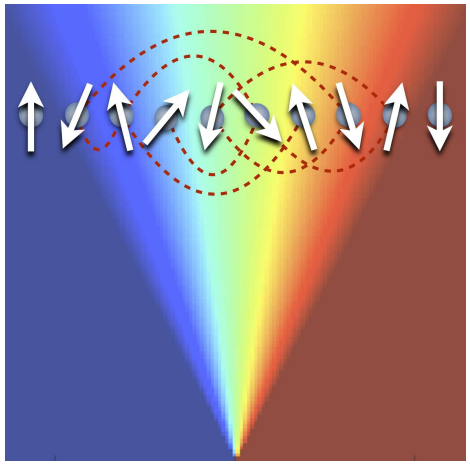
Quantum information and quantum matter far from equilibrium



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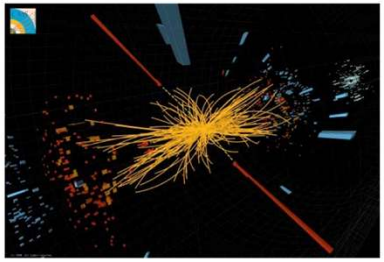
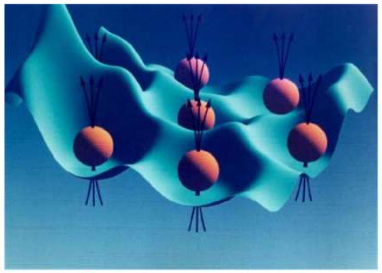
Frontiers of Physics

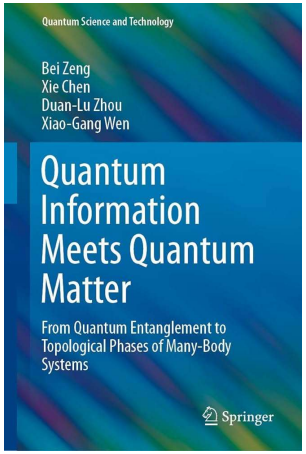
short distance	long distance	complexity
		

[credit: John Preskill]

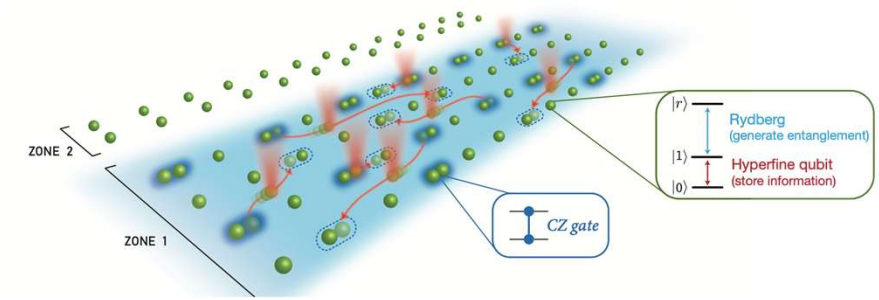
Quantum systems of many correlated (entangled!) particles

Emergent properties: “More is different”

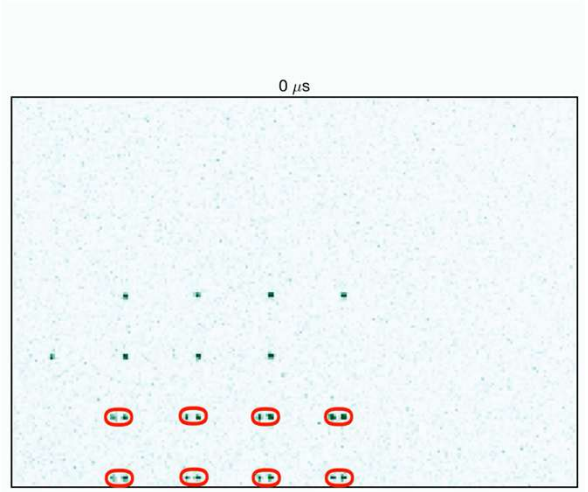
How to describe and control such systems? Technological applications?



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. ⇒ quantum computing!

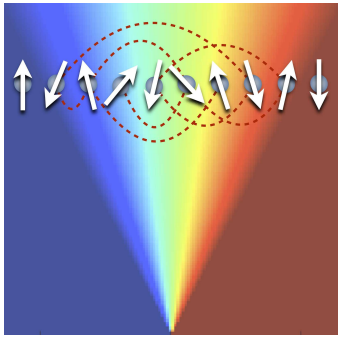
…and many theoretical questions

- How does quantum entanglement spread out over time?
  (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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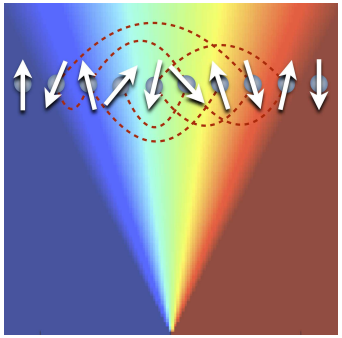

- Is it possible to follow this dynamics on a classical computer?

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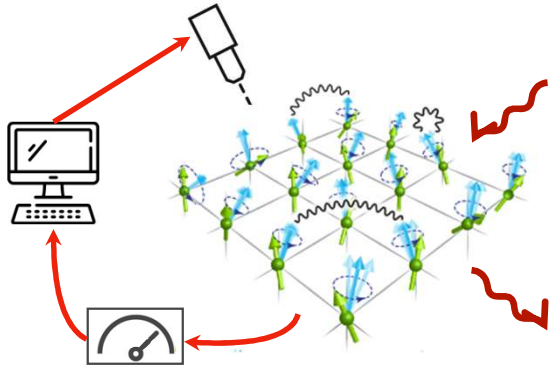
- Robust behavior in systems that exchange information, energy etc. with their environment? (“active quantum matter”)

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



- How to protect quantum information from noise?

  [Rakovszky, Placke, Breuckmann, Khemani: arXiv 2412.09598]

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