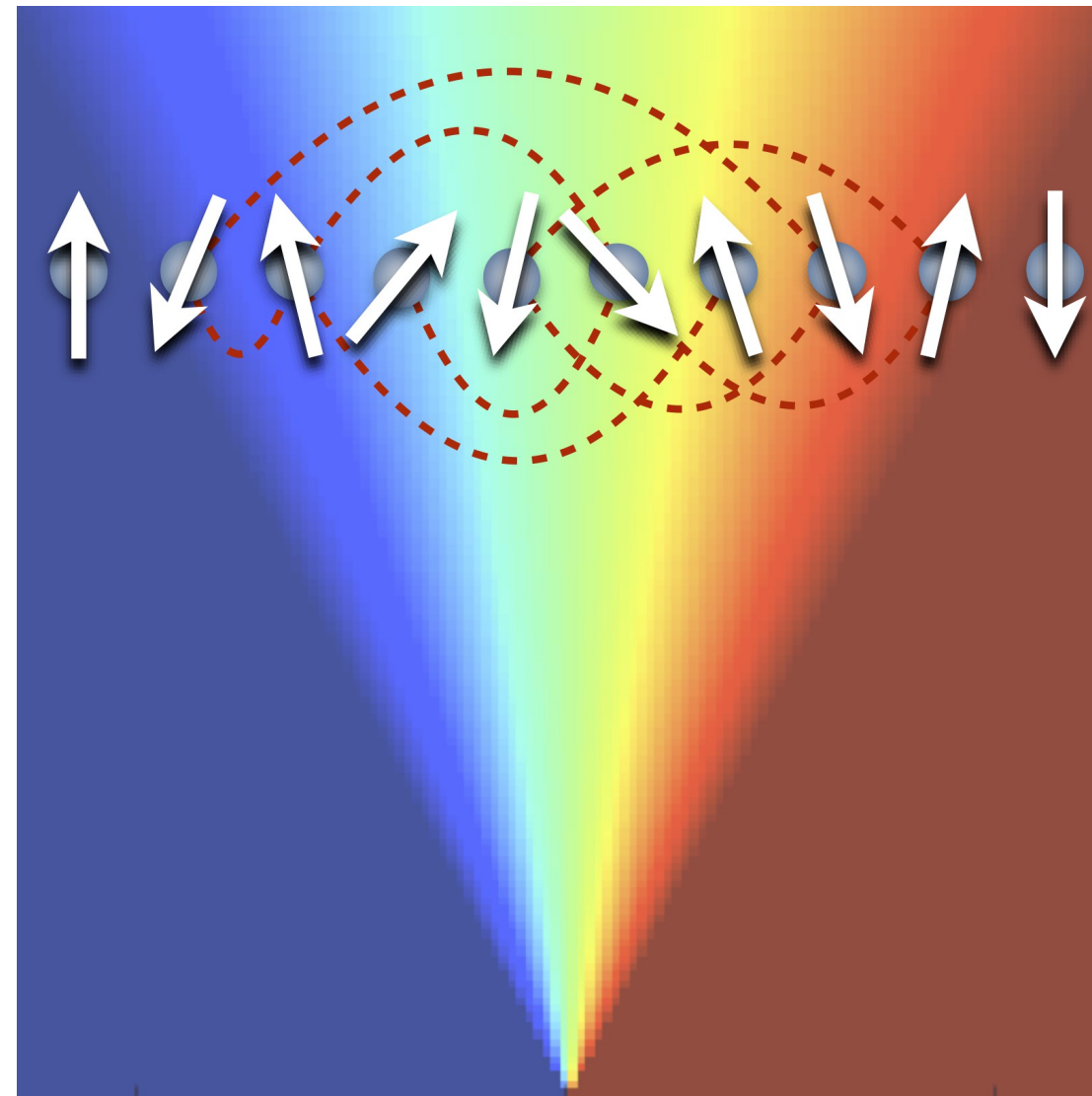


# The dynamics of quantum information



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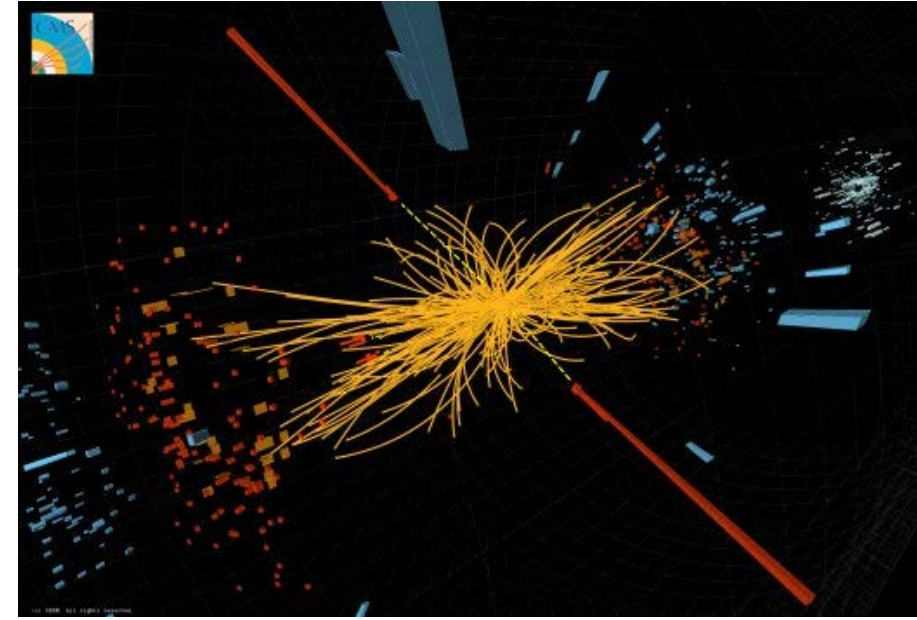
# Frontiers of Physics

short distance	long distance	complexity
		

[credit: John Preskill]

