Communication using quantum entanglement: benefits and limitations

Teresa Piovesan

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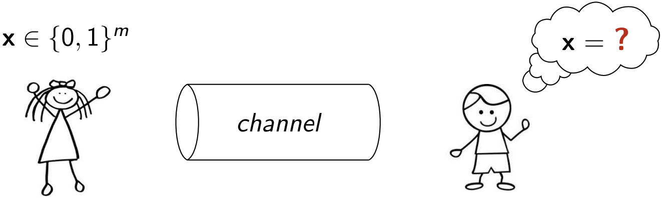
Channel coding



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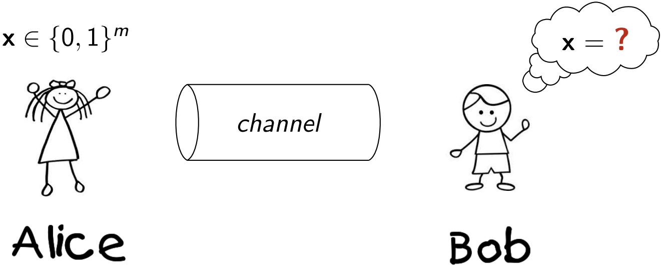
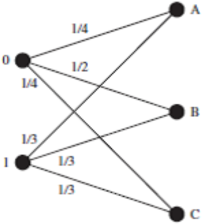


Channel coding

$\mathbf{x} \in \{0,1\}^m$



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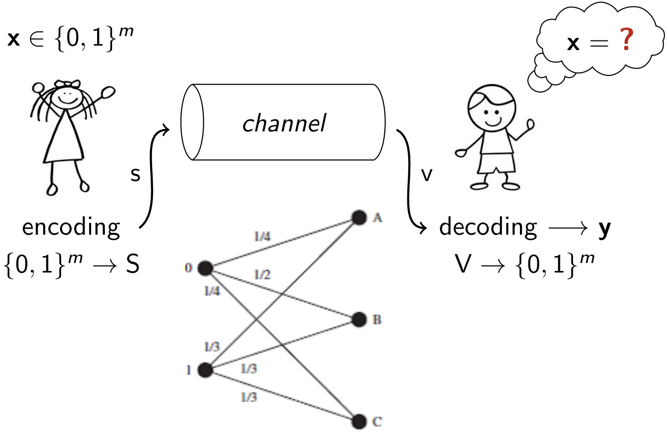

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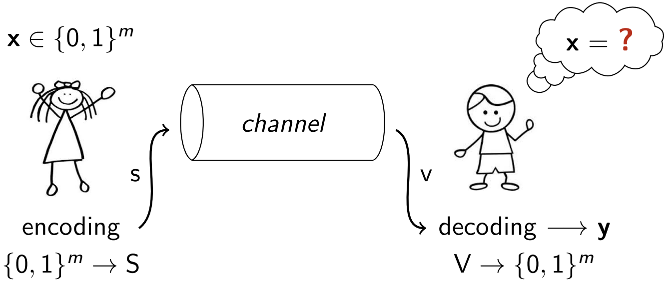
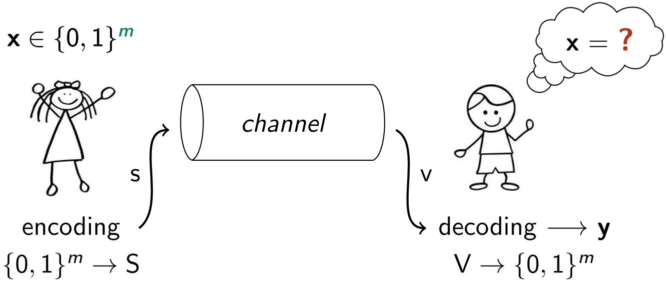


GOAL:

- $\mathbf{y} = \mathbf{x}$ with high probability

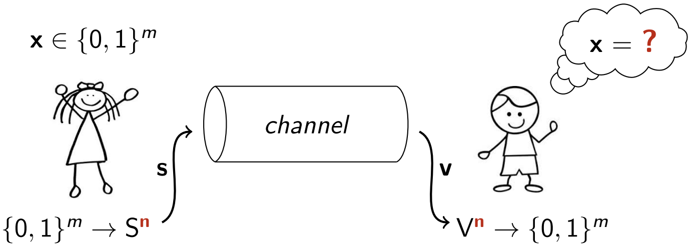
Channel coding



GOAL:

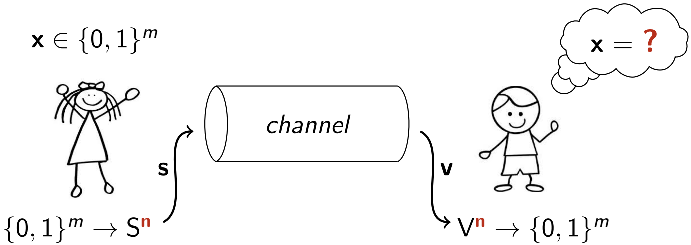
- $\mathbf{y} = \mathbf{x}$ with high probability
- maximize **m**

Block coding



- Encoding **x** into a **sequence** of channel inputs can be more efficient

Block coding



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Shannon (1948):
Number of bits that can be *theoretically* transmitted per channel use

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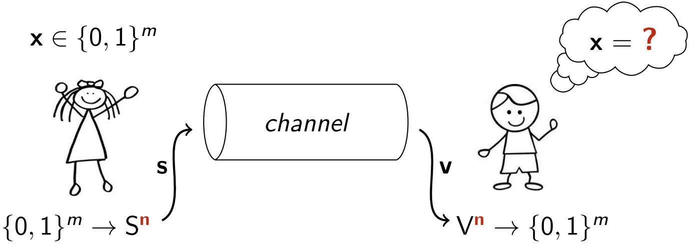

- Encoding $\mathbf{x}$ into a **sequence** of channel inputs can be more efficient

Shannon (1948):
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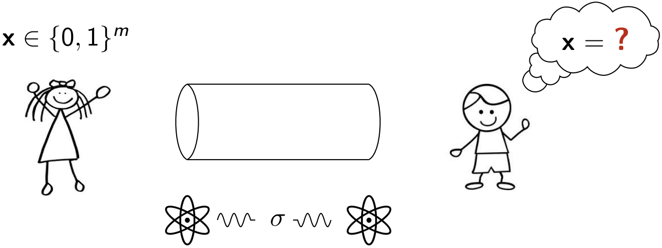
- error probability goes to zero as $\mathbf{n} \to \infty$

Channel coding with *entanglement*



Quantum entanglement

Entanglement is one of the most striking features of quantum mechanics

Measurements on *entangled* quantum systems can give outcomes that are non-classically correlated

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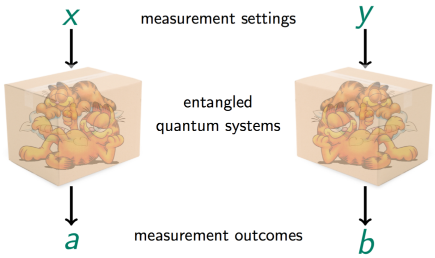

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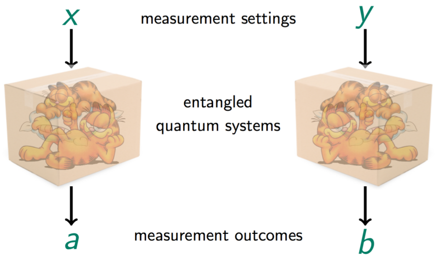

