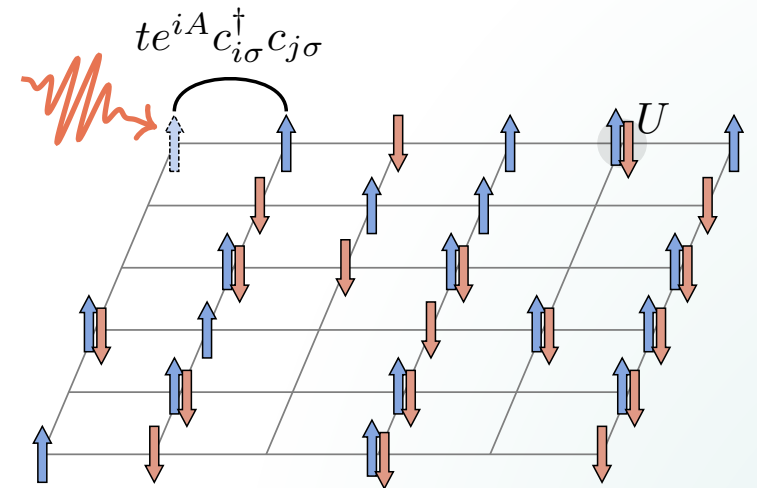
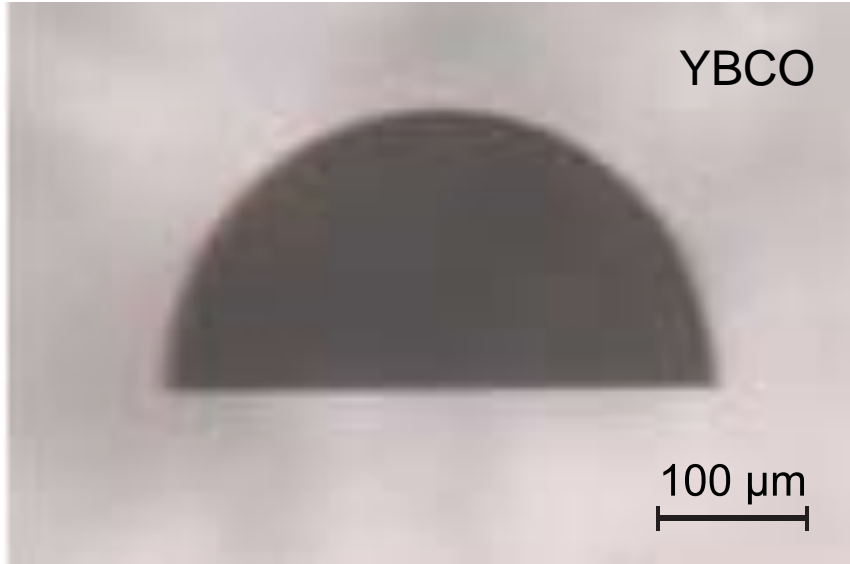


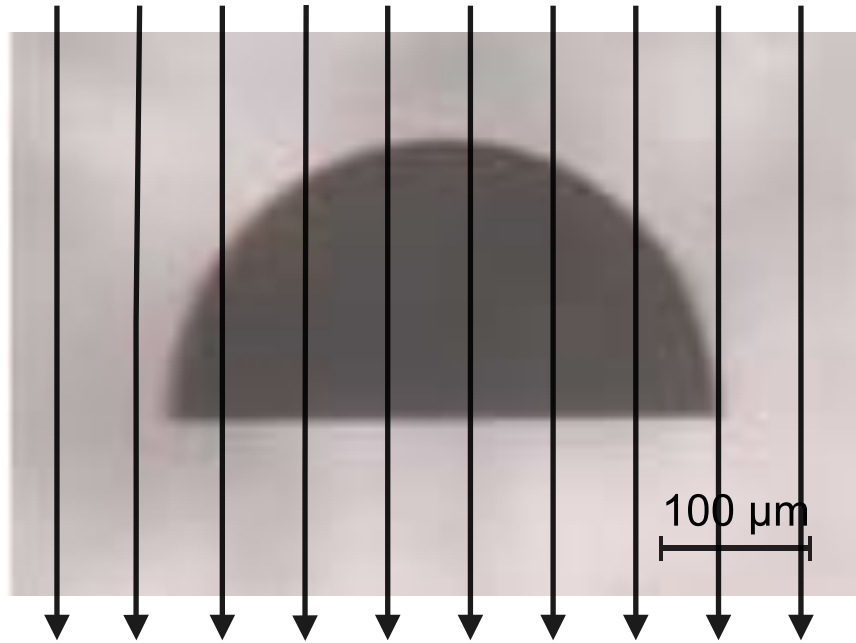
Superconducting pairing correlations on a trapped-ion quantum computer

arXiv:2511.02125

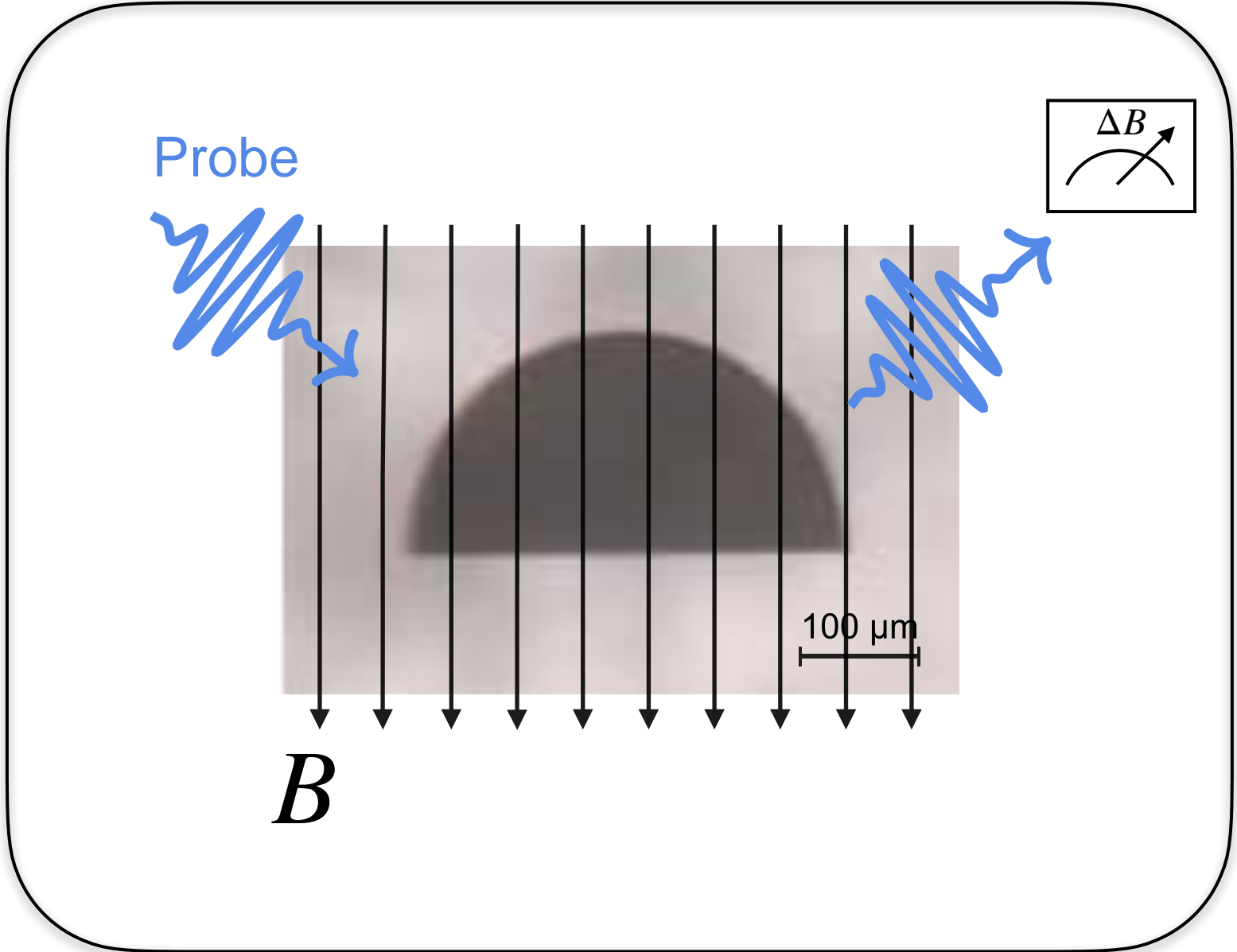
Henrik Dreyer
Mathematical Picture Language Seminar
10 Feb 2026

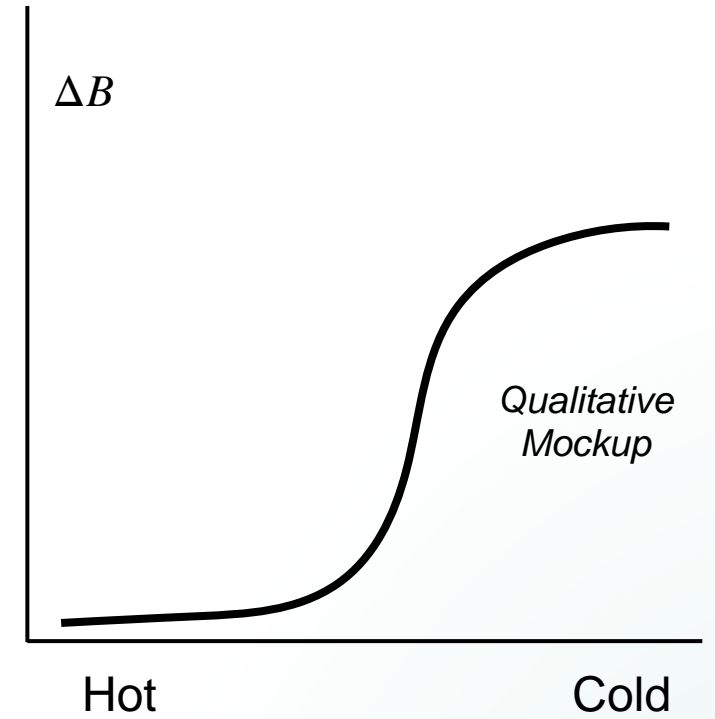
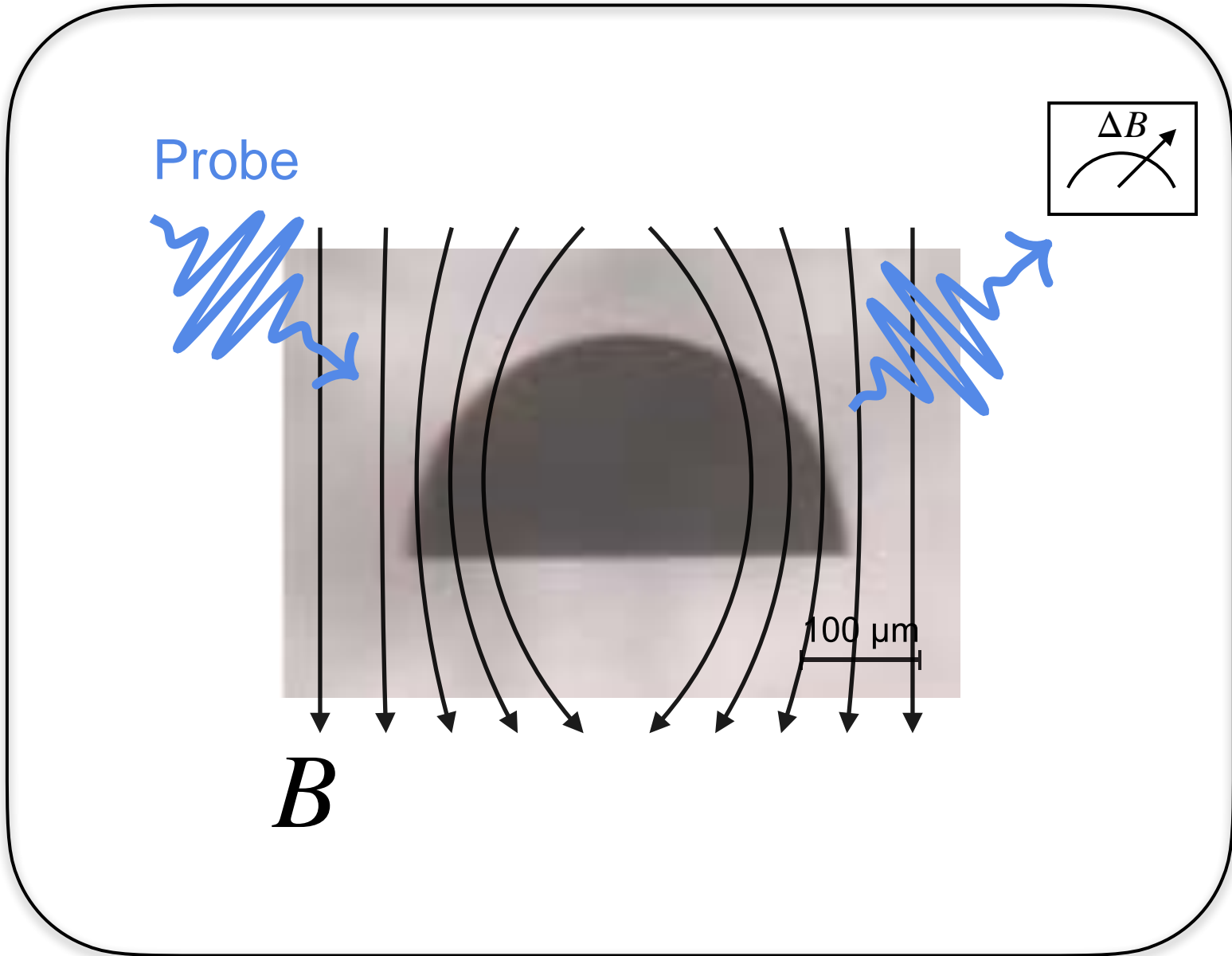


