: food webs [3].



Diagrams in particle physics: Feynman diagrams [6].

The Dagrammatic Notation

- Proposed by Coecke and Kissinger in 2017, in *Picturing Quantum Processes* [1].



The Aim

- Taking into account the rising popularity of quantum cryptography and the fact that its current notation is insufficient for describing it intuitively we want to give the diagrammatic method a place in the field of quantum cryptography by...

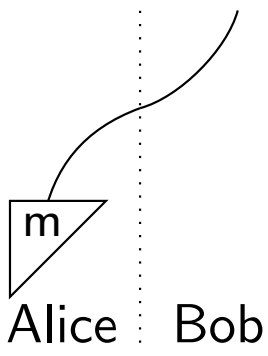
  1. Writing a short handbook-style introduction to this notation for physicists who do not want to read the entire book *Picturing Quantum Processes [1].*

  2. Constructing some recent quantum cryptographic developments and protocols in this new notation.

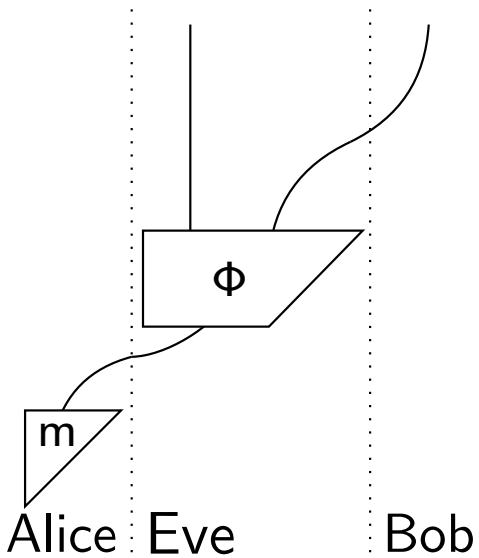
The Classical One Time Pad

The Classical One Time Pad

Ideal situation:



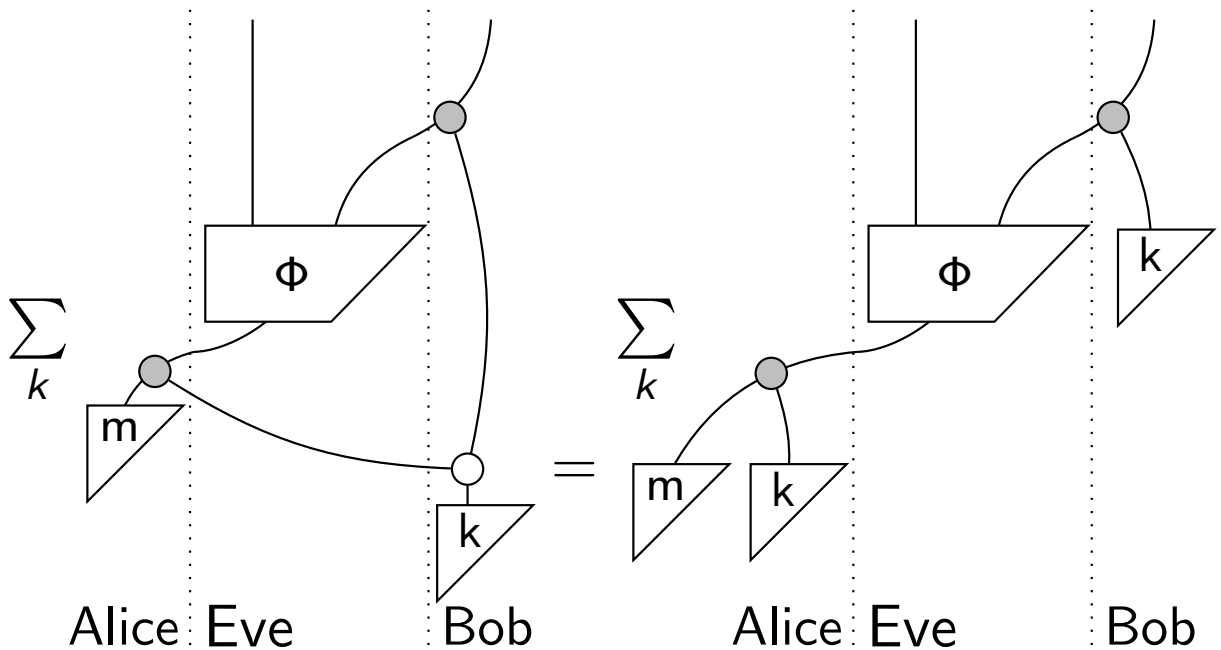
Real situation:



(1)

The Classical One Time Pad

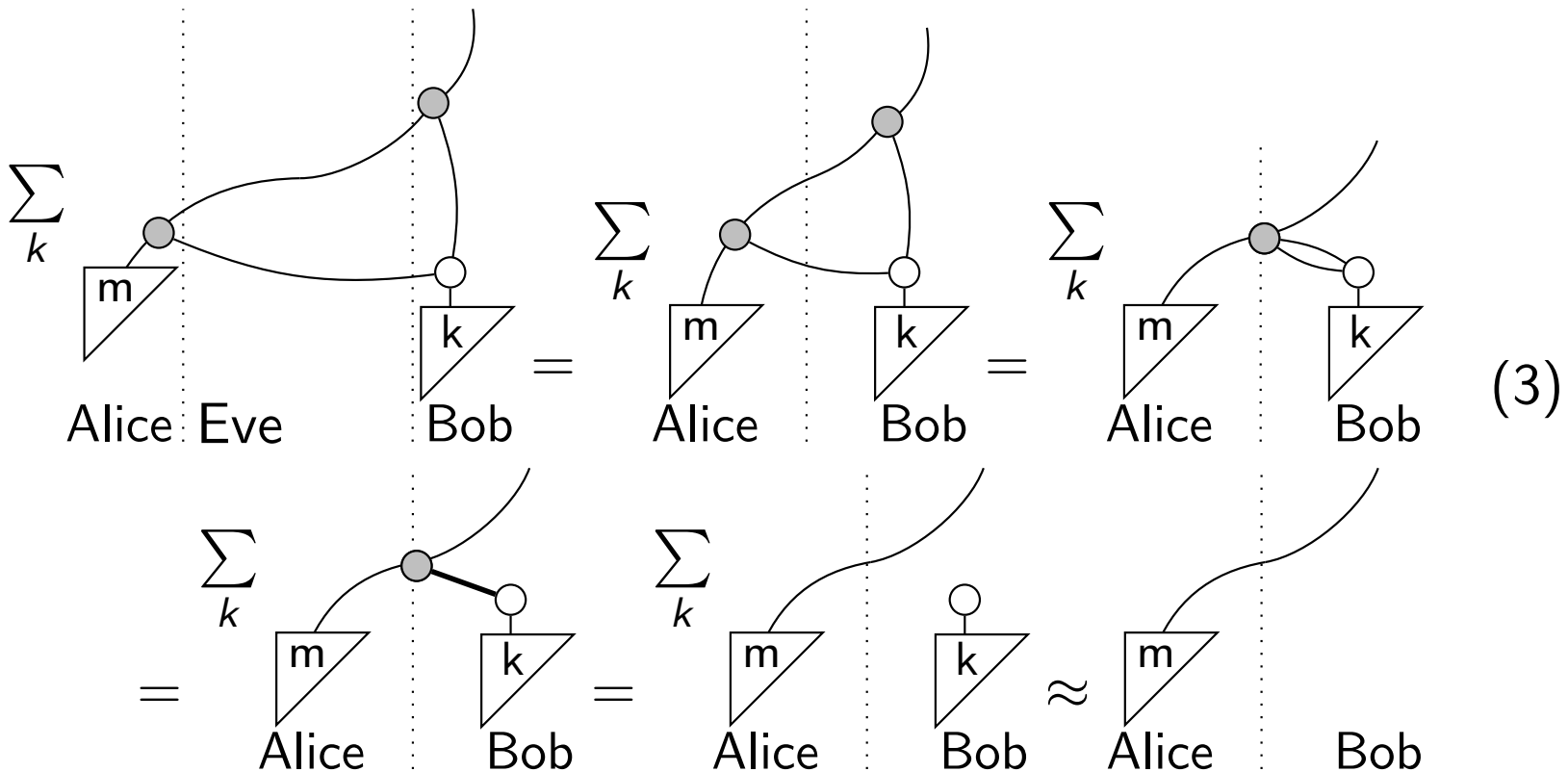
- The One Time Pad solution: xor with secret random variable k



(2)

The Classical One Time Pad

- If Eve does not interfere, communication should be provably correct.