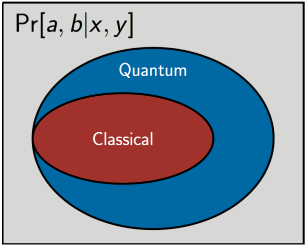

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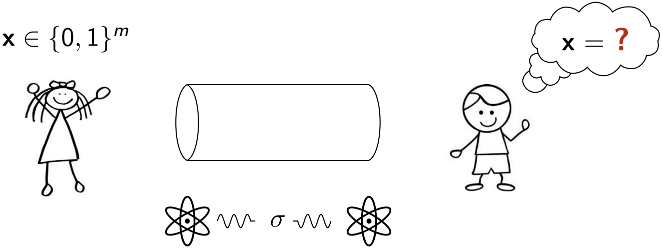

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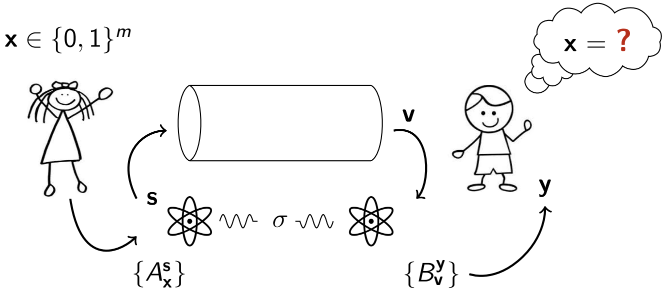
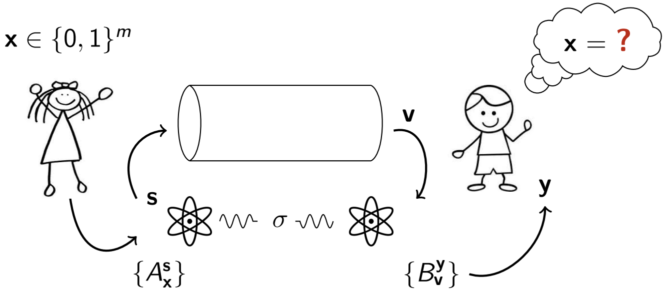


Can entanglement be beneficial?

Channel coding with *entanglement*



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Depends

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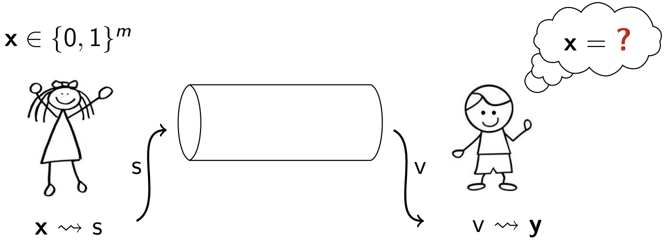
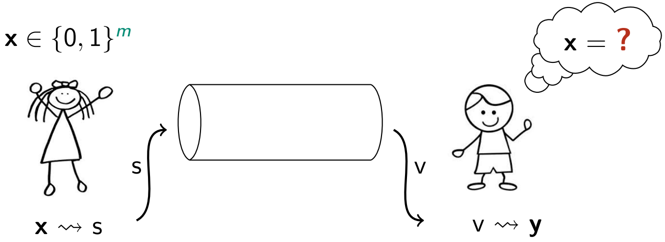
  Positive results both for *finite* and *asymptotic* number of uses of the channel ✓

Zero-error channel coding



GOAL: $\mathbf{y} = \mathbf{x}$ with zero probability of error and maximize m

Zero-error channel coding



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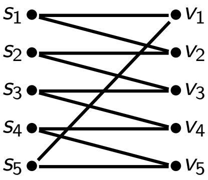

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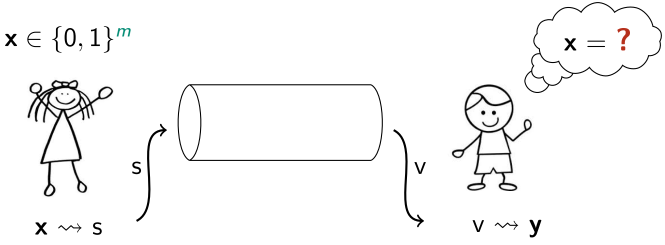

