Quantum resources group

Presentation of the group members and research agenda

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FNP Foundation for Polish Science

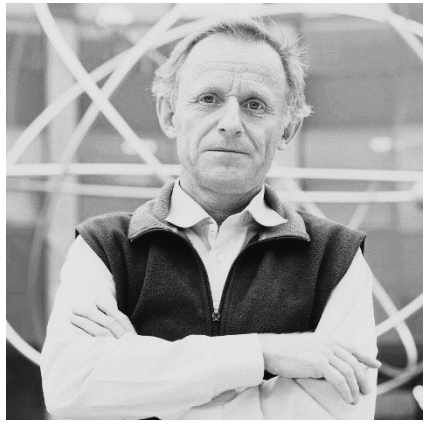
TEAM-NET

Outline

1. Our team
2. Quantum technologies and resources
3. Research projects

Our team

Post-docs



Karol Życzkowski

Roberto Salazar

Oliver Reardon-Smith

PhD students

Martin Seltmann

Alexssandre de Oliveira

Quantum technologies and resources

First Quantum Revolution

- laser systems
- nuclear power
- MRI imagers
- transistors
- semi-conductor electronics

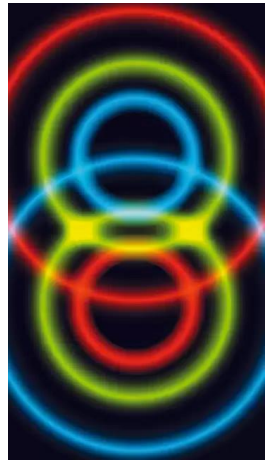
Second Quantum Revolution

- quantum computing

  Shor's & Grover's algorithm, simulating quantum systems
- quantum communication

  Secure BB84 & E91 protocols, quantum internet
- quantum thermodynamics

  Increased power of heat engines & efficiency of energy harvesting



New quantum technologies
actively create, manipulate and read out quantum states

Quantum technologies and resources

Harnessing quantum resources

1. Identification

Technology $\Leftrightarrow$ Particular resource

1 teleported qubit = 1 entangled Bell pair

1 secure bit = 1 coherent state

Task: designing quantum protocols

2. Characterisation

Particular resource $\Leftrightarrow$ General resource

x entangled Bell pairs = 5 entangled states $|\psi\rangle$

1 entangled Bell pair = y entangled states $|\psi\rangle$

Task: finding limits on resource manipulation

3. Implementation

General resource $\Leftrightarrow$ Physical system

Task: Experimental proposals

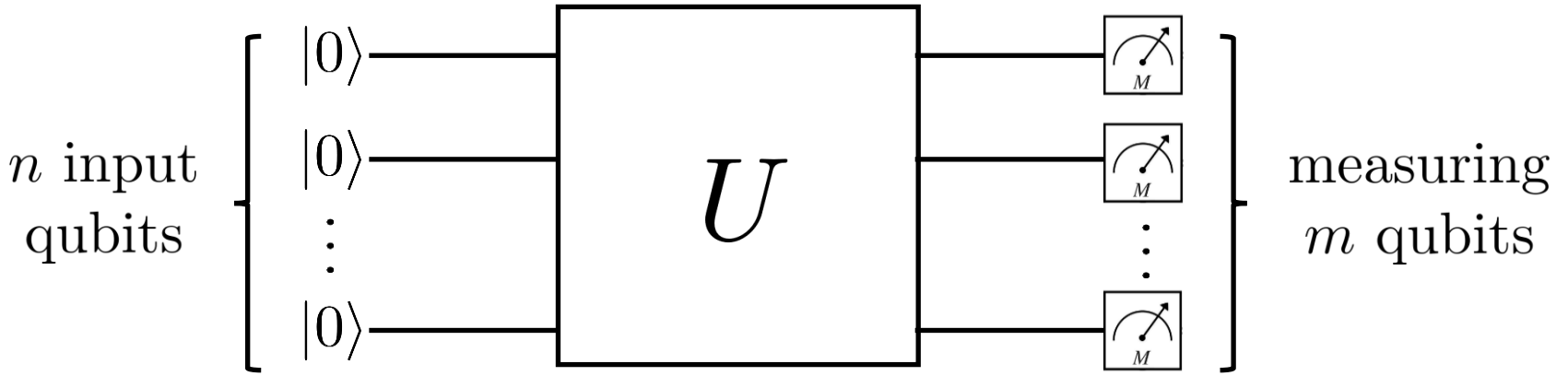
Research projects