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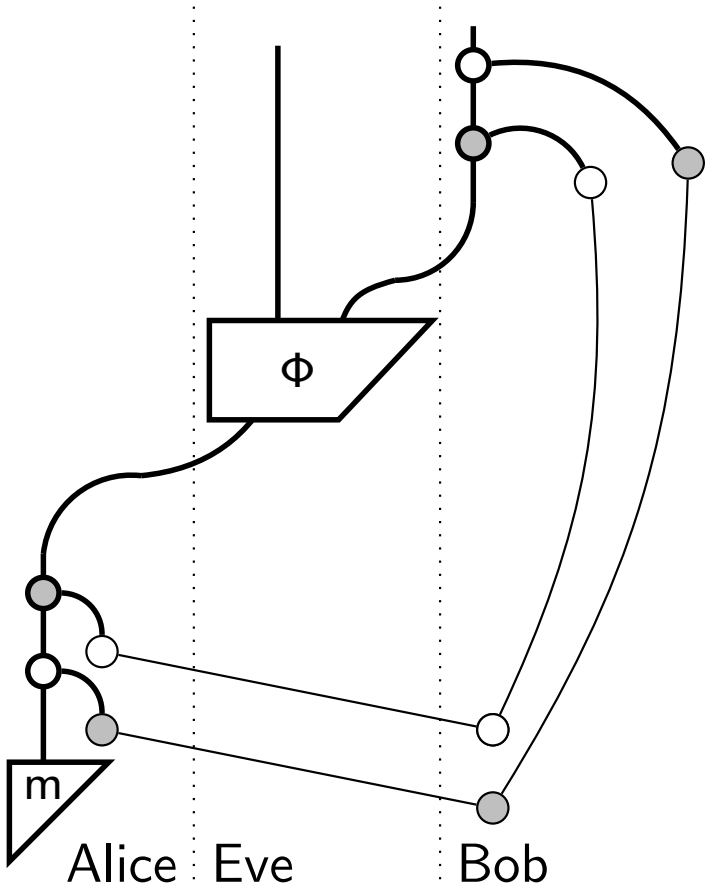

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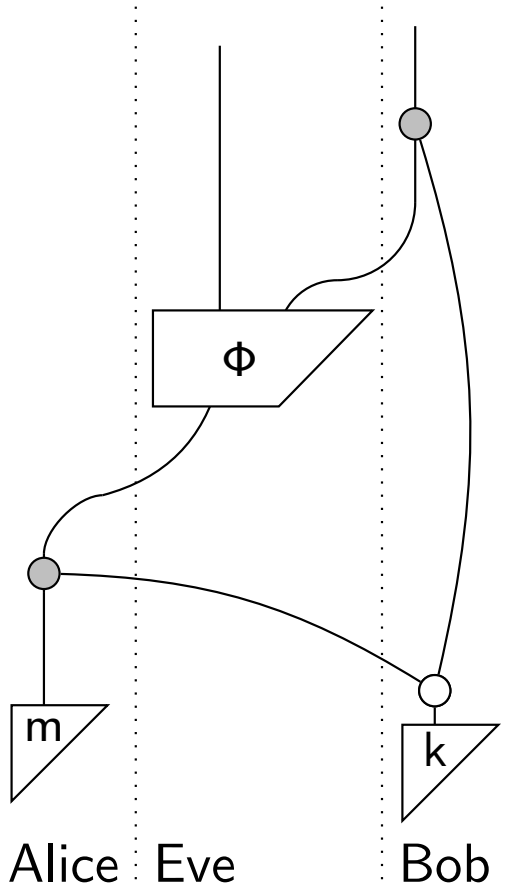