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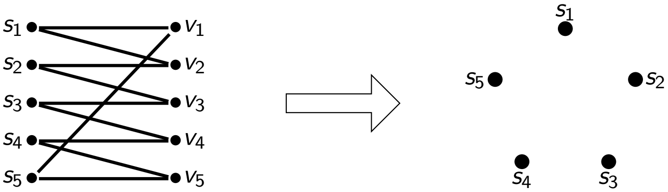

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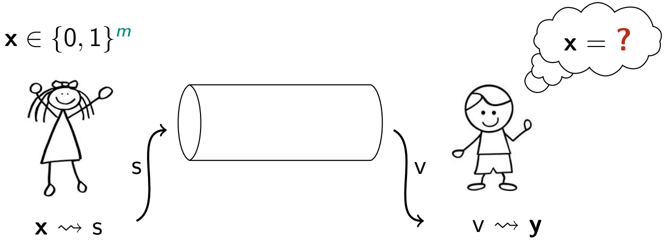

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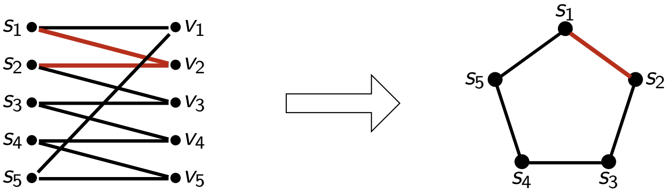

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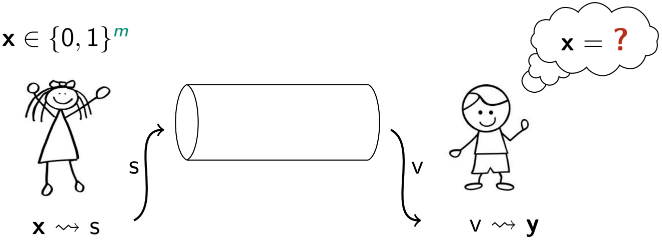

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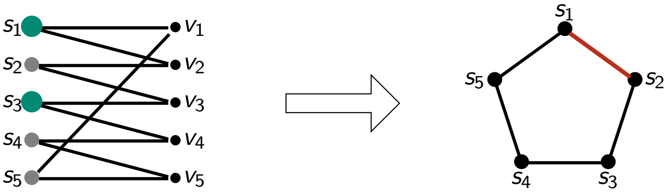

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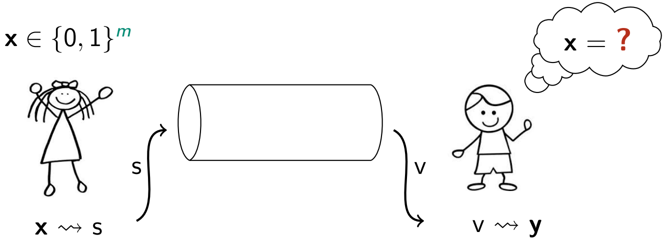

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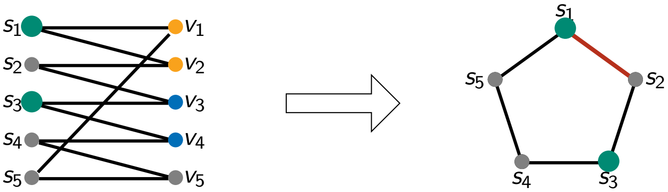

Channel capacities

	One-shot	Asymptotic
Classical		
Quantum		

Channel capacities

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Channel capacities

	One-shot		Asymptotic
Classical	$\alpha(G)$	$\leq$	$c(G)$
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Channel capacities

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Classical	$\alpha(G)$	$<$	$c(G)$	Shannon 1956
Quantum				

- $\exists$ graph G : $\alpha(G) < c(G)$

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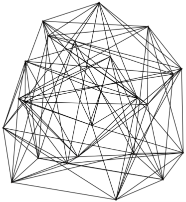
Cubitt et al. 2010



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	$\rotatebox{90}{$\geq$}$	$\rotatebox{45}{$\neg$}$	
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Leung et al. 2012

Briët et al. 2012

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Thank you!