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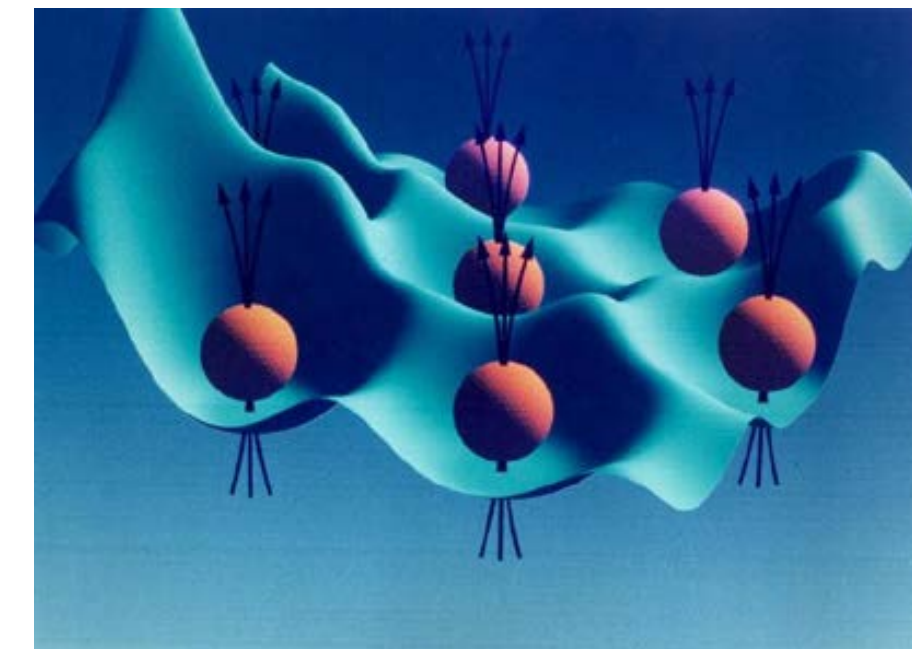
short distance



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# Frontiers of Physics

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Quantum systems of many correlated (entangled!) particles

Emergent properties: “More is different”

How to describe and control such systems? Technological applications?