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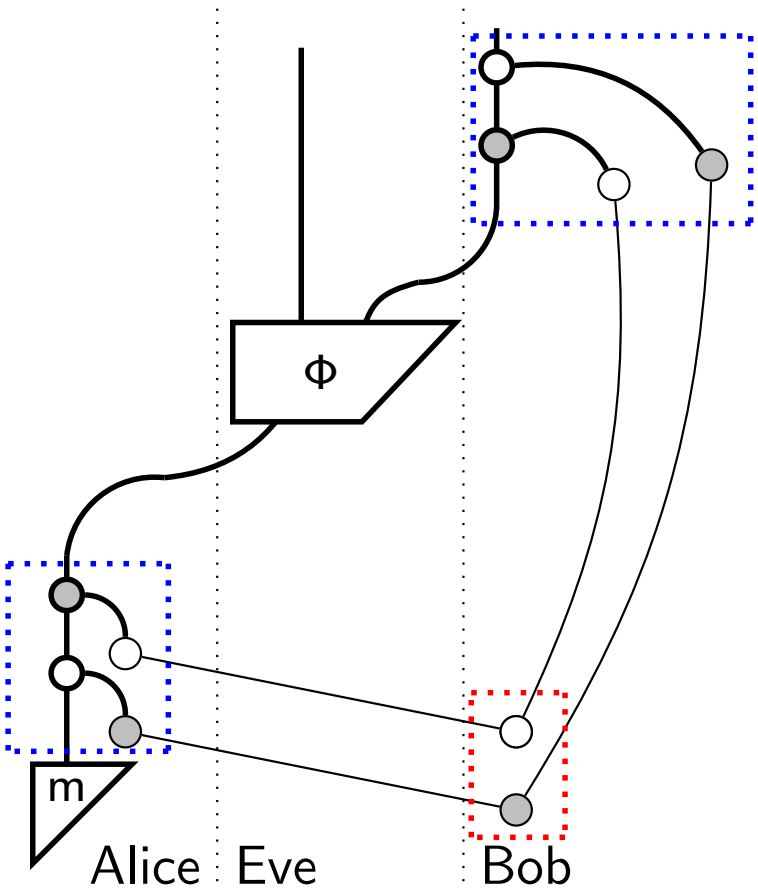

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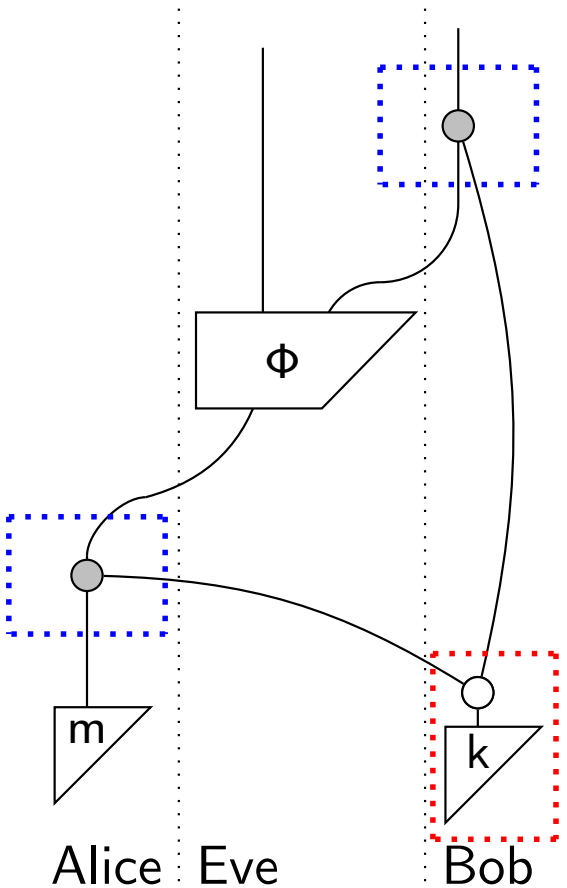

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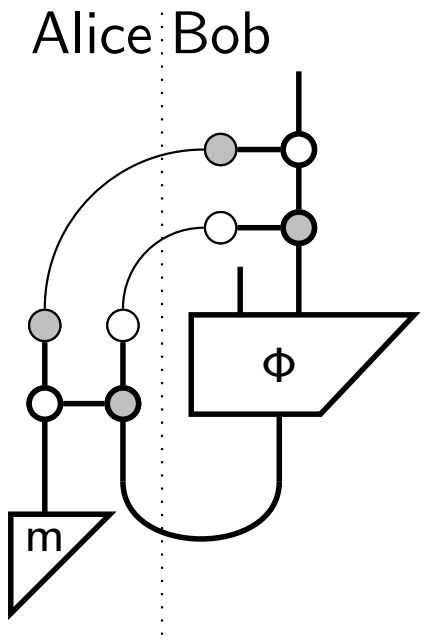
Quantum Teleportation and Quantum One Time Pad Equivalence