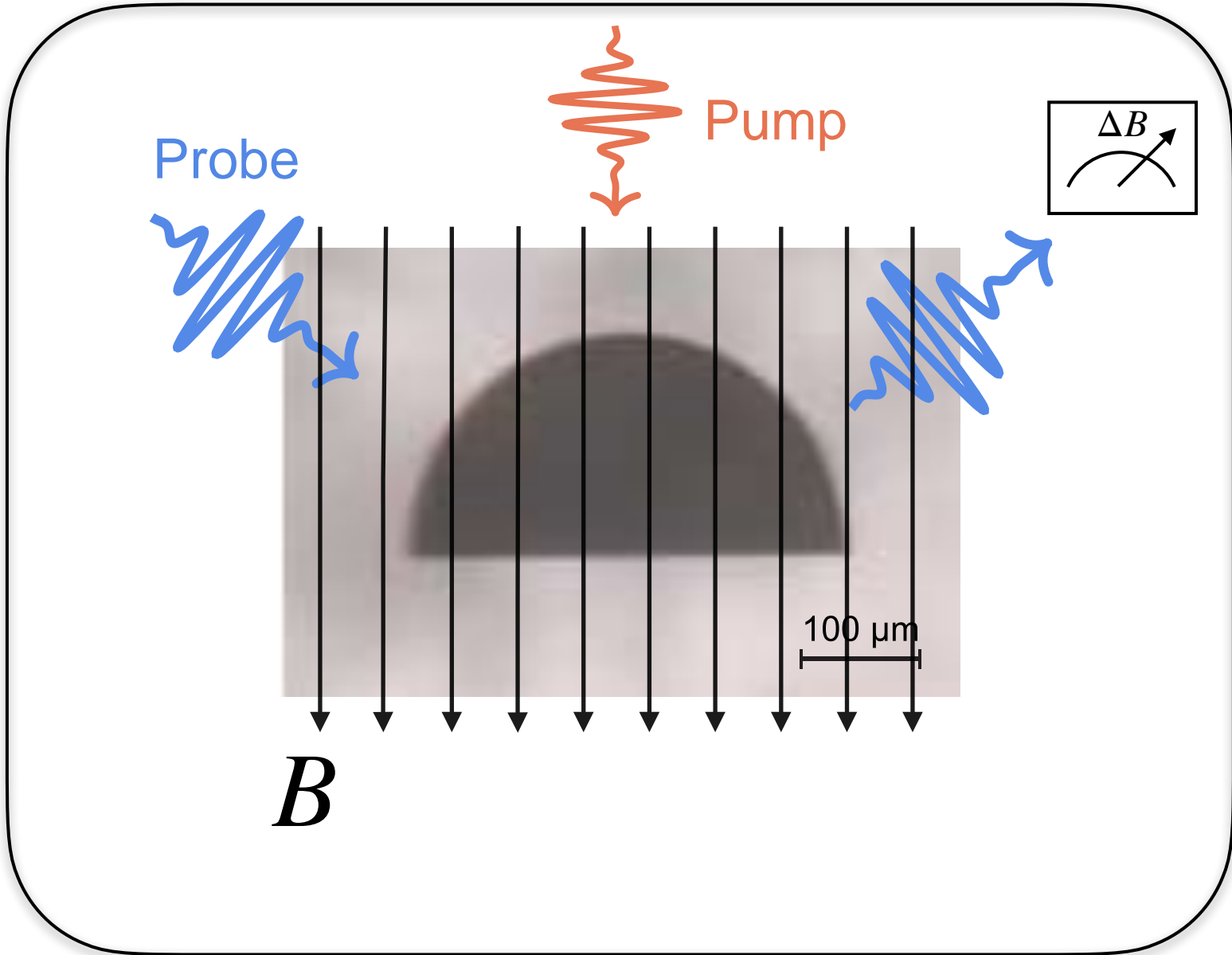


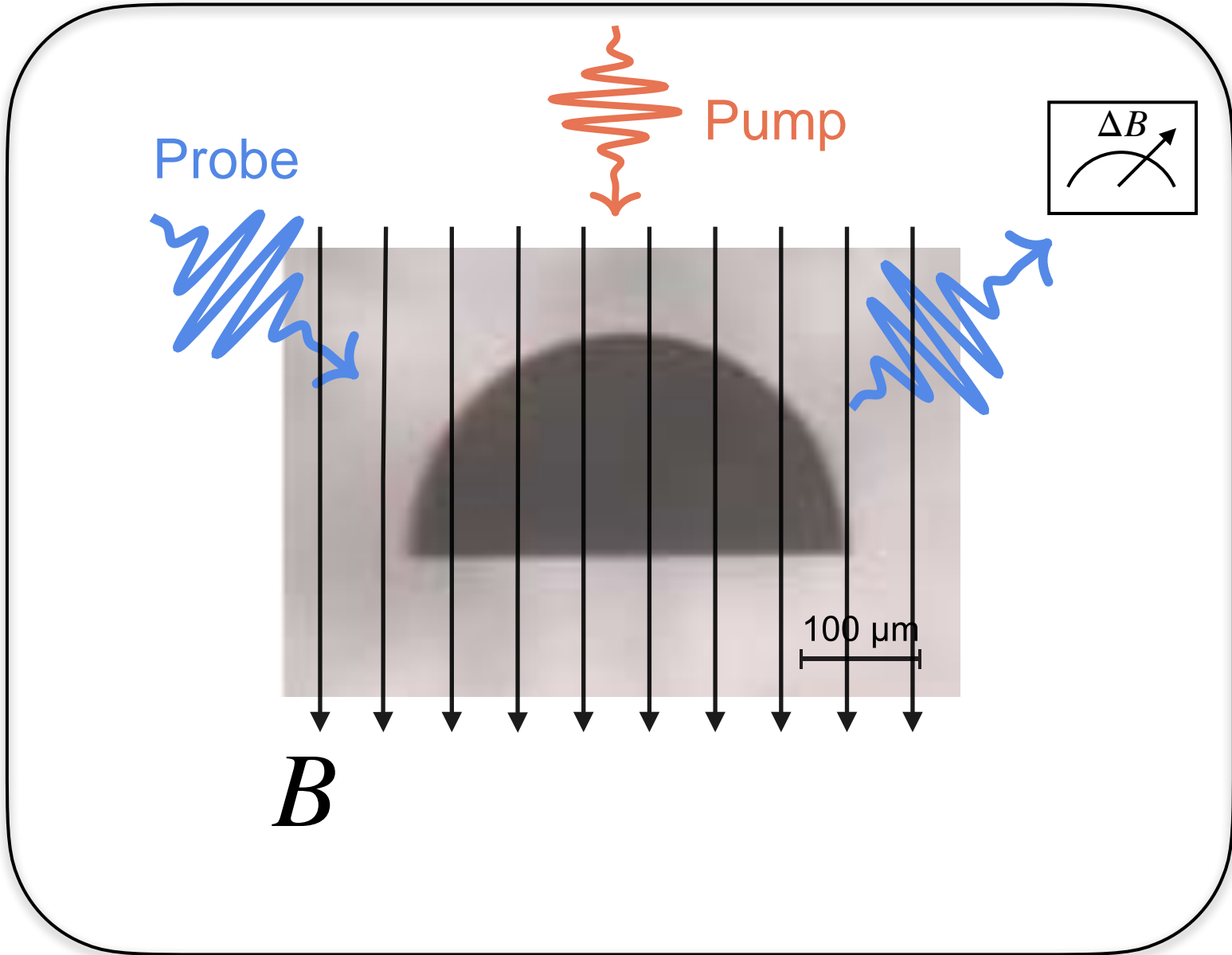


B

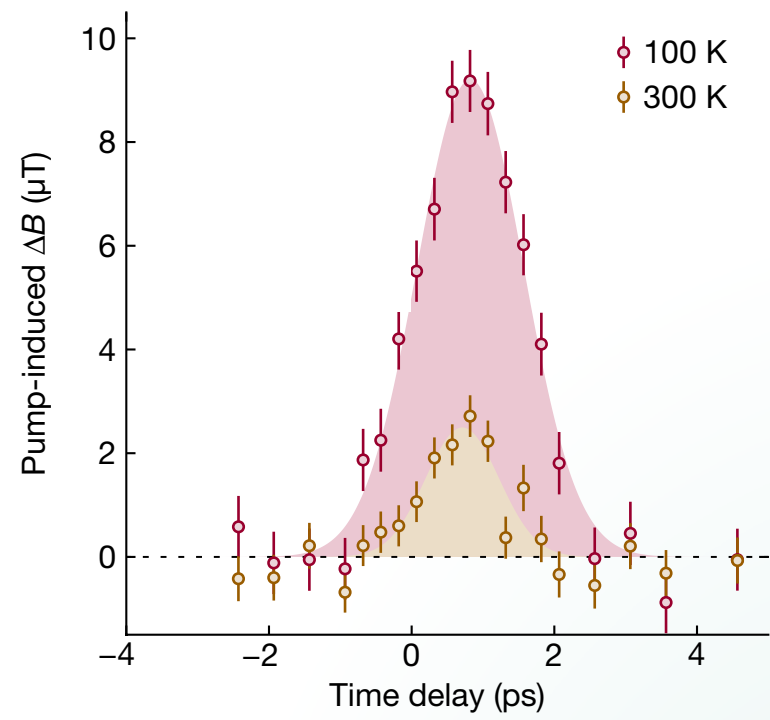
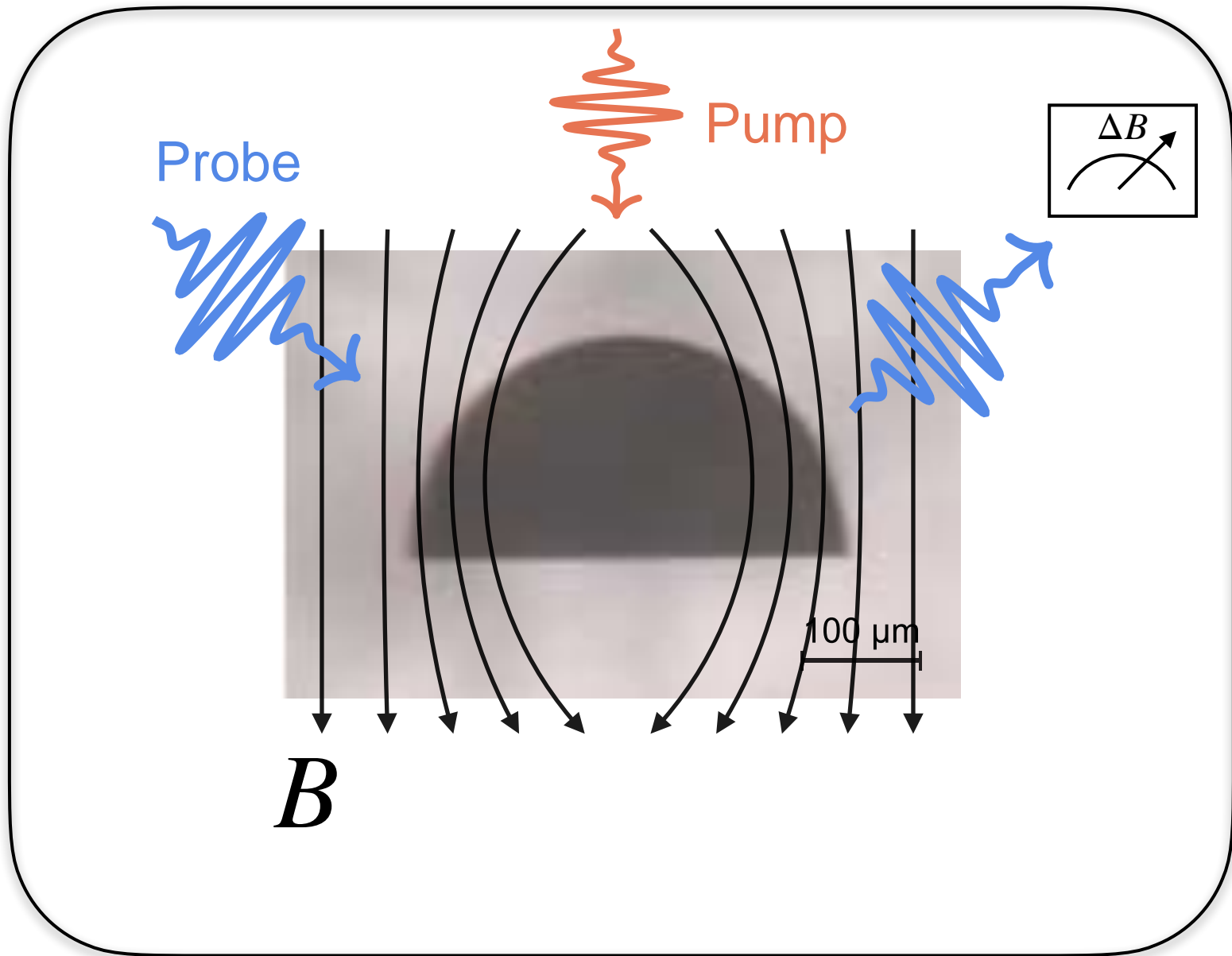