# Frontiers of Physics

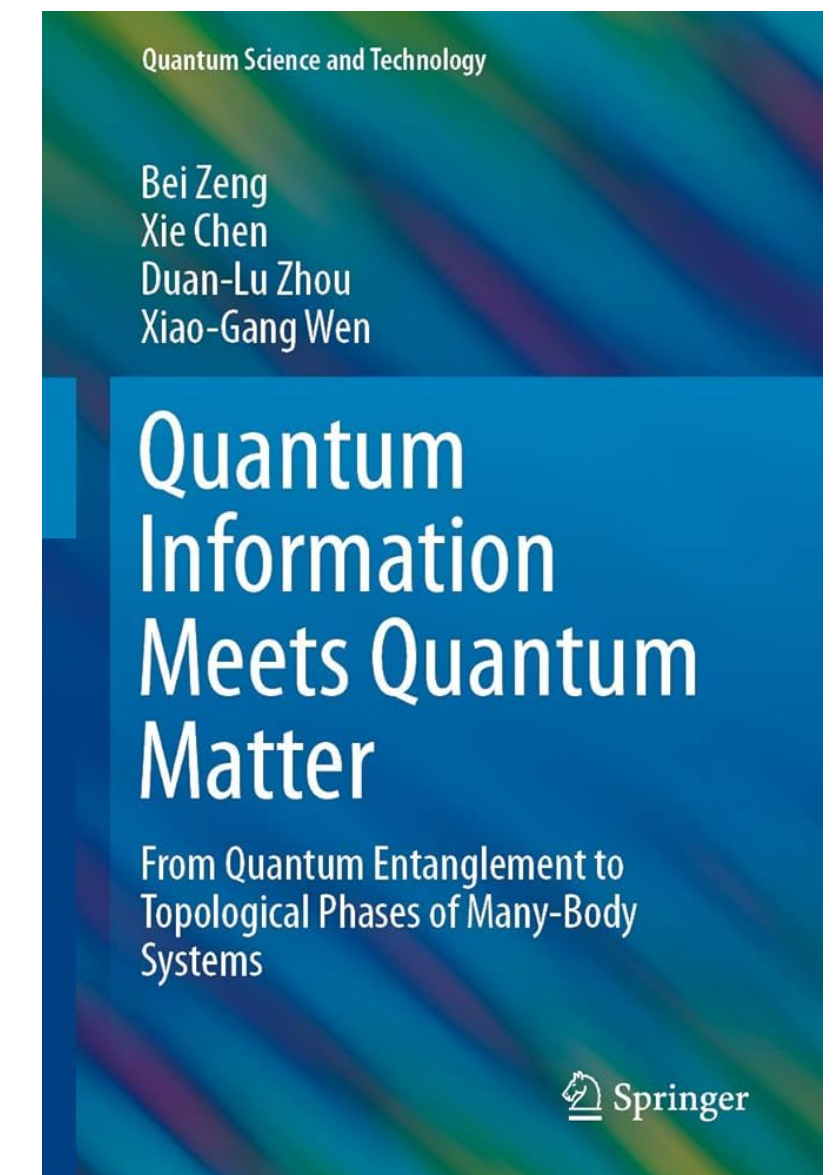
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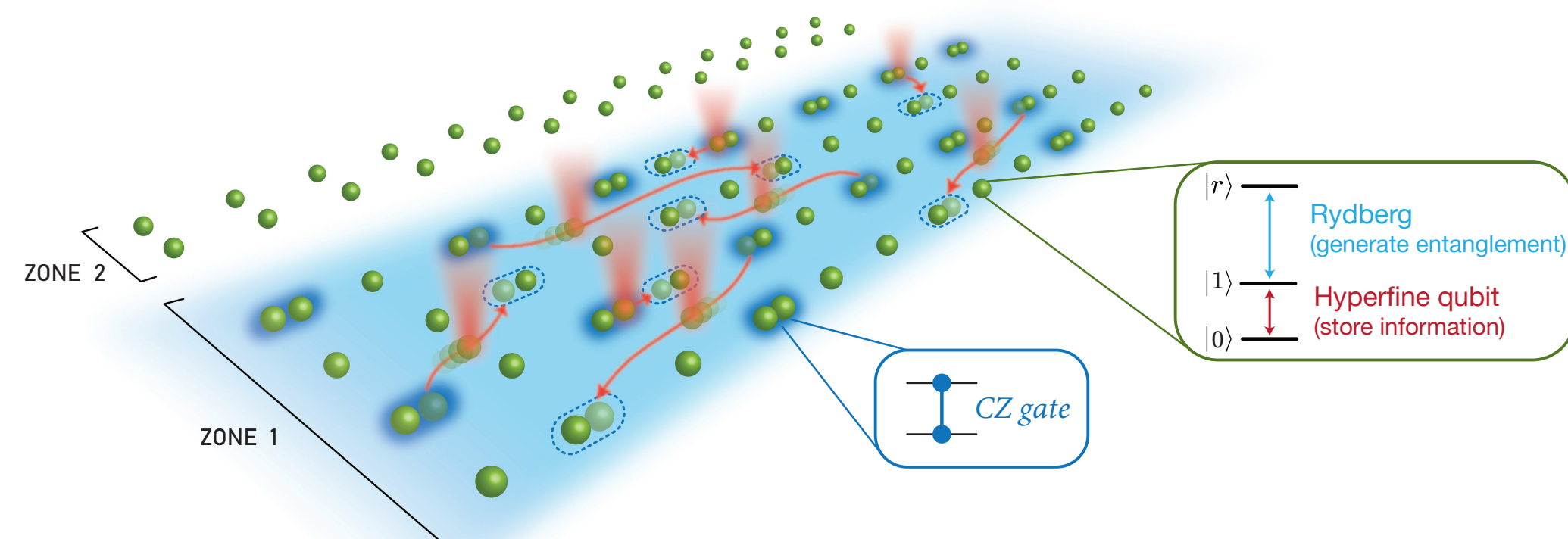
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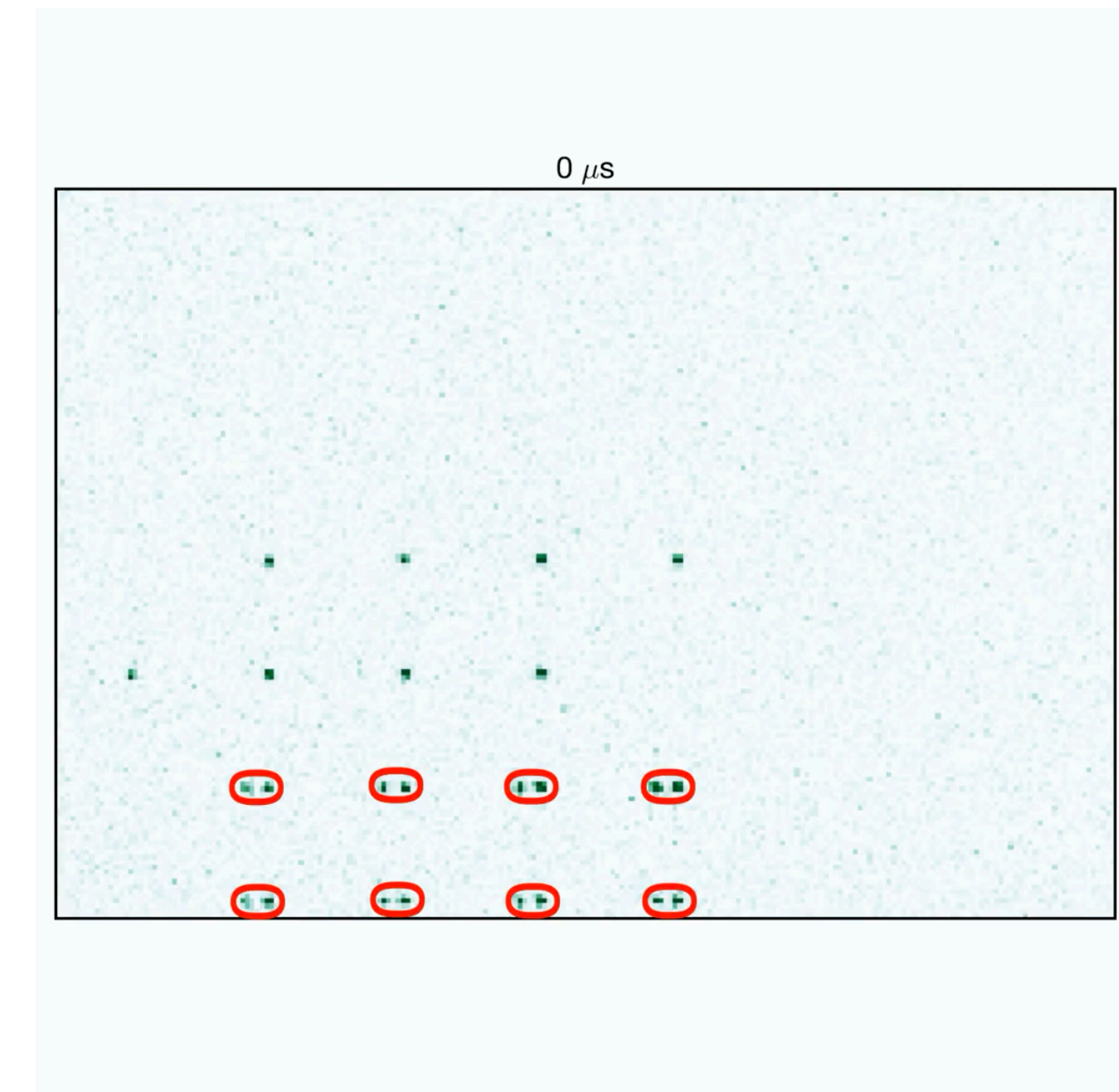
How to describe and control such systems? Technological applications?