Quantum computing ⟷ **Quantum communication**

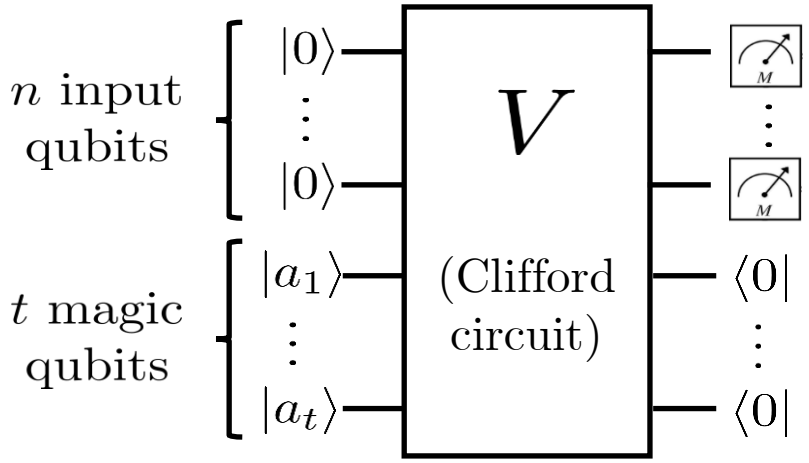
Quantum resources

Quantum thermodynamics

Resources for quantum computation



Classically simulable subtheories + resource states

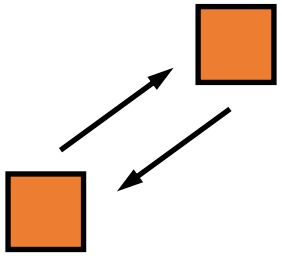


Short-term goal:
State-of-the-art Clifford+T simulator

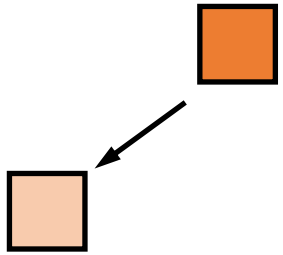
Long-term goal:
Unified simulation framework

Dissipation of quantum resources

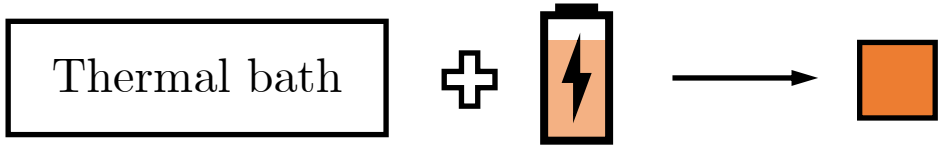
Reversible processes



Irreversible processes



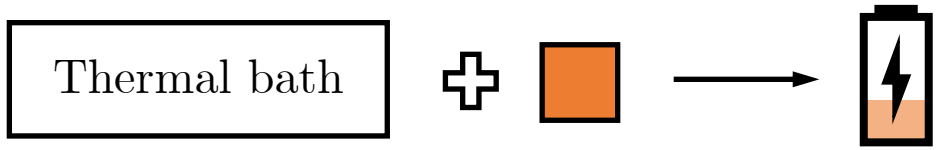
Dissipation of resources – initial and final states have different resource content



Resource dilution

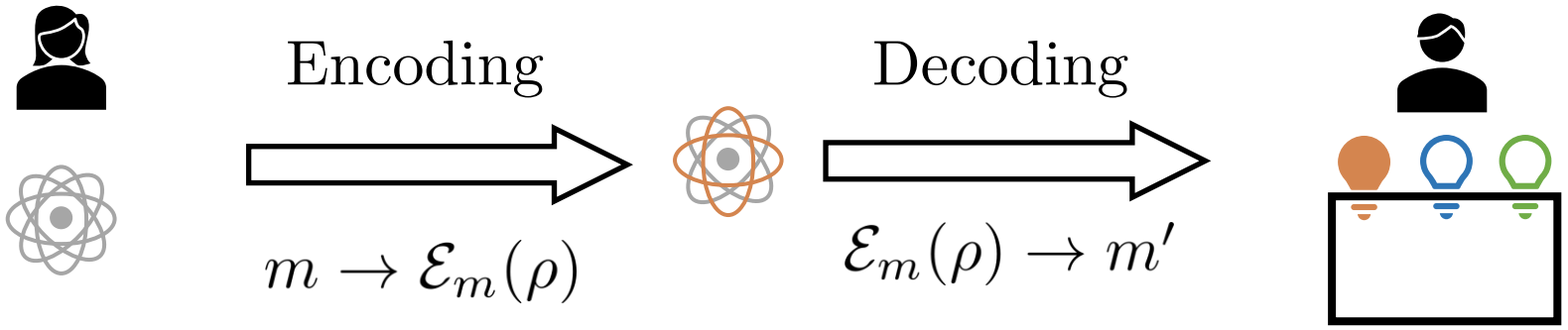
Short-term goal:
Energy dissipation in coherent processes

Long-term goal:
Fluctuation-dissipation theorem for resources



Resource distillation

Quantum resources and communication



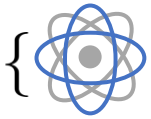
System
All degrees of freedom (DOGs)

$\rho =$ 

Resources
Specific DOGs

$\mathcal{D}($  $) =$ 

Encodings
Encoding only in resource DOGs

$\mathcal{E}_m($  $) = \{$  ,  ,  $\}$

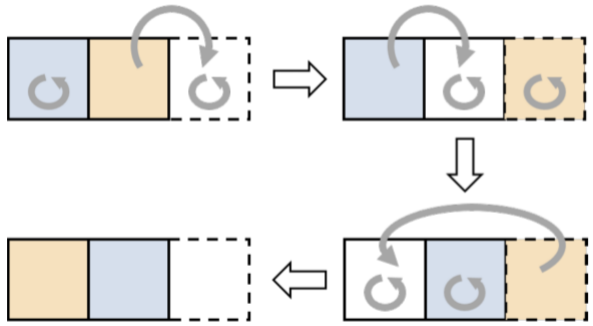
Short-term goal:
Ecoding information into coherence of channels

Long-term goal:
Resource theory for quantum channels

Quantum advantage in thermodynamics

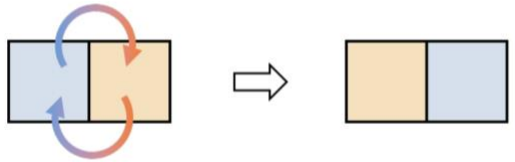
Classical bit flip

1 memory state, 3 time-steps



Quantum bit flip

0 memory state, 1 time-step



Short-term goal:
Find physical realisation of the advantage

Long-term goal:
Design a thermodynamic cycle employing the advantage

Markovian cooling of a two-level system