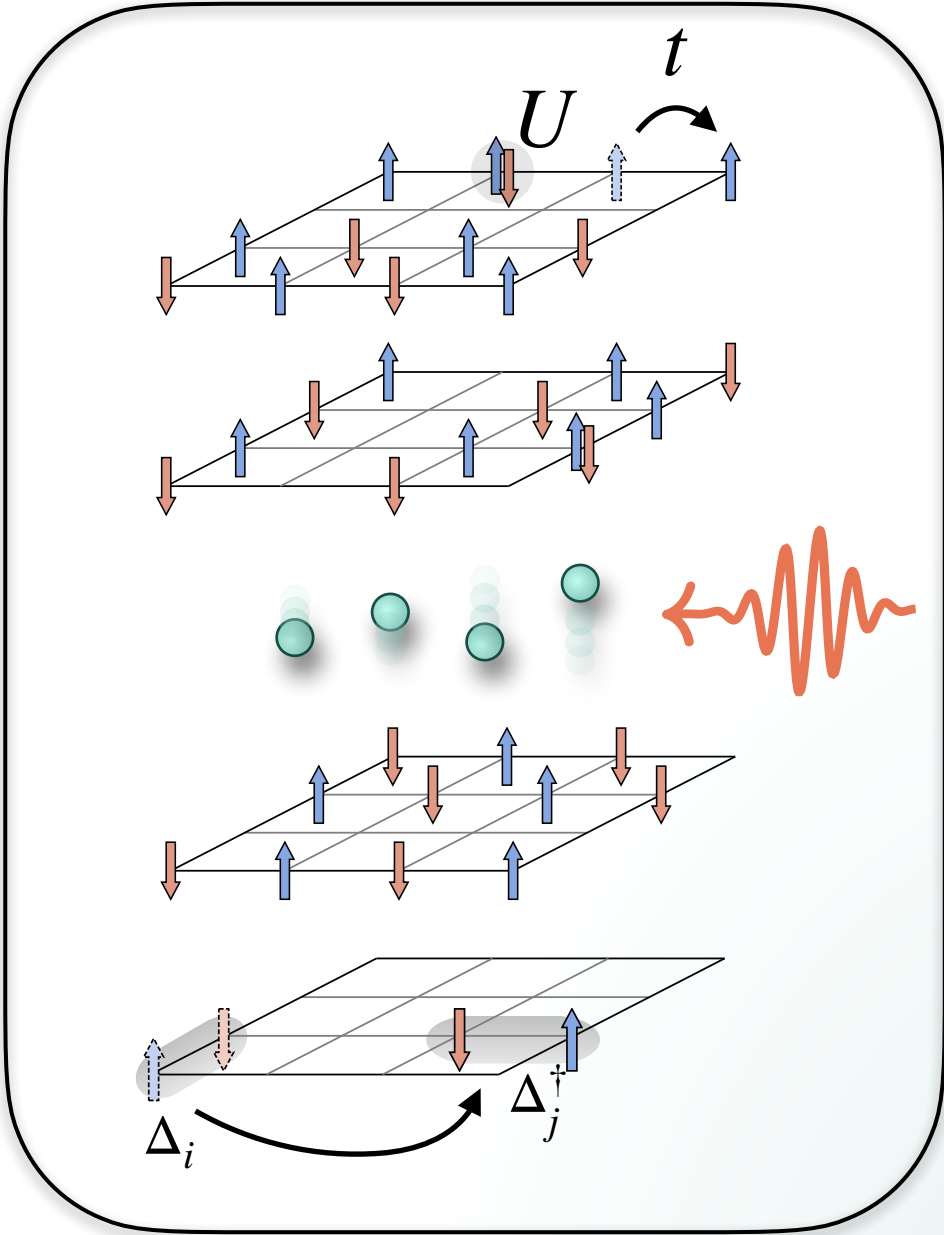






ϕ 100 K
 ϕ 300 K

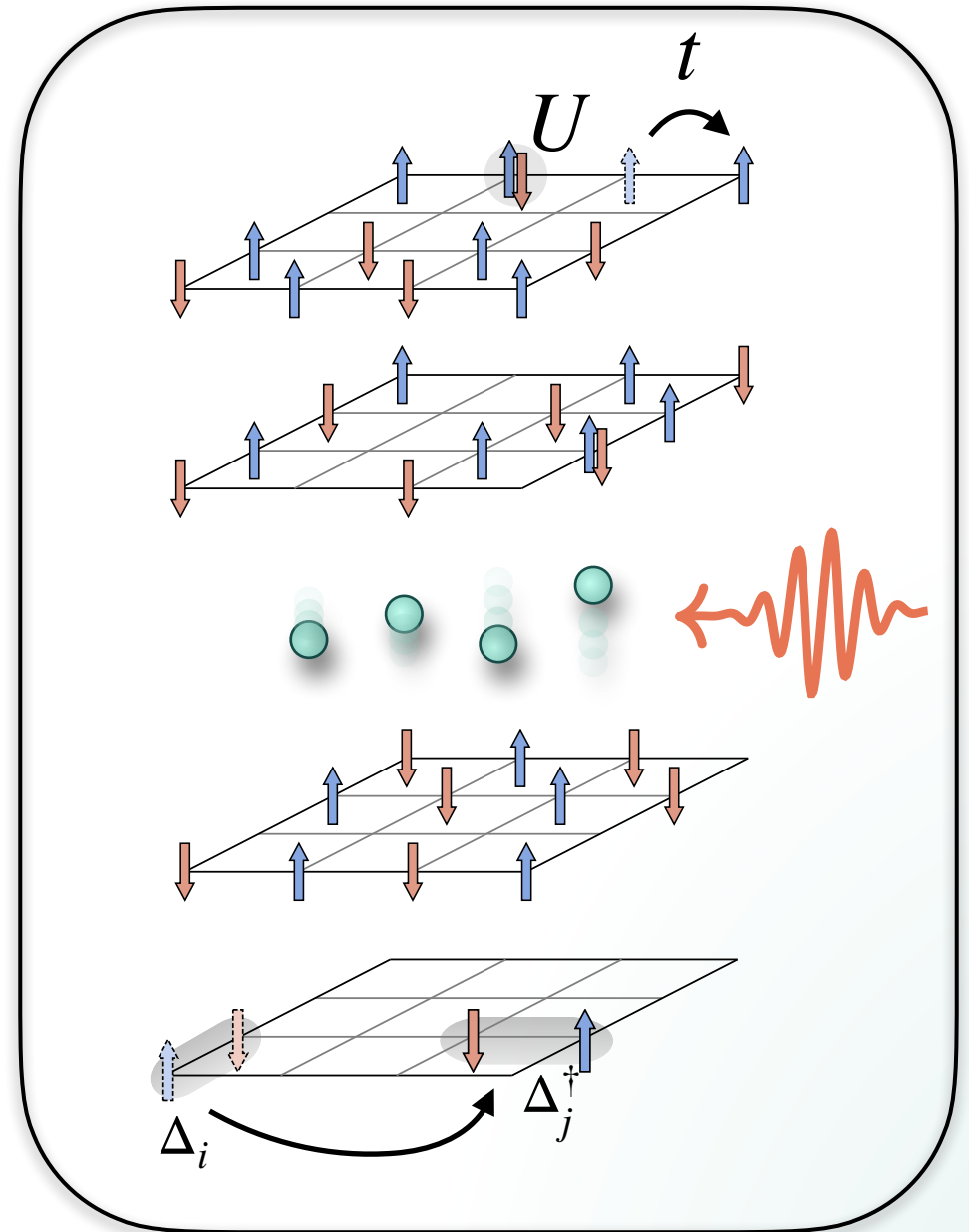




Features of a microscopic model

Strong Electronic Correlation

$$H = \sum_{ij\sigma} t_{ij} c_{i\sigma}^\dagger c_{j\sigma} + U \sum_i n_{i\uparrow} n_{i\downarrow} + \dots$$



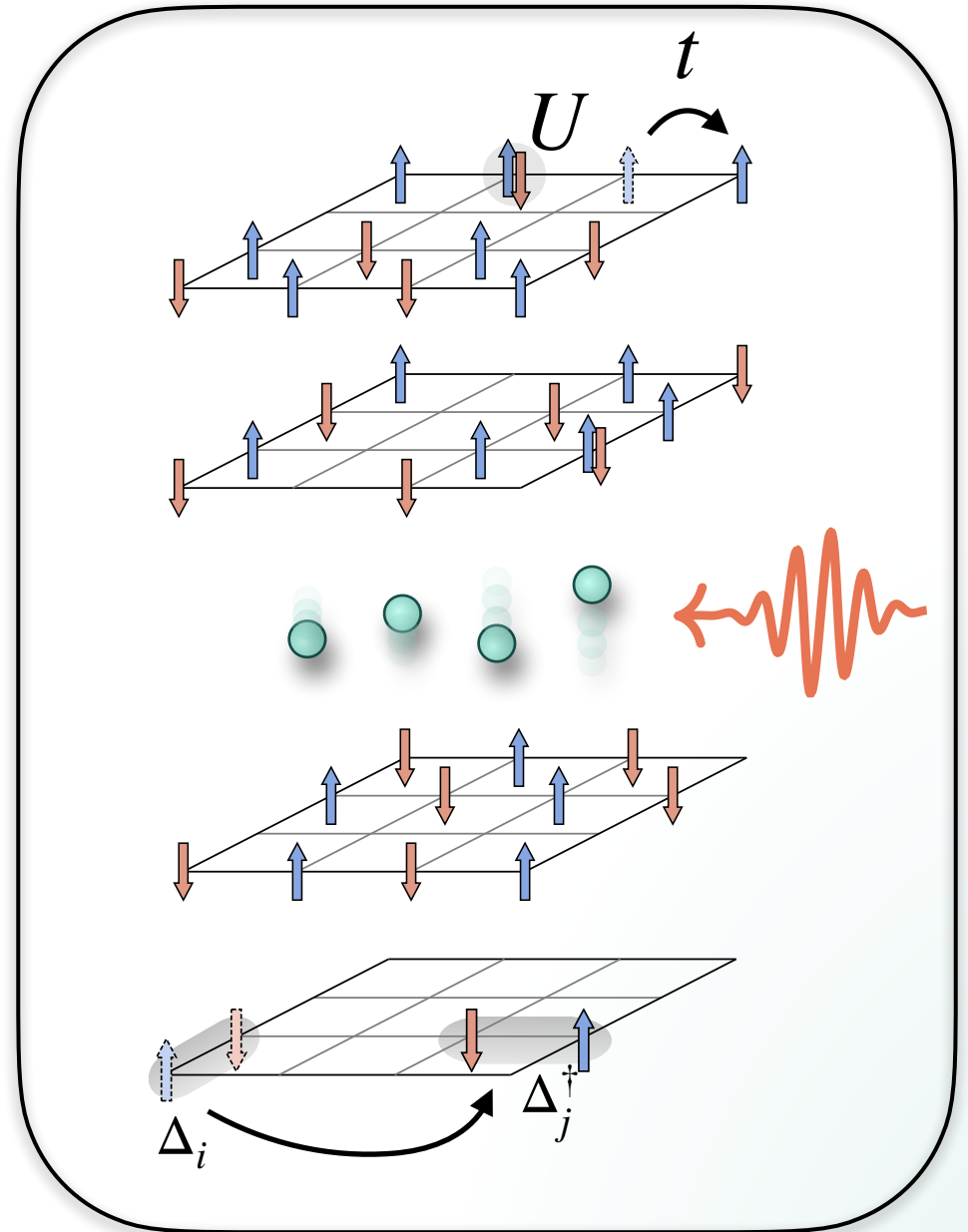
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Non-Equilibrium Drive