# Experimental motivation: controlled synthetic quantum systems



Bluvstein, ... , Lukin: Nature (2022)



Many-body systems far from equilibrium

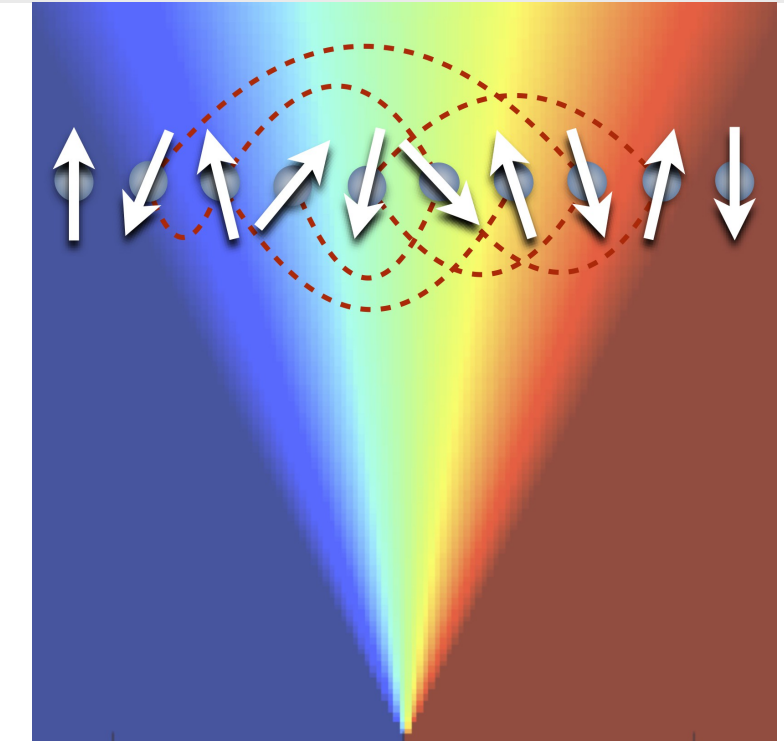
Appears as a closed system for long (but not infinite!) times, coherent quantum dynamics

Control over dynamics, geometry, measurements etc.  $\Rightarrow$  quantum computing!

# ...and many theoretical questions

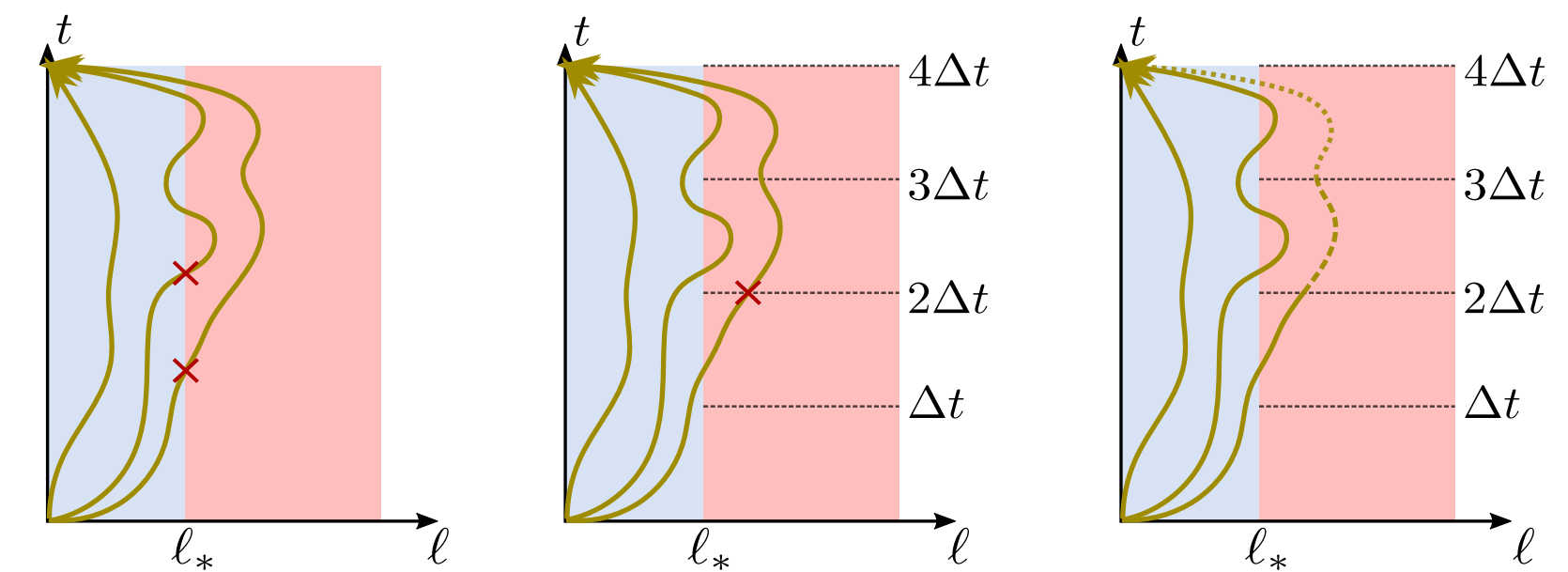
- ◆ How does quantum entanglement spread in times?  
(Information is retained, but gets delocalized)