Quantum Teleportation



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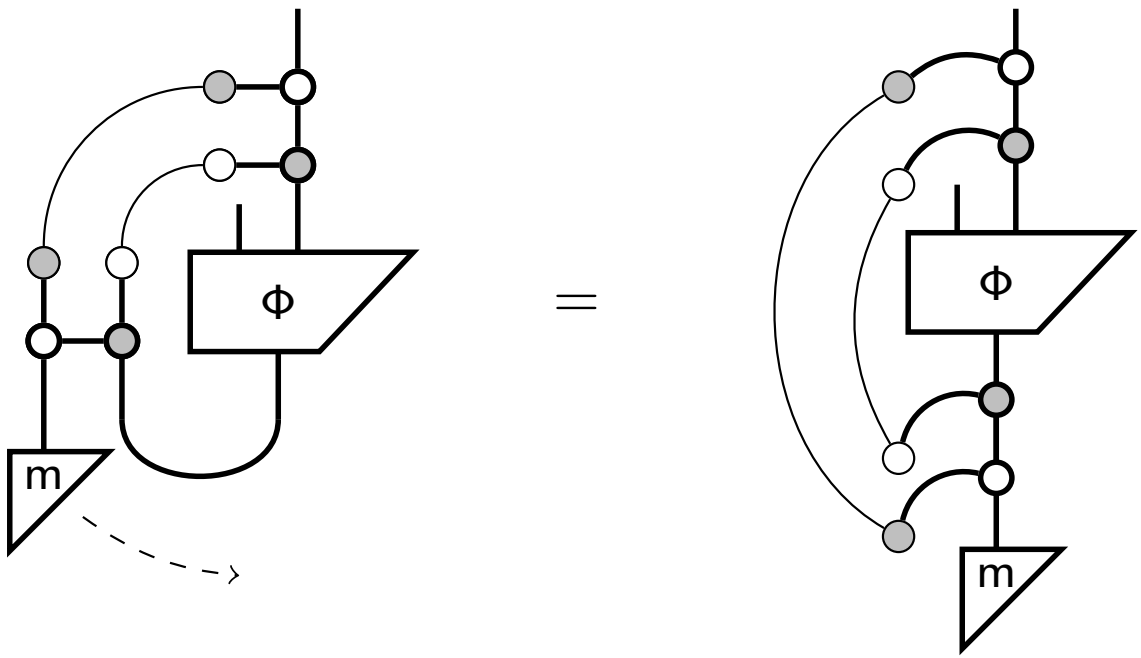
Quantum Teleportation and Quantum One Time Pad Equivalence

Quantum Teleportation = The Quantum One Time Pad



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Quantum Key Recycling

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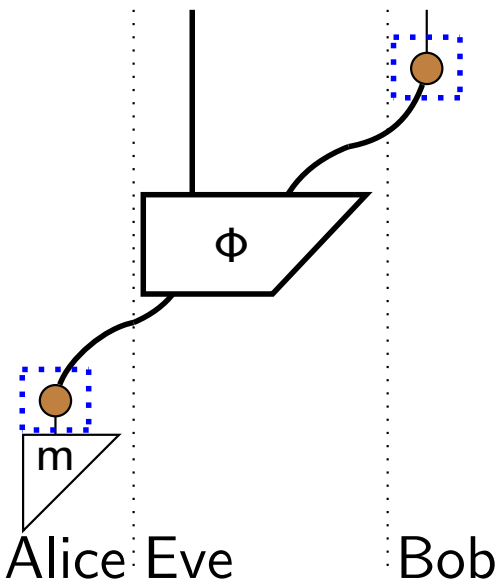