$$H = H(\tau)$$



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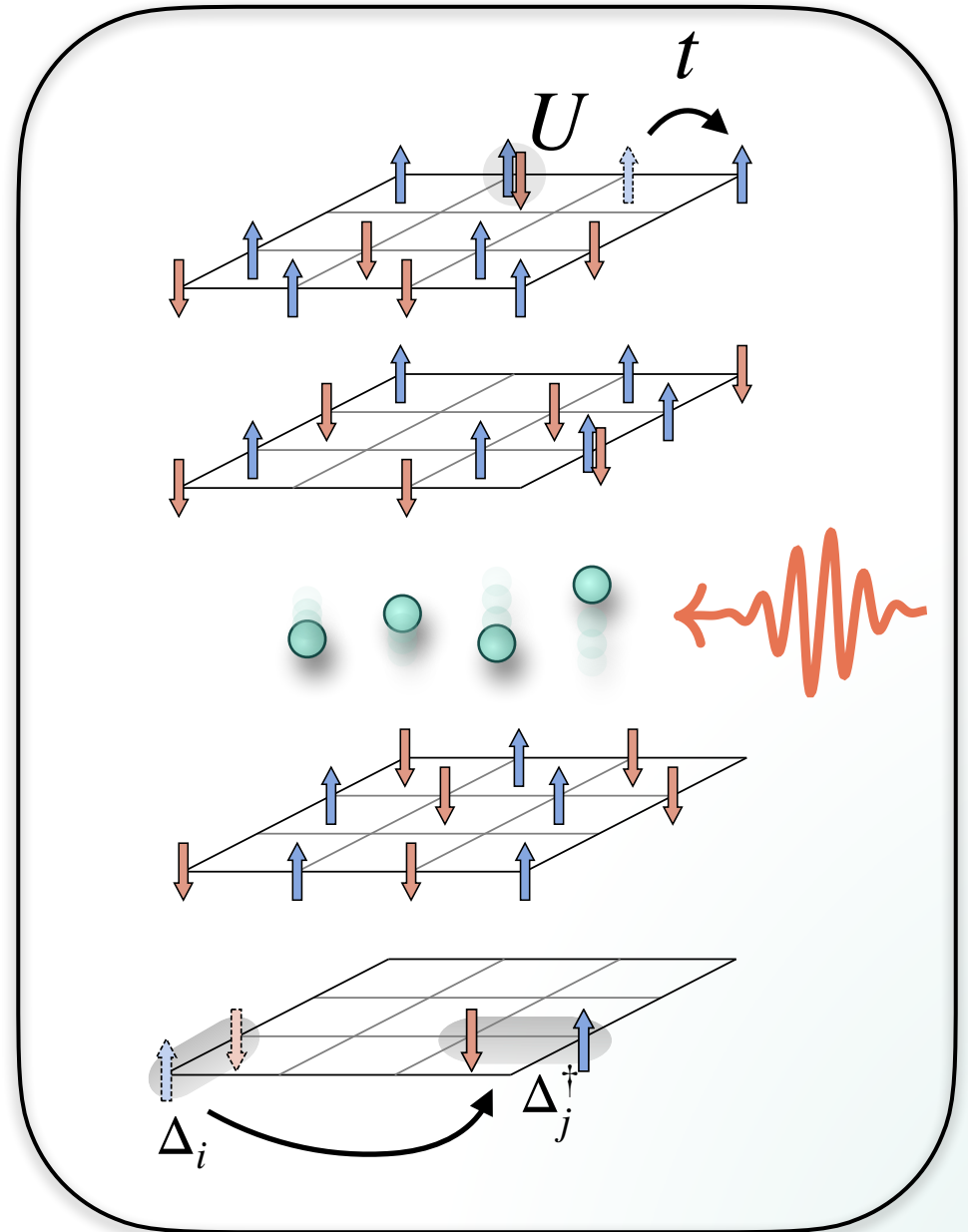
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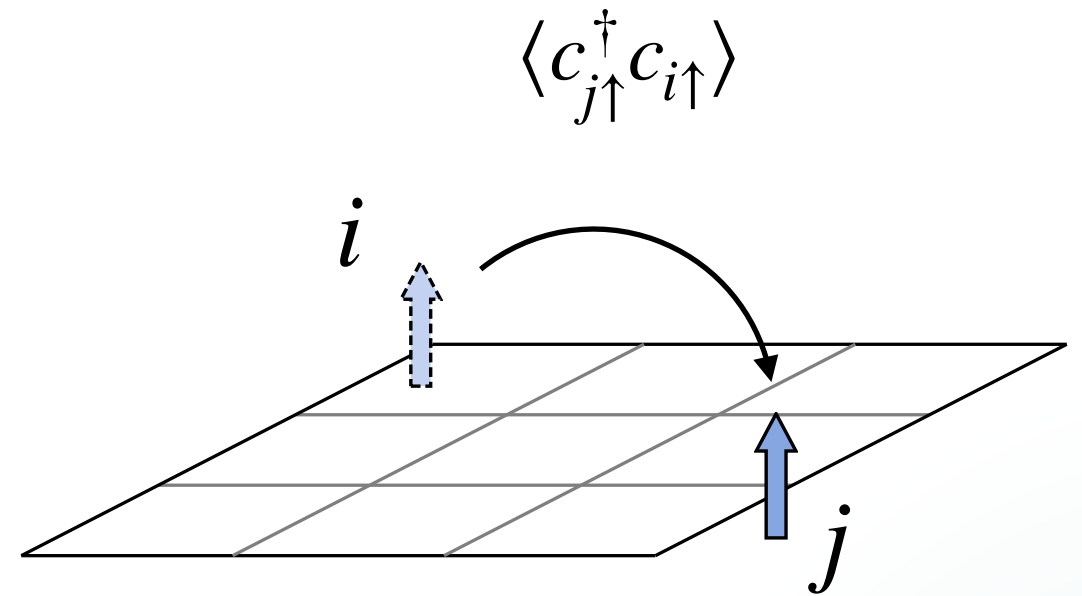
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Superconducting Pairing Correlation Measurement

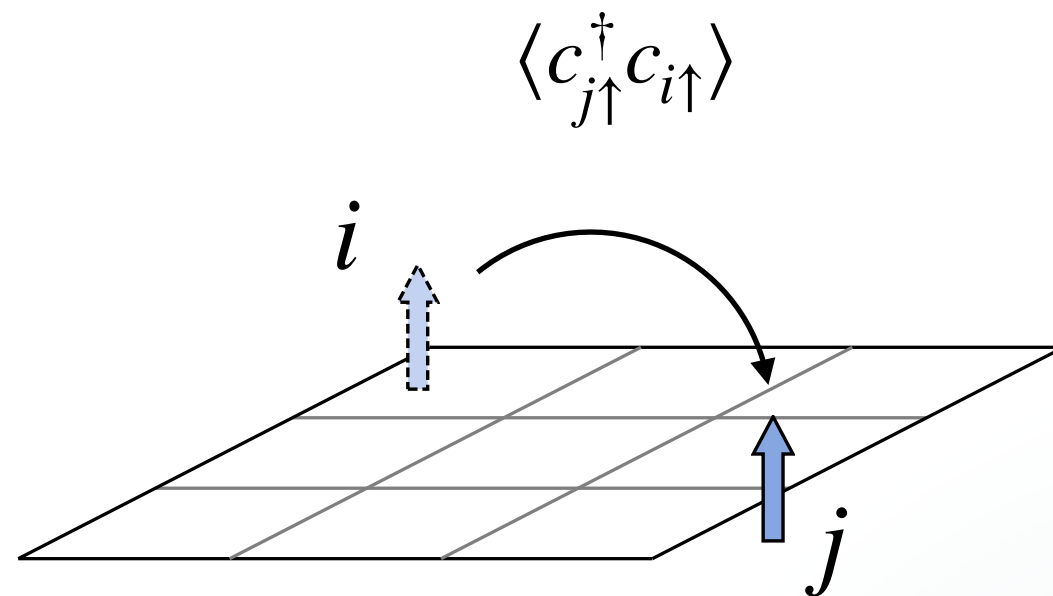
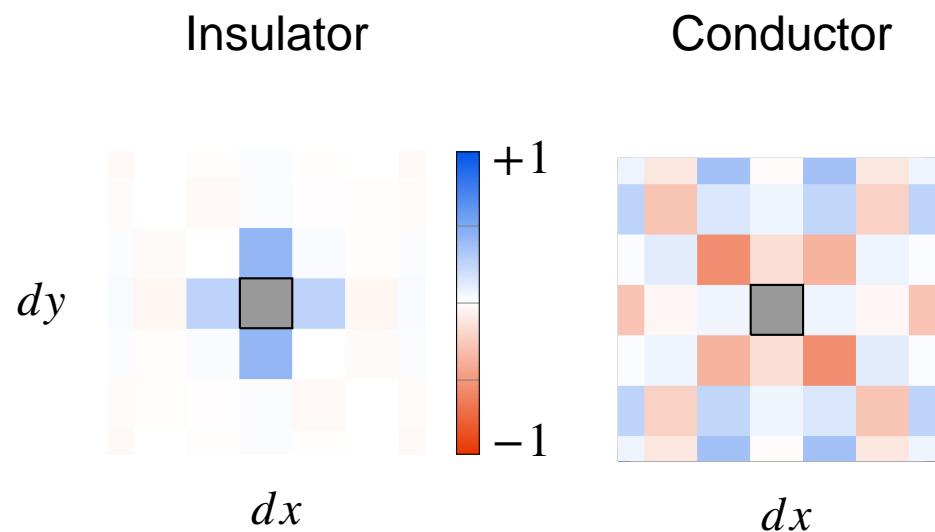
$$\text{Tr}[U(\tau)\rho_{\text{ini}}U^\dagger(\tau)\Delta_i^\dagger\Delta_j]$$



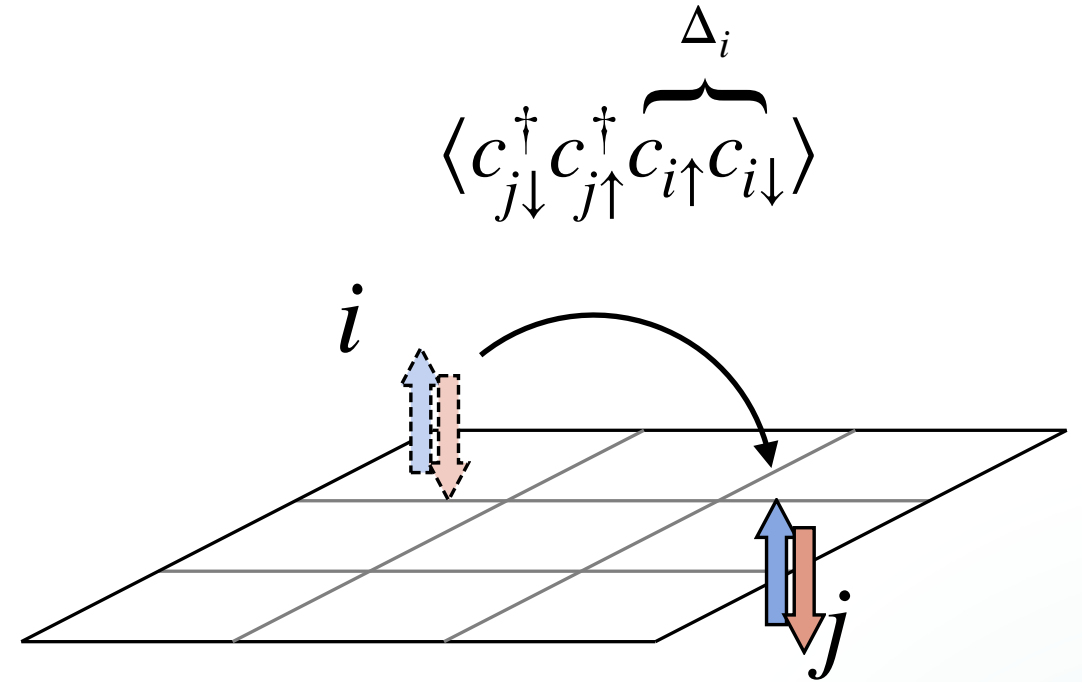
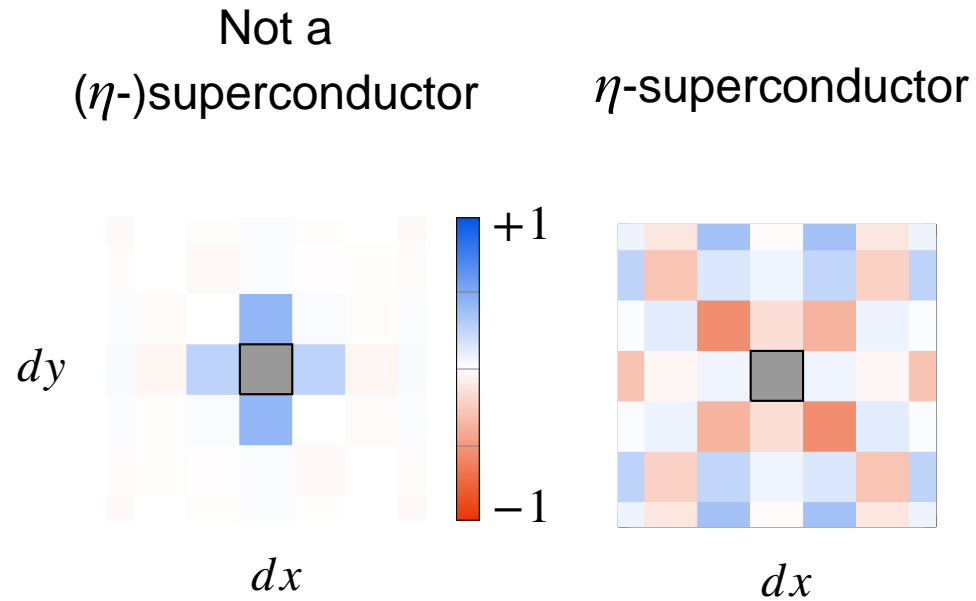
Superconducting Pairing Correlations