[von Keyserlingk, Rakovszky, Pollmann, Sondhi: PRX (2018)]



- ◆ Is it possible to follow this dynamics on a classical computer?

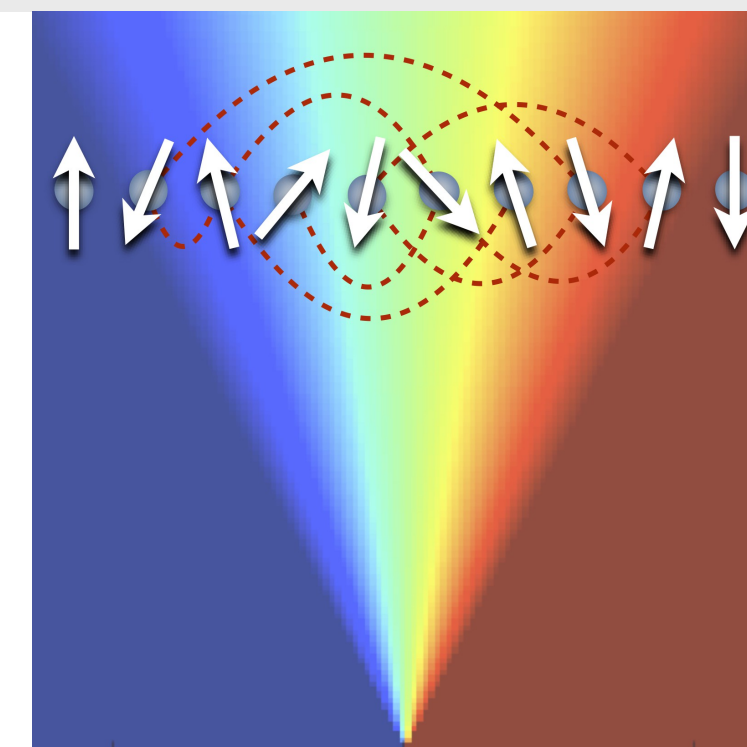
[Rakovszky, von Keyserlingk, Pollmann: PRB (2022)]



