

# Quantum Cryptography

## Lecture 23

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- Beyond QKD: some (limited) multi-party computation results; also, security for “quantum information”

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- Qubit refers to a quantum state that allows encoding (and decoding) one bit of information
- But there are several possible ways to encode/decode the information in a qubit, leading to interesting properties
- A system of multiple qubits shows even more interesting properties, beyond just holding all the bits of information



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  - In either case at the end the needle is aligned along a leg of the cross (as reported by the measurement)

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- Think of color as “axis-parallel” or “diagonal” needle/cross position
  - Note: not exploiting all possibilities, but already useful

BB84

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- Will describe in terms of red/blue cards and card-readers

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Send the cards to Bob  
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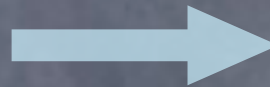
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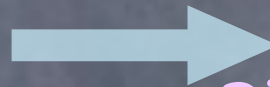
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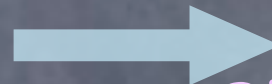
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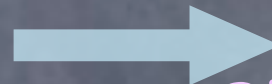
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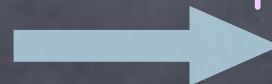


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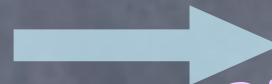
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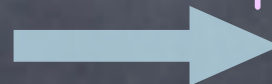


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  - But then Eve can read only (at most) those cards

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    - Alice picks a seed at random and publicly sends it to Bob; shared key is defined as  $\text{Extract}(\text{RawKey}, \text{Seed})$

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- Quantum teleportation: Pre-processing quantum communication
  - If some “entangled” qubits are shared a priori, then can use a classical channel to “teleport” an unknown qubit (without reading it)

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    - Measuring two entangled qubits (cards) appears co-ordinated, as if the two card readers communicate with each other
- Bell inequality: limit of correlation that is possible classically. Experimentally violated by quantum systems (with caveats)

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  - Universally Composable Security for QKD (2005)
- Original proofs of security considered restricted Eve (e.g., in BB84 Eve that measured/transformed each transmitted qubit separately)

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- Bennett and Brassard proposed BB84 in 1984
  - Similar ideas by Wiesner in early 1970s
- QKD scheme based on entanglement by Ekert in 1990
- Several other schemes by now
- Security definitions originally based on information leaked to Eve
  - But key distribution needs composability (because key will be used for other tasks later, and attack may not be separately on QKD and subsequent use)
  - Universally Composable Security for QKD (2005)
- Original proofs of security considered restricted Eve (e.g., in BB84 Eve that measured/transformed each transmitted qubit separately)
  - Complete proof in 1996, followed by several refined proofs

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  - Possibly using “quantum repeaters”

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- Secret-sharing: requiring quantum communication for reconstruction

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  - Several OWF candidates are not quantum-OWF

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