Superconducting Pairing Correlations



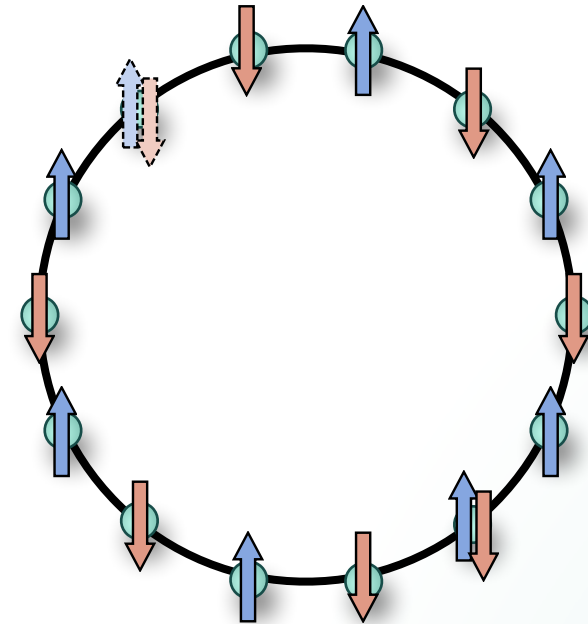
Superconducting Pairing Correlations



Classical State of the Art

($U/t = 8$)

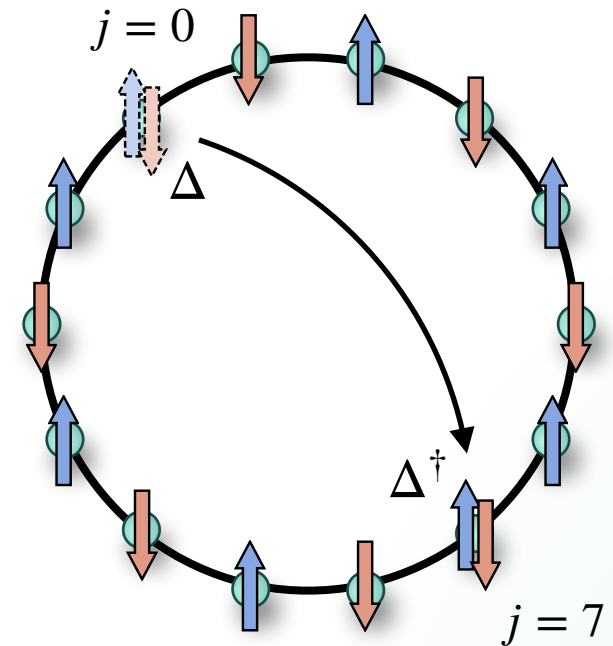
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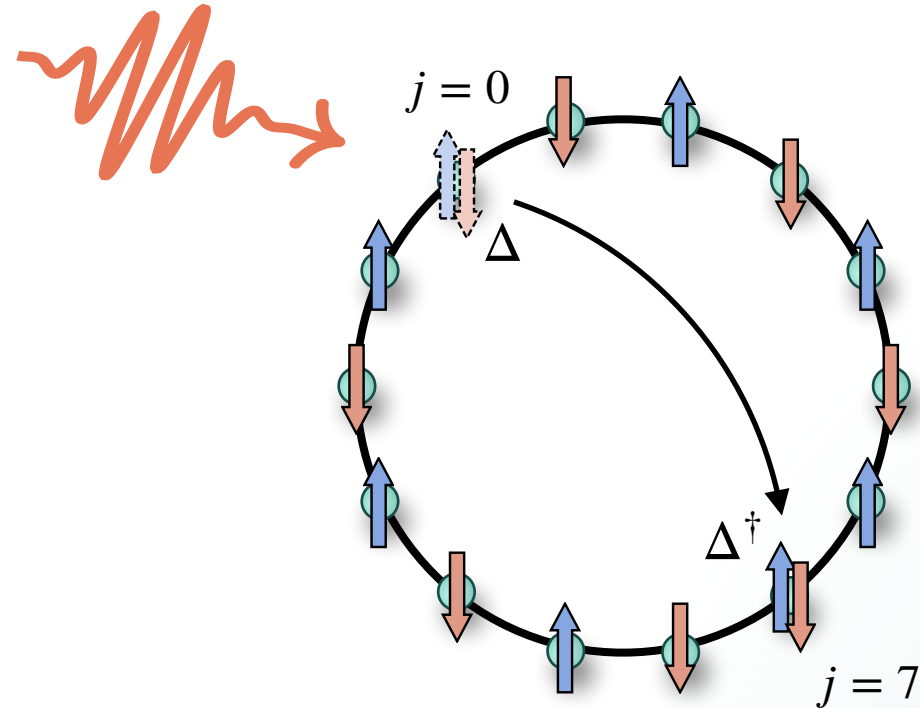
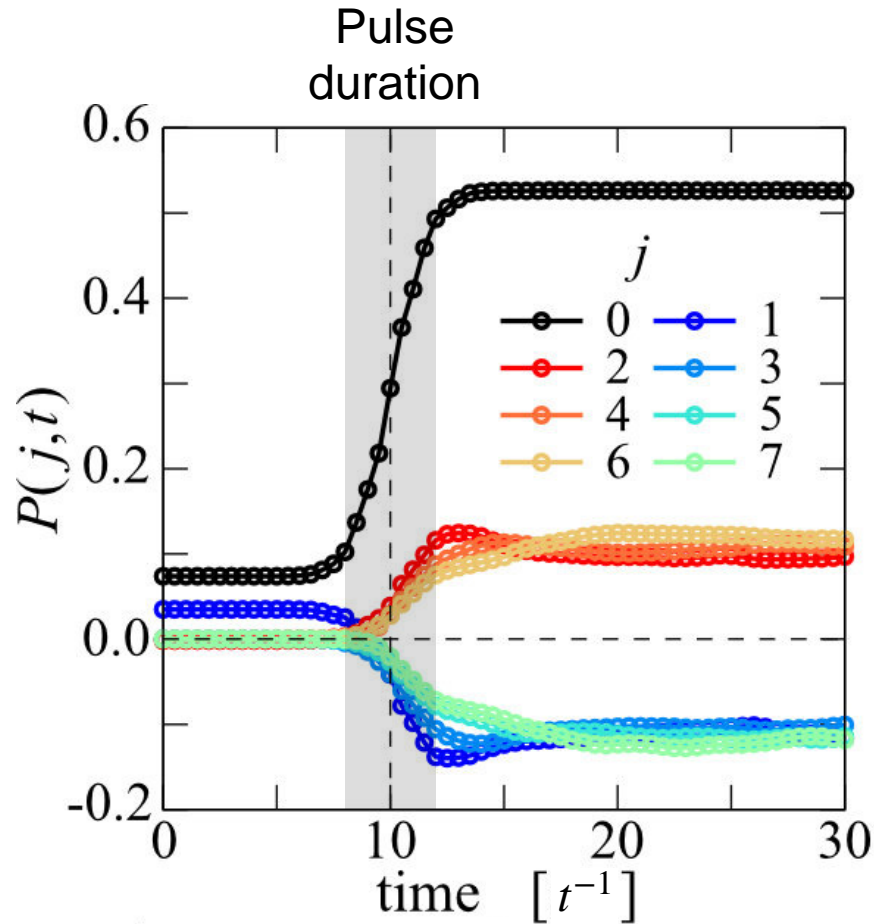
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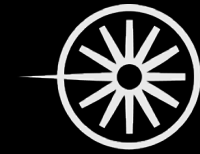


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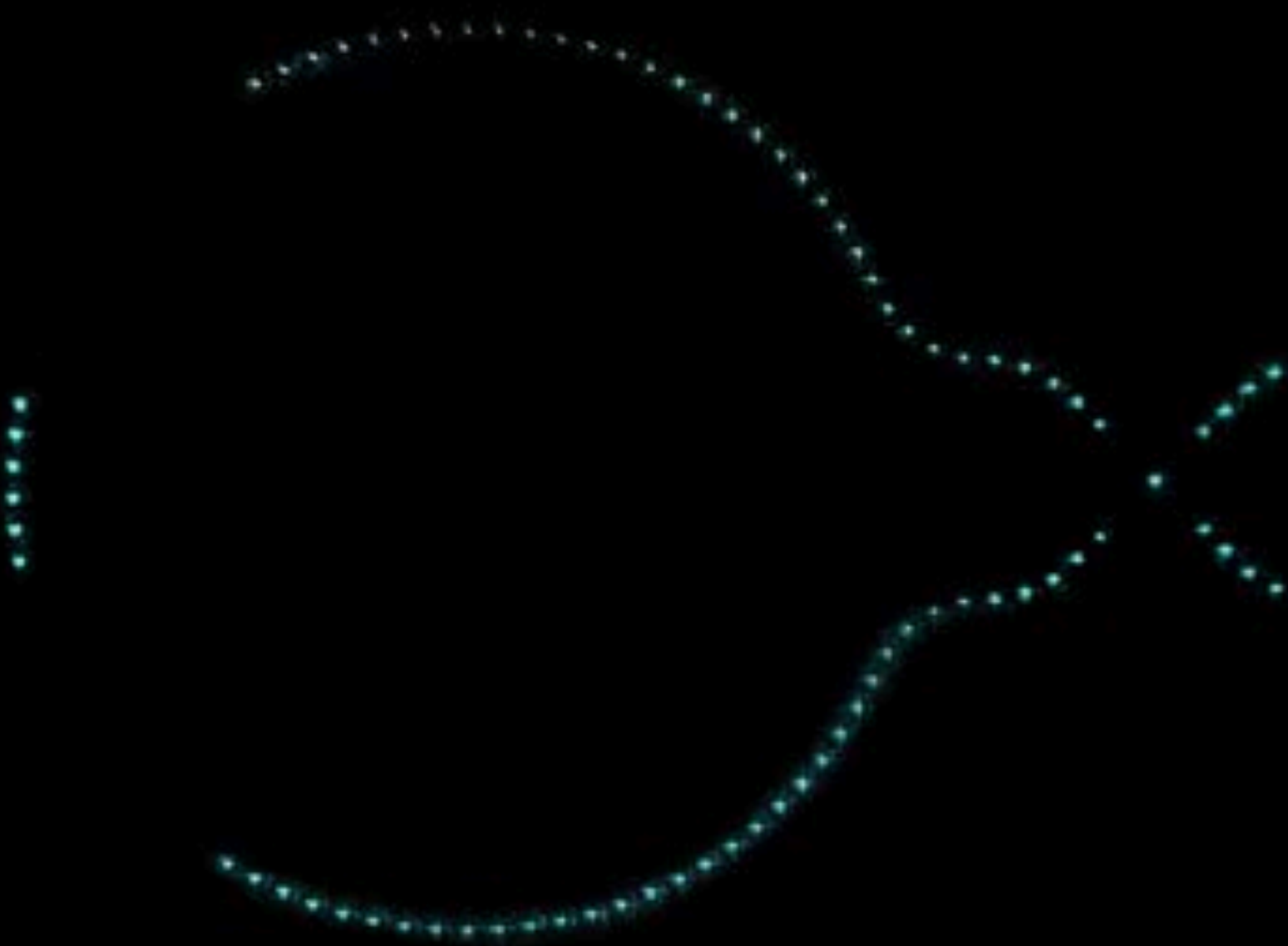
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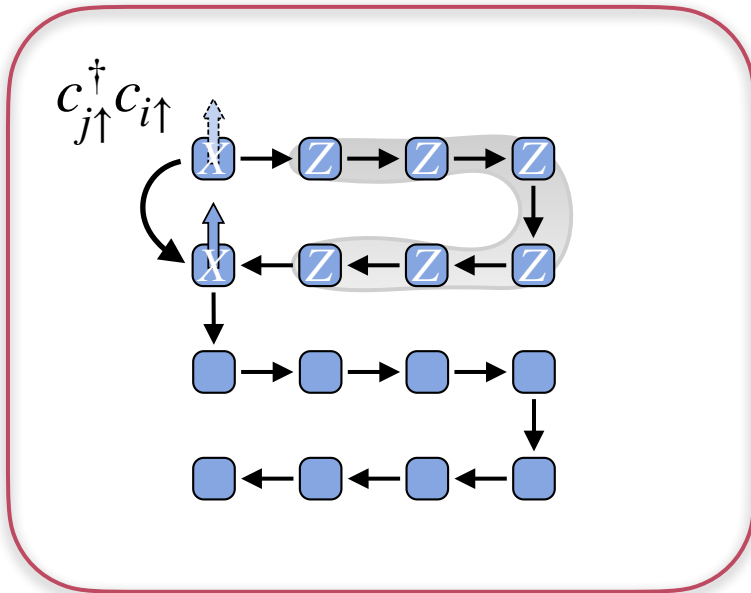
QUANTINUUM
HELIOS