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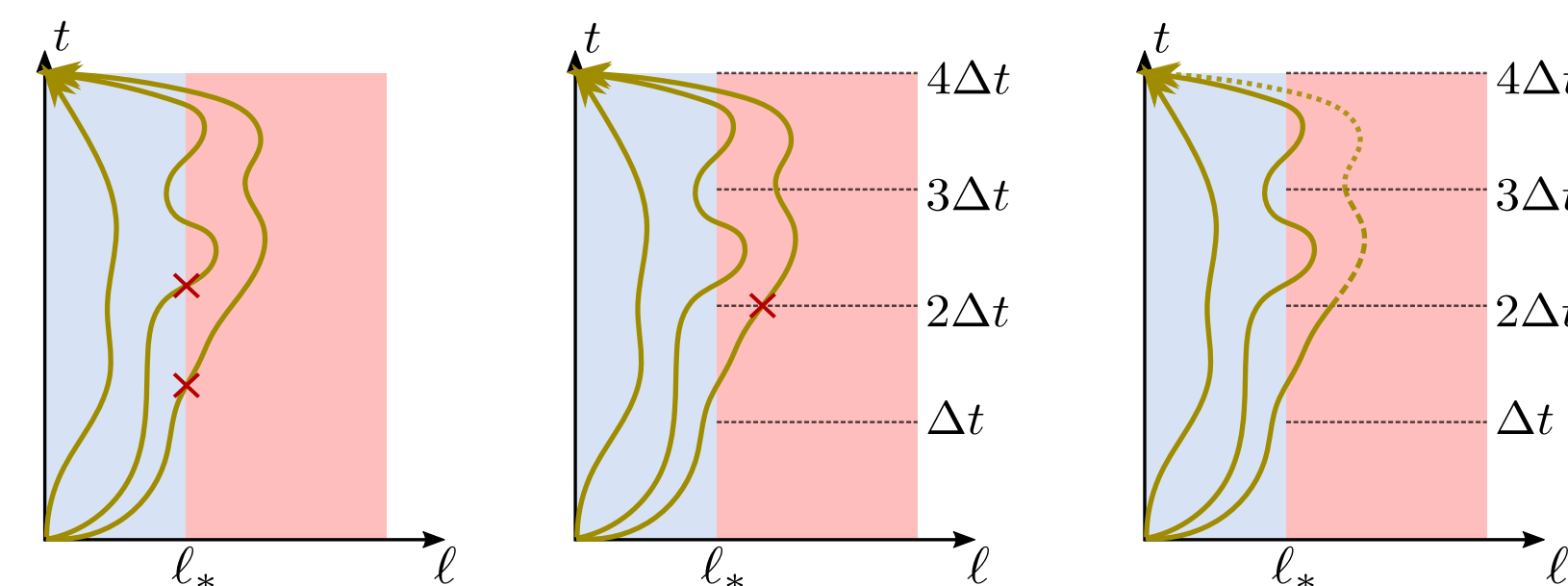
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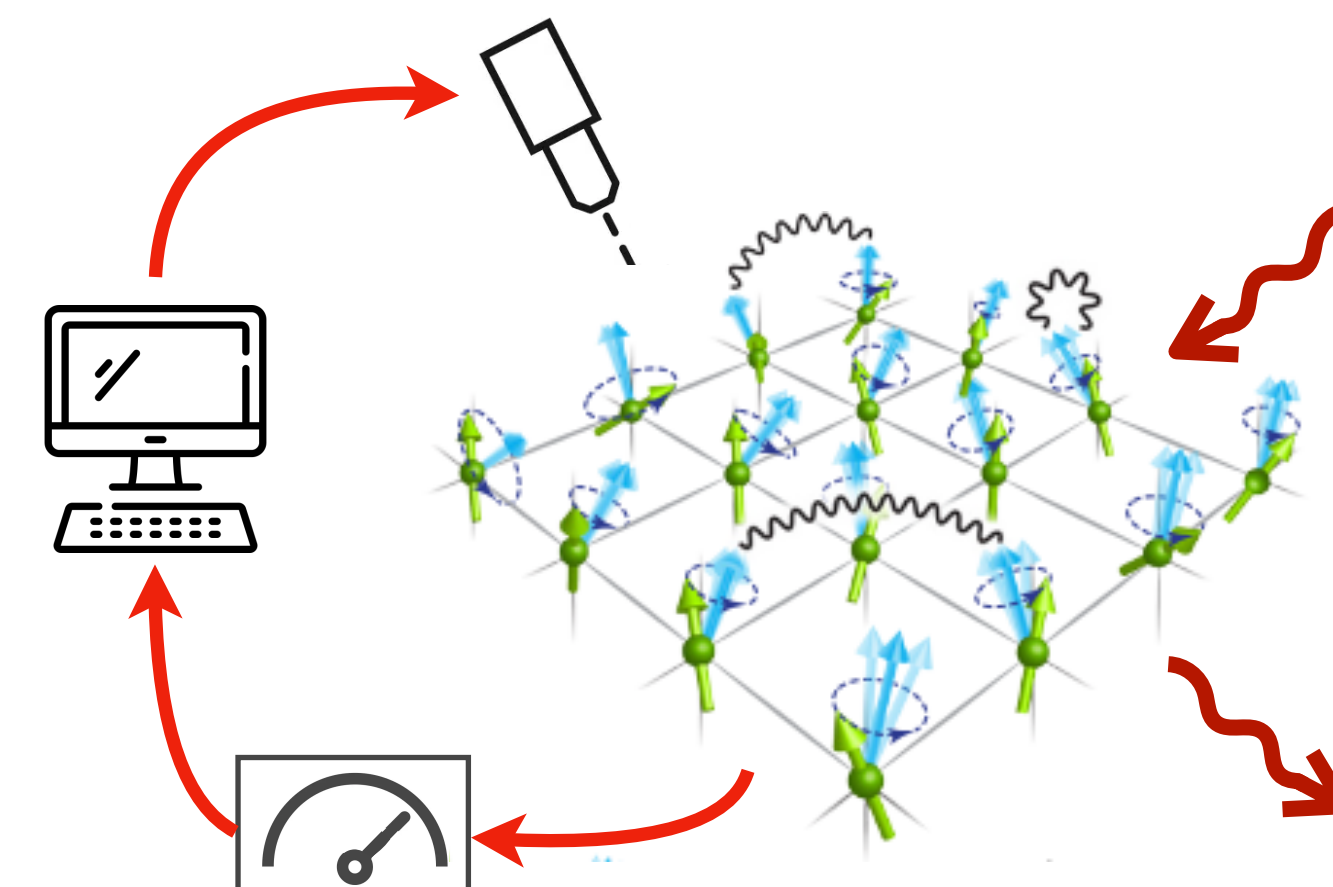


- ◆ Robust behavior in the presence of dissipation and decoherence?  
("active quantum matter")

[Rakovszky, von Keyserlingk, Gopalakrishnan: PRX (2024)]