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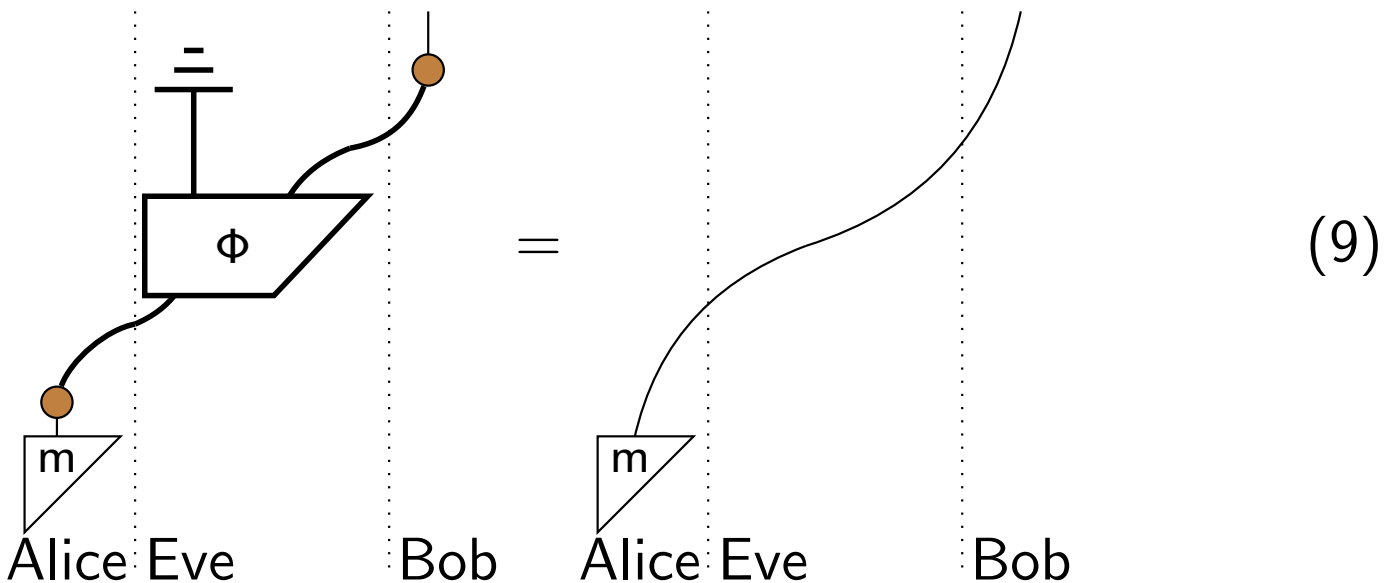
Quantum Key Recycling

- Security proof for quantum key recycling in the noiseless case, the starting point:



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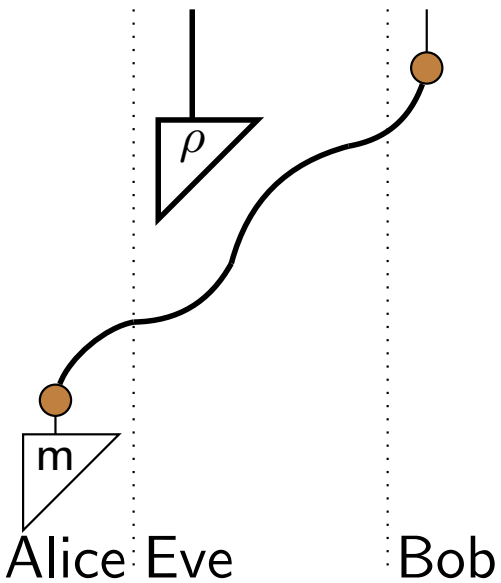
Quantum Key Recycling

- With a lot of steps in between, the end result becomes:



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- In words: Eve's part of the diagram separates entirely from Alice and Bob's communication channel!

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  - Developed the **quantum One Time Pad** diagrammatically and showed that it both works and is secure
  - Showed that **Quantum Teleportation** is equivalent to the quantum One Time Pad, and therefore also works and is secure
  - Developed **Quantum Key Recycling** diagrammatically, included a fully fledged security proof and worked out equivalences from a recent paper [4]

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     Yes!

Discussion and Conclusions

- Role of diagrammatic notation?
- More technical: classical channels have a basis?

(11)

Discussion and Conclusions

- In future research it would be interesting to...
  - Develop a full security proof for Quantum Key Recycling with noise
  - Generally work out more protocols and equivalences in this notation

Questions?

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