Powered by Honeywell



Fermionic Encodings

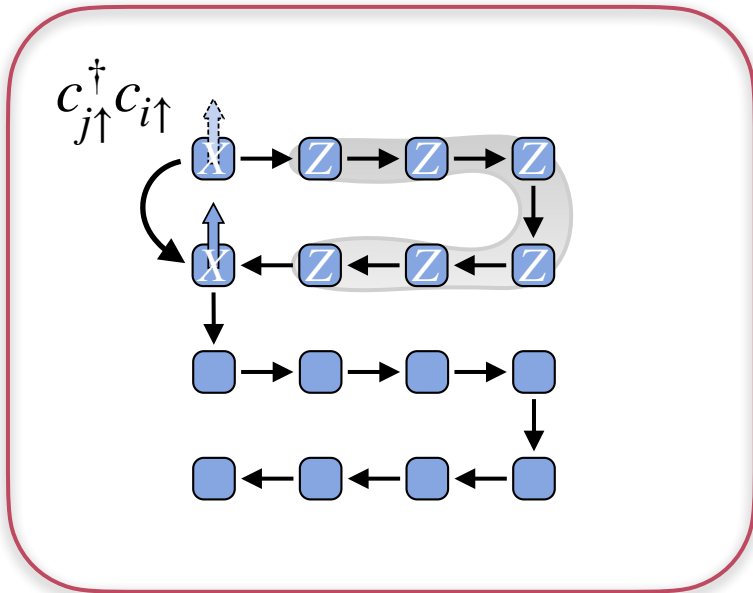
Jordan-Wigner



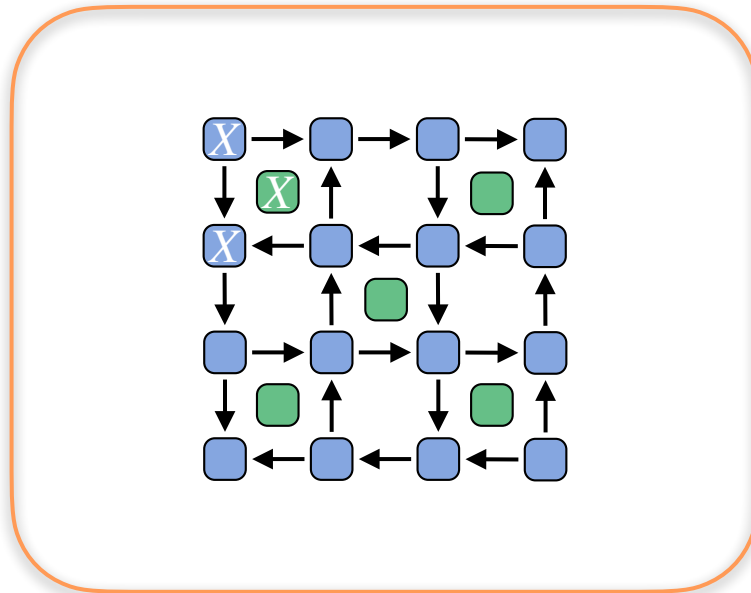
C Derby & J Klassen, *Phys. Rev. B* 104, 035118 (2021),
Dilution of Error in Digital Hamiltonian Simulation, E Granet & H Dreyer, *PRX Quantum* (2025)
E Chertkov et al, *arXiv:2410.10794*,
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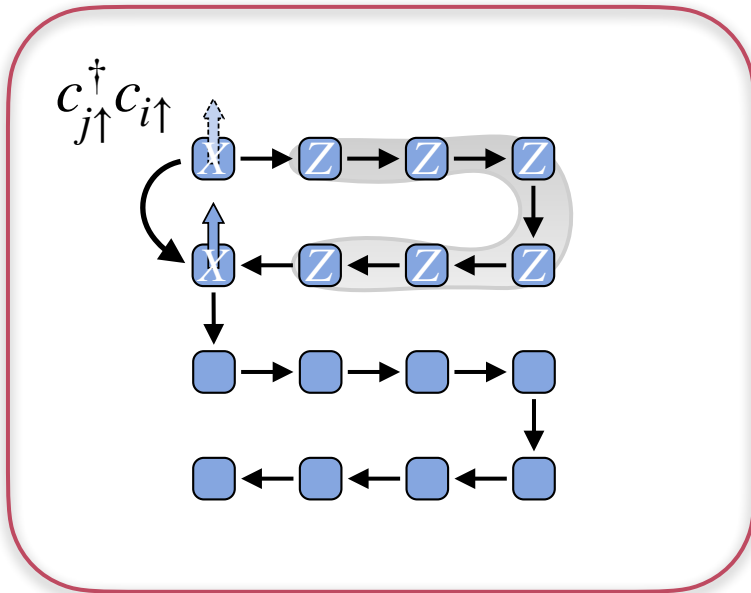
Compact



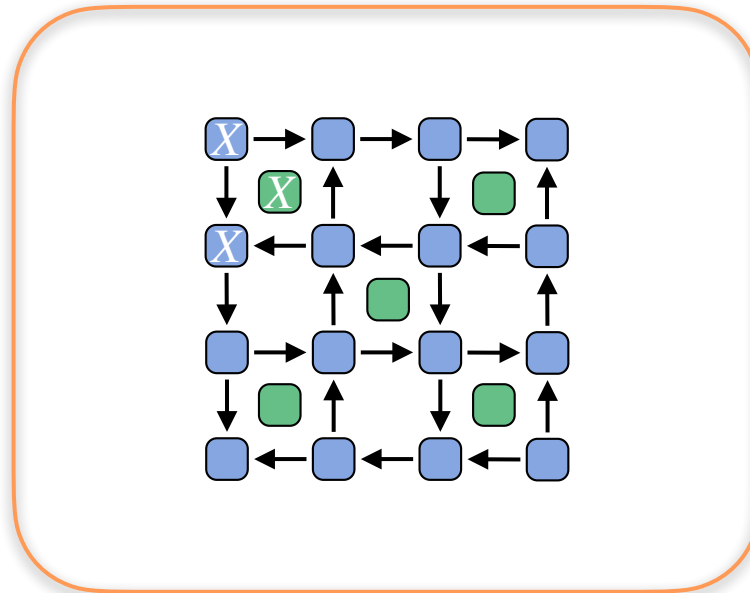
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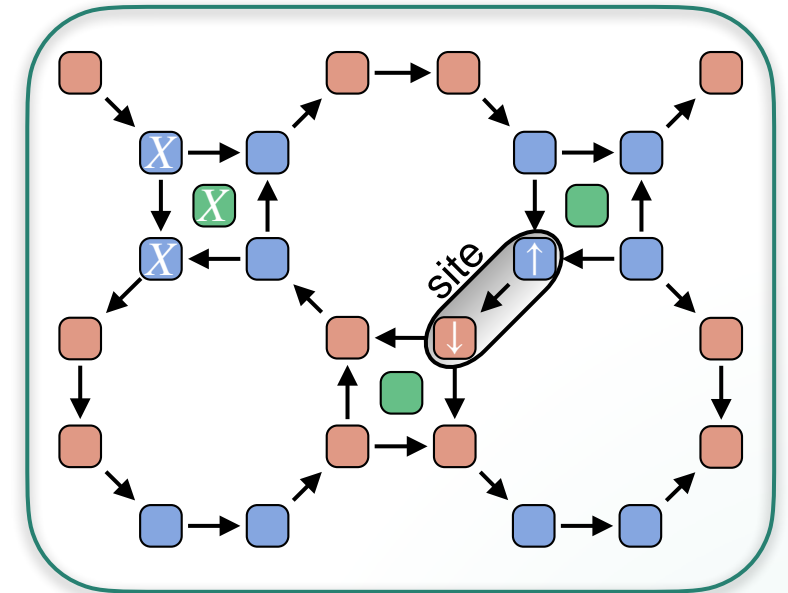
Jordan-Wigner



Compact



Octagon

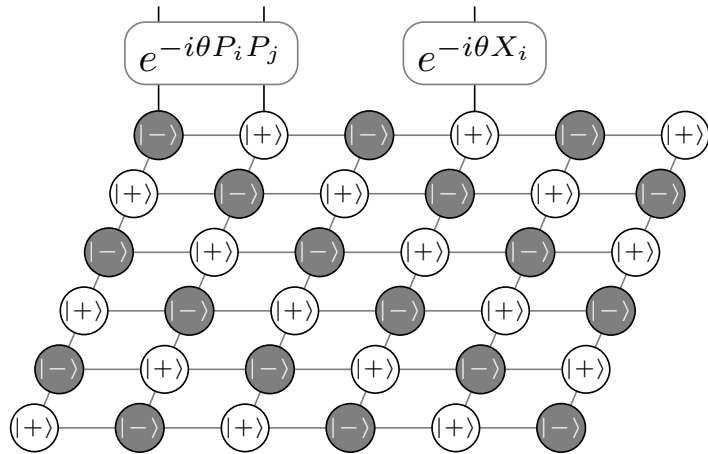


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Injection for low energy state preparation

$(U/t = \infty)$

$$H_{\text{Heisenberg}} = J \sum_{ij} X_i X_j + Y_i Y_j + Z_i Z_j$$

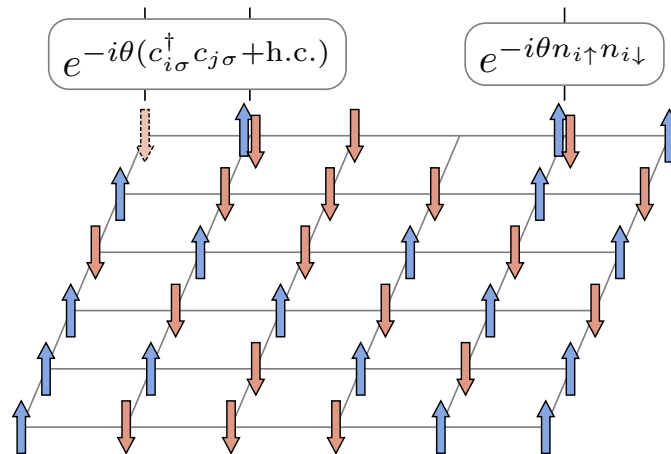
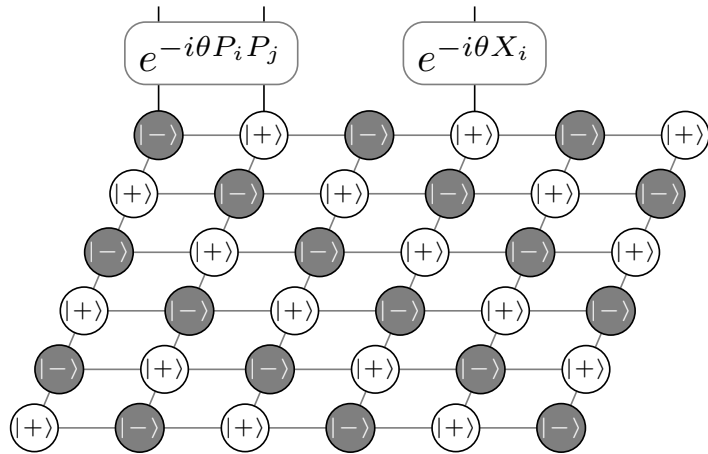


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($U/t = \infty \rightarrow 8$)

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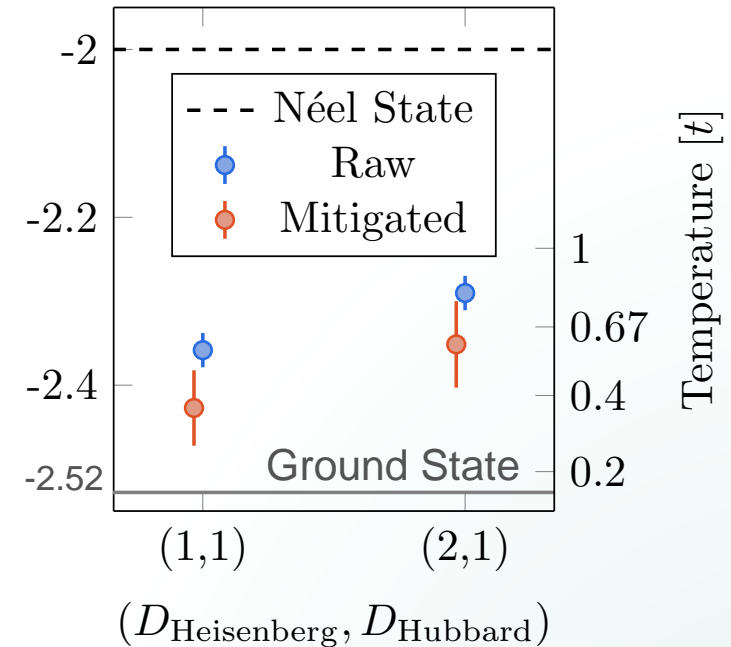
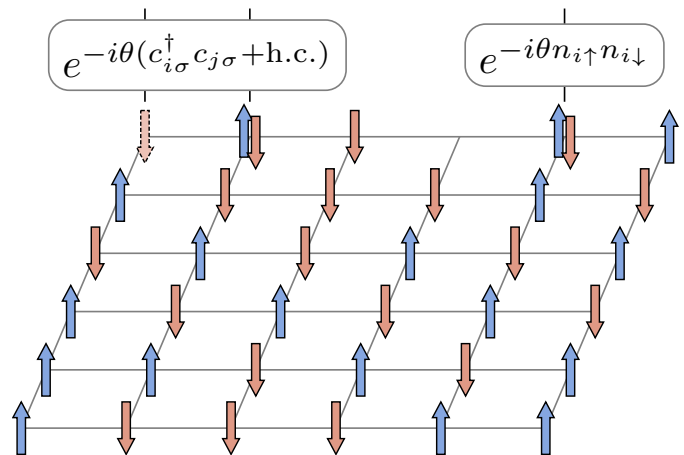
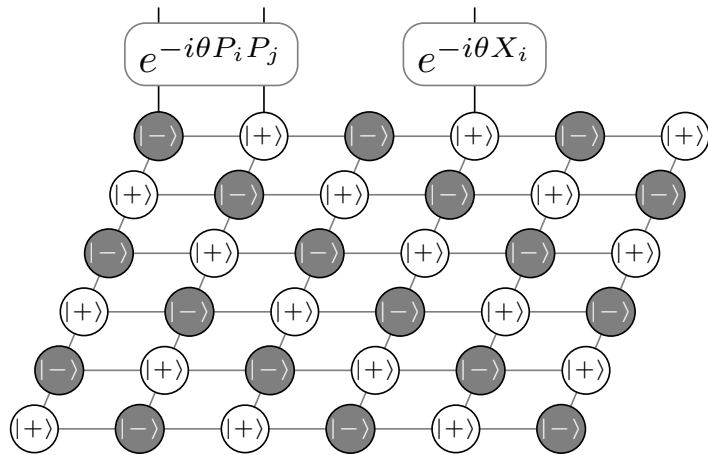


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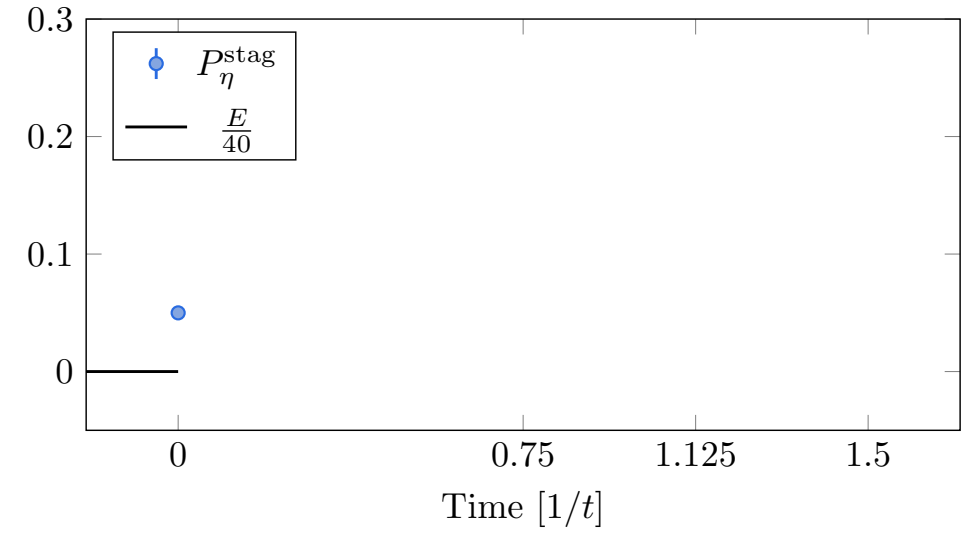
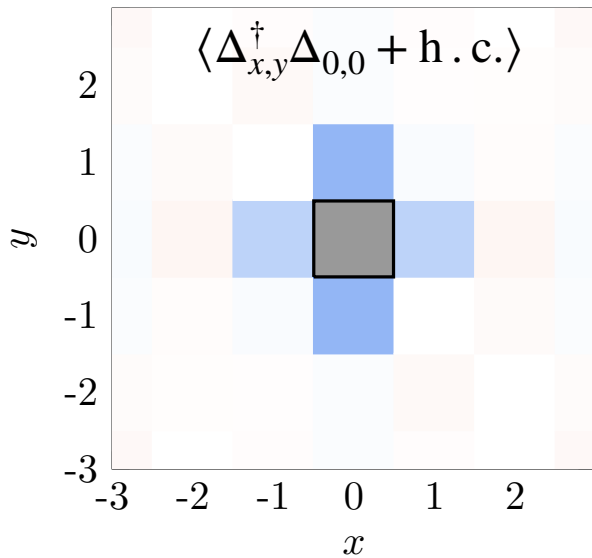
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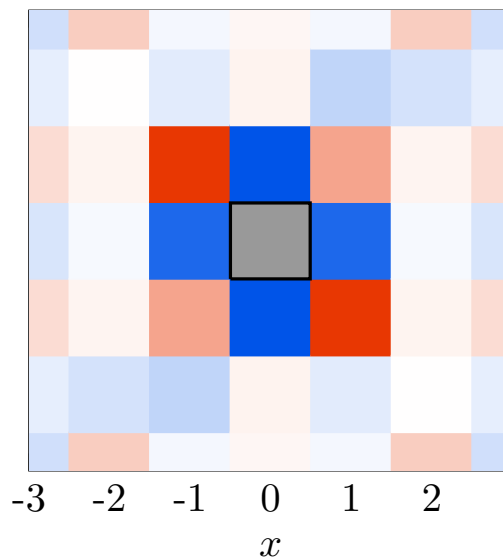
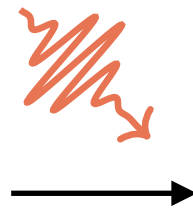
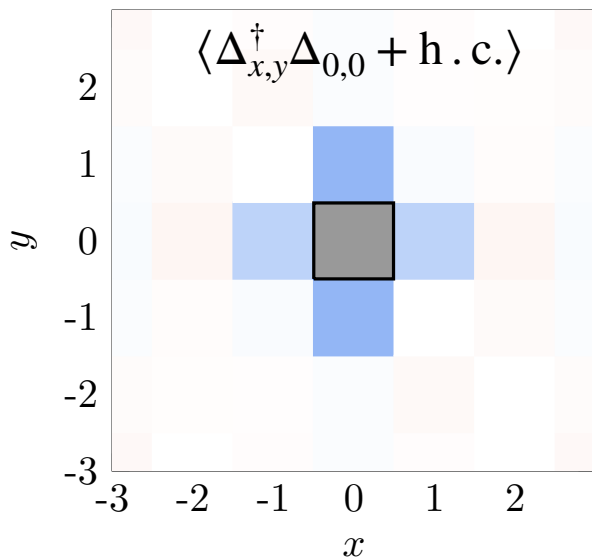
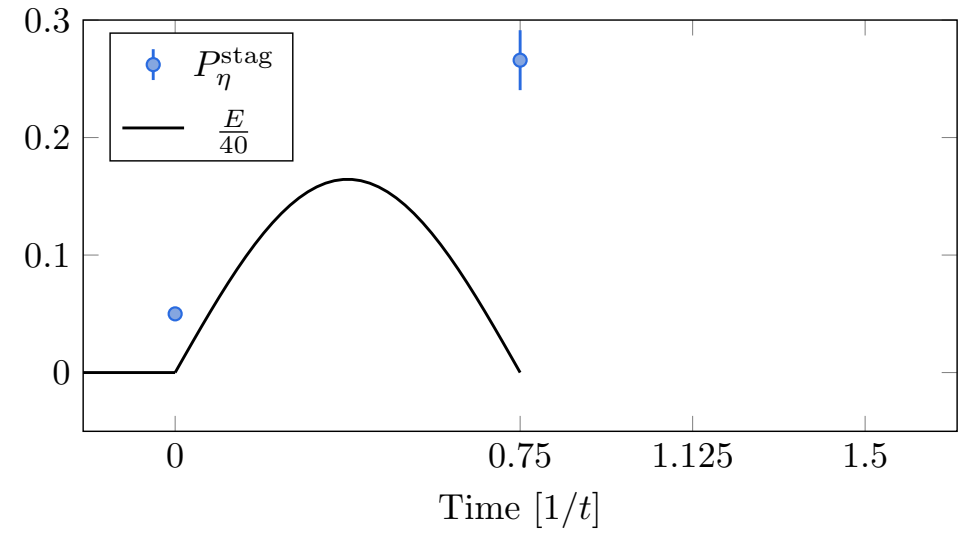
η -correlations

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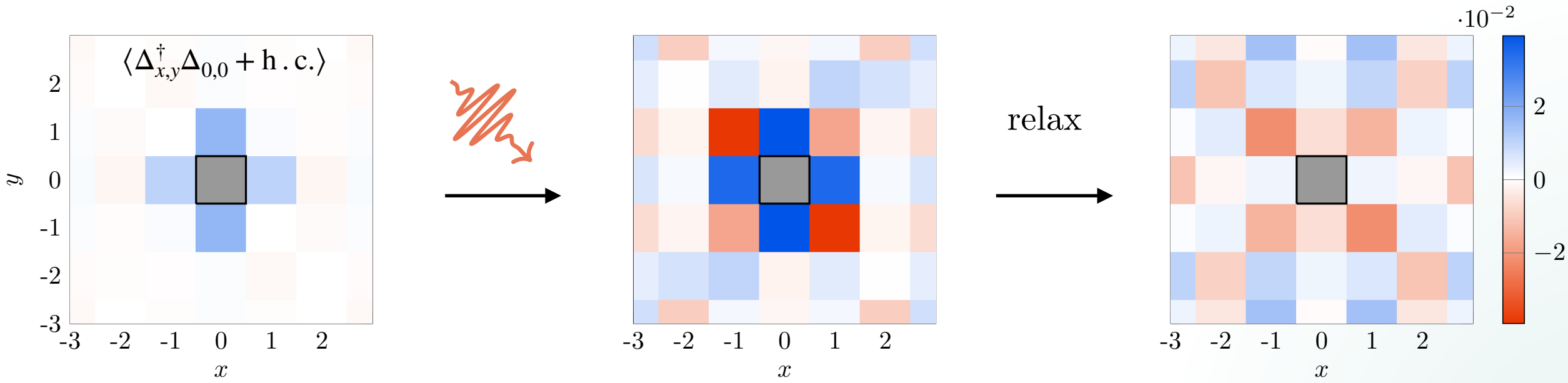
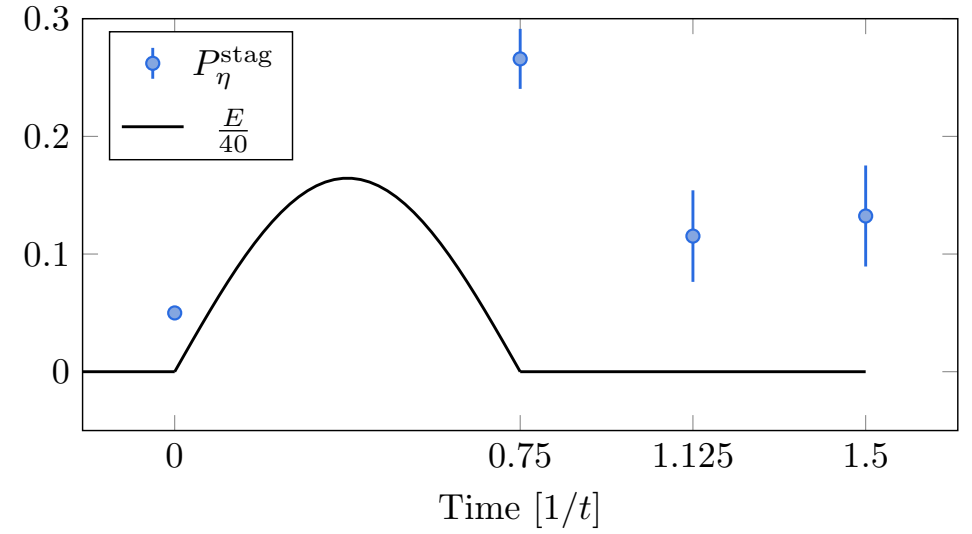


η -correlations after light pulse

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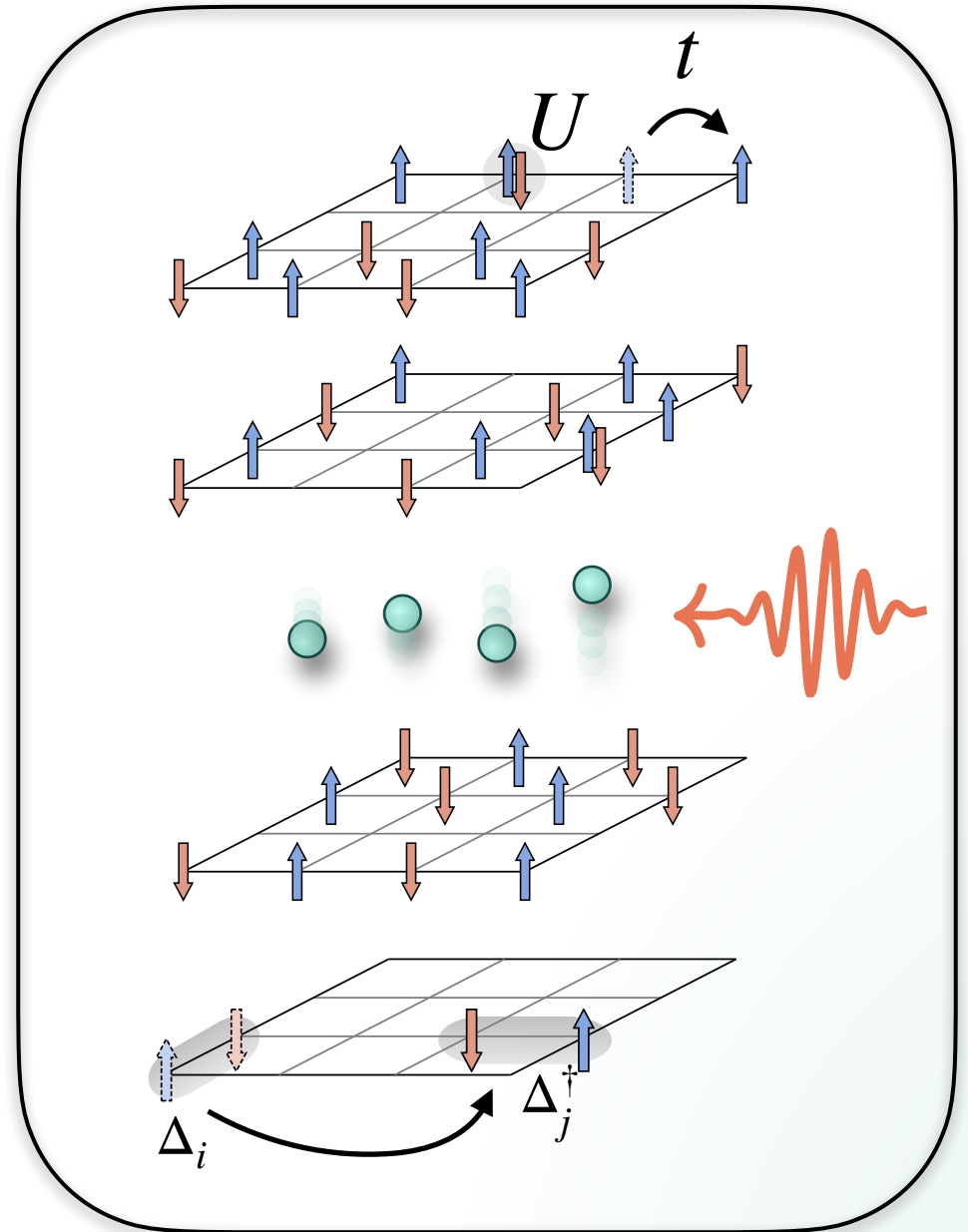


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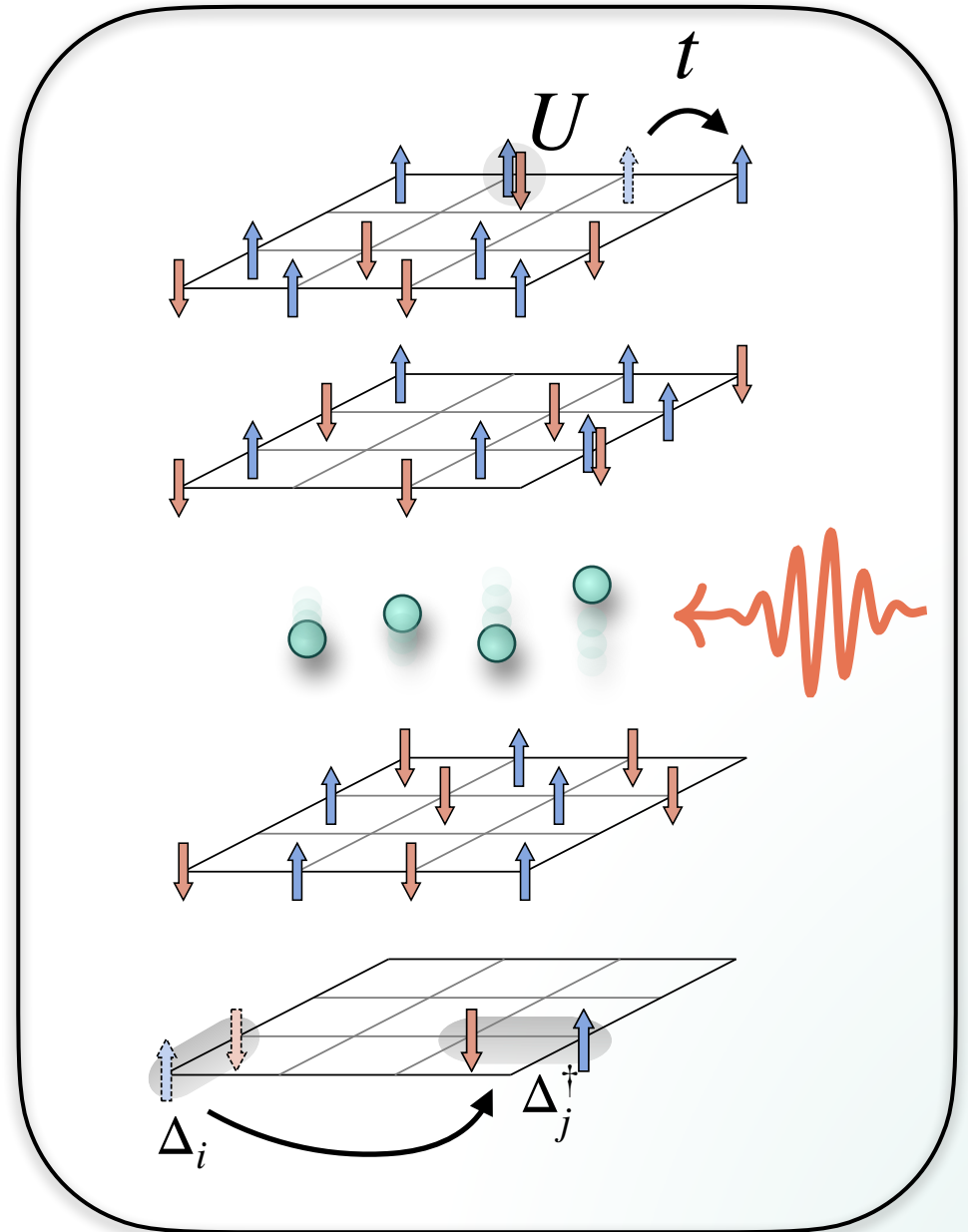
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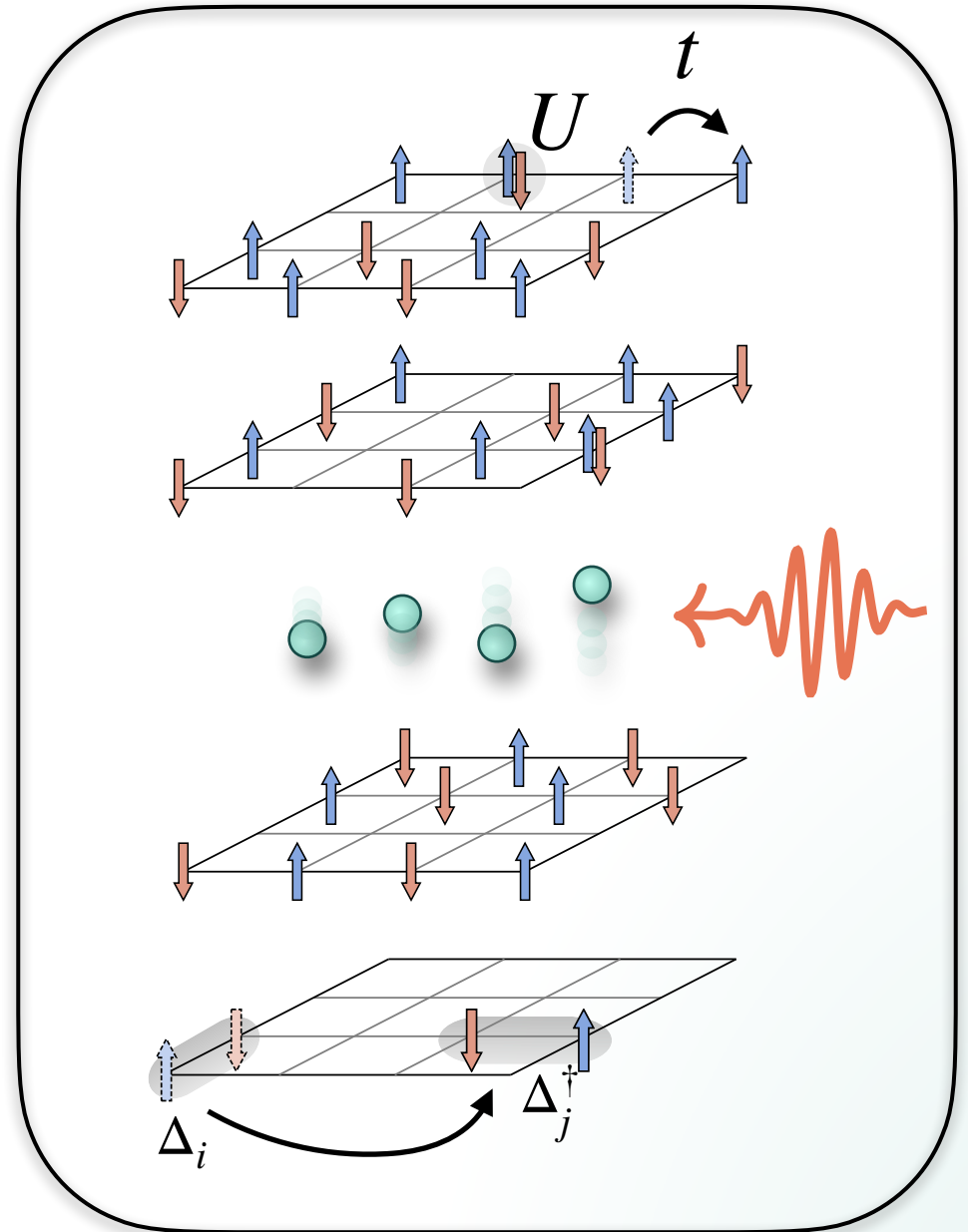
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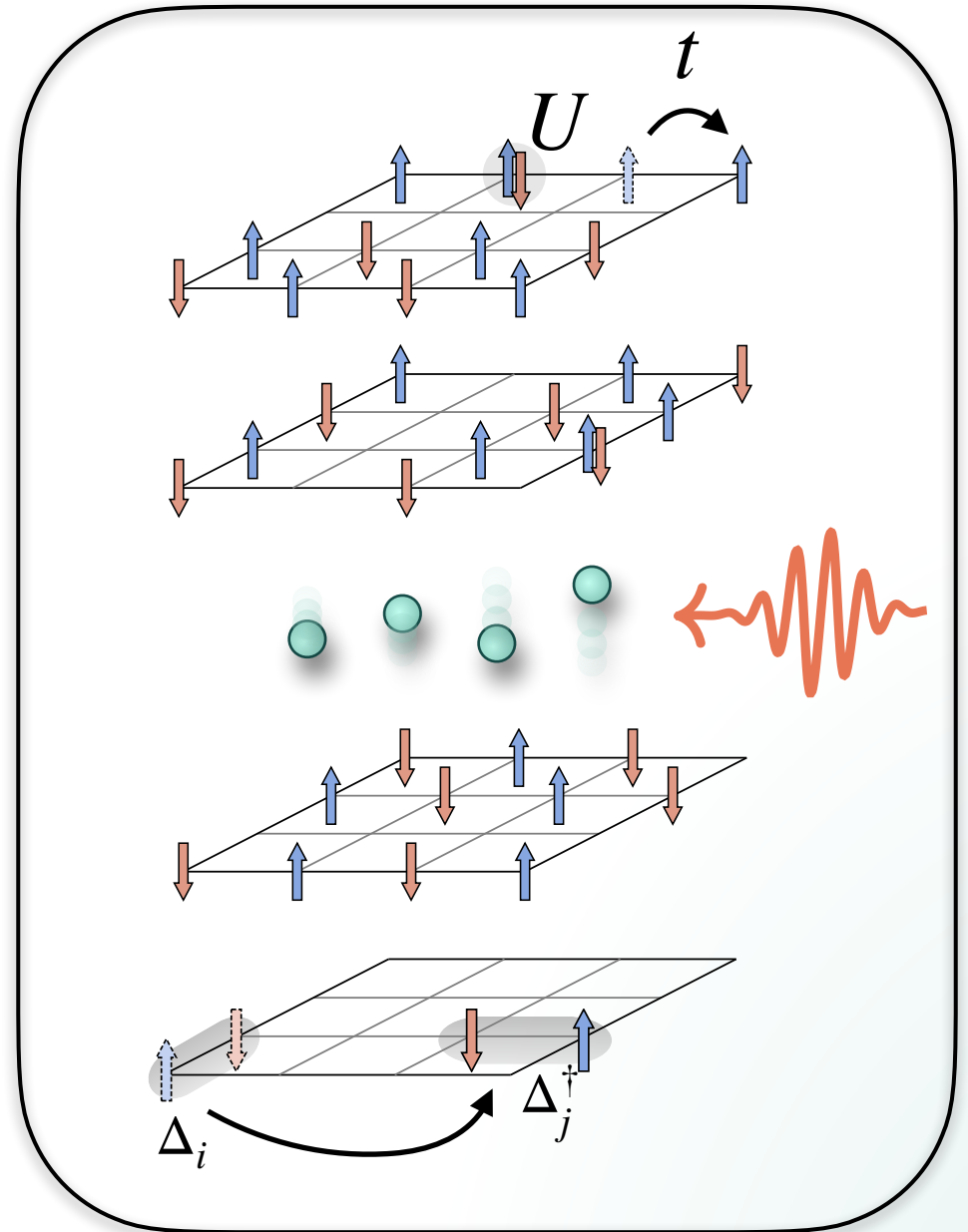
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