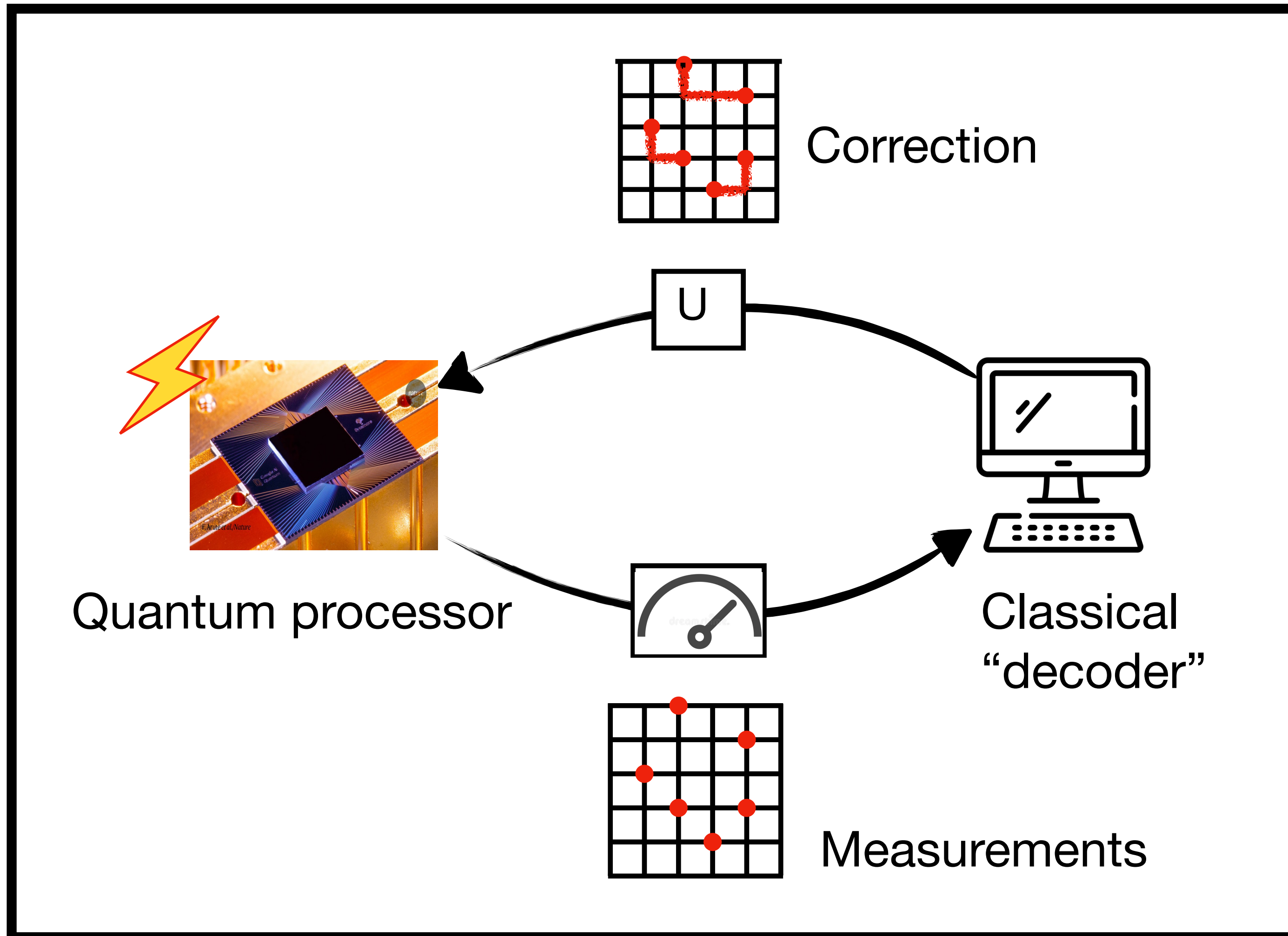
- ◆ How to hide quantum information from the environment?

[Rakovszky, Khemani: arXiv 2310.16032]



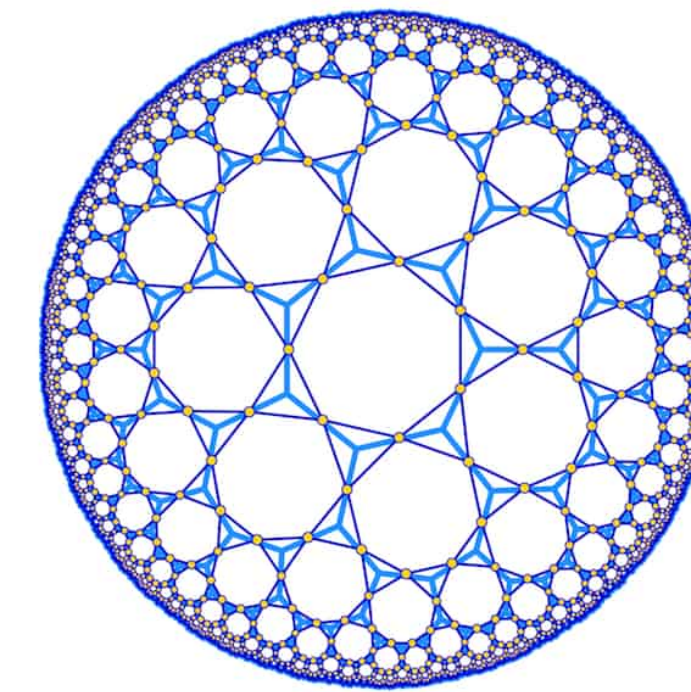


# Quantum error correction



## Questions, problems:

- ❖ Use non-local interactions to better protect information

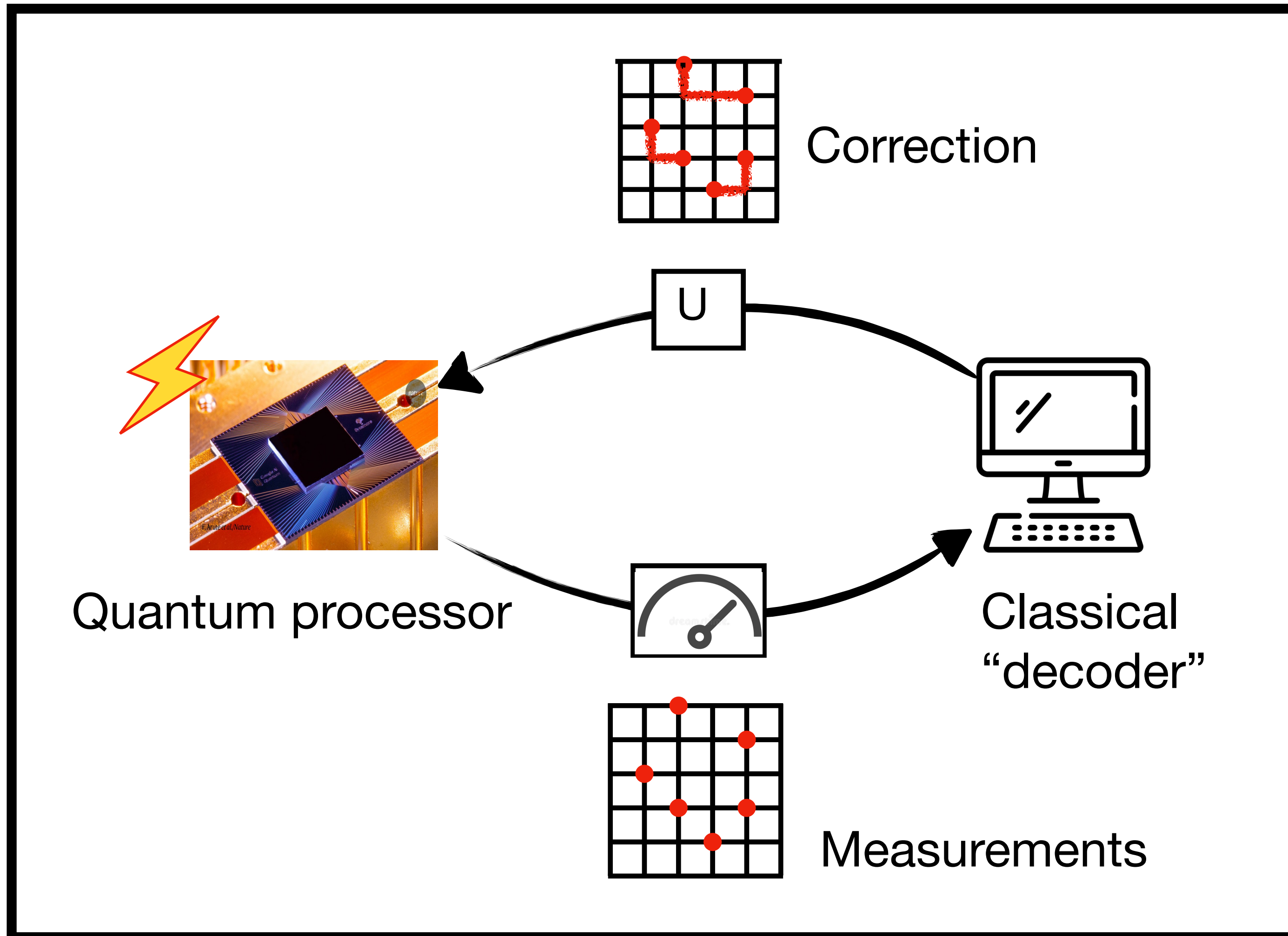


[Rakovszky, Khemani:  
arXiv 2310.16032]

- ❖ How to decode?  
Active vs. passive, global vs. local

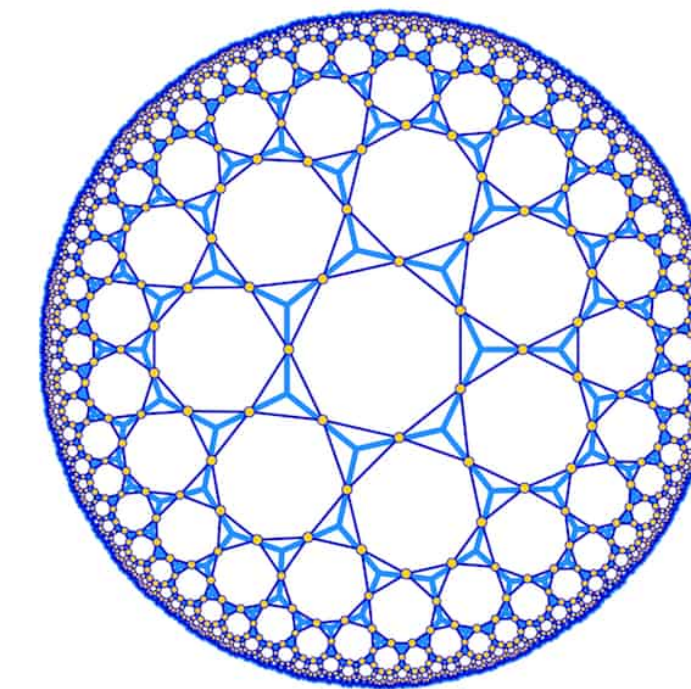
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# Quantum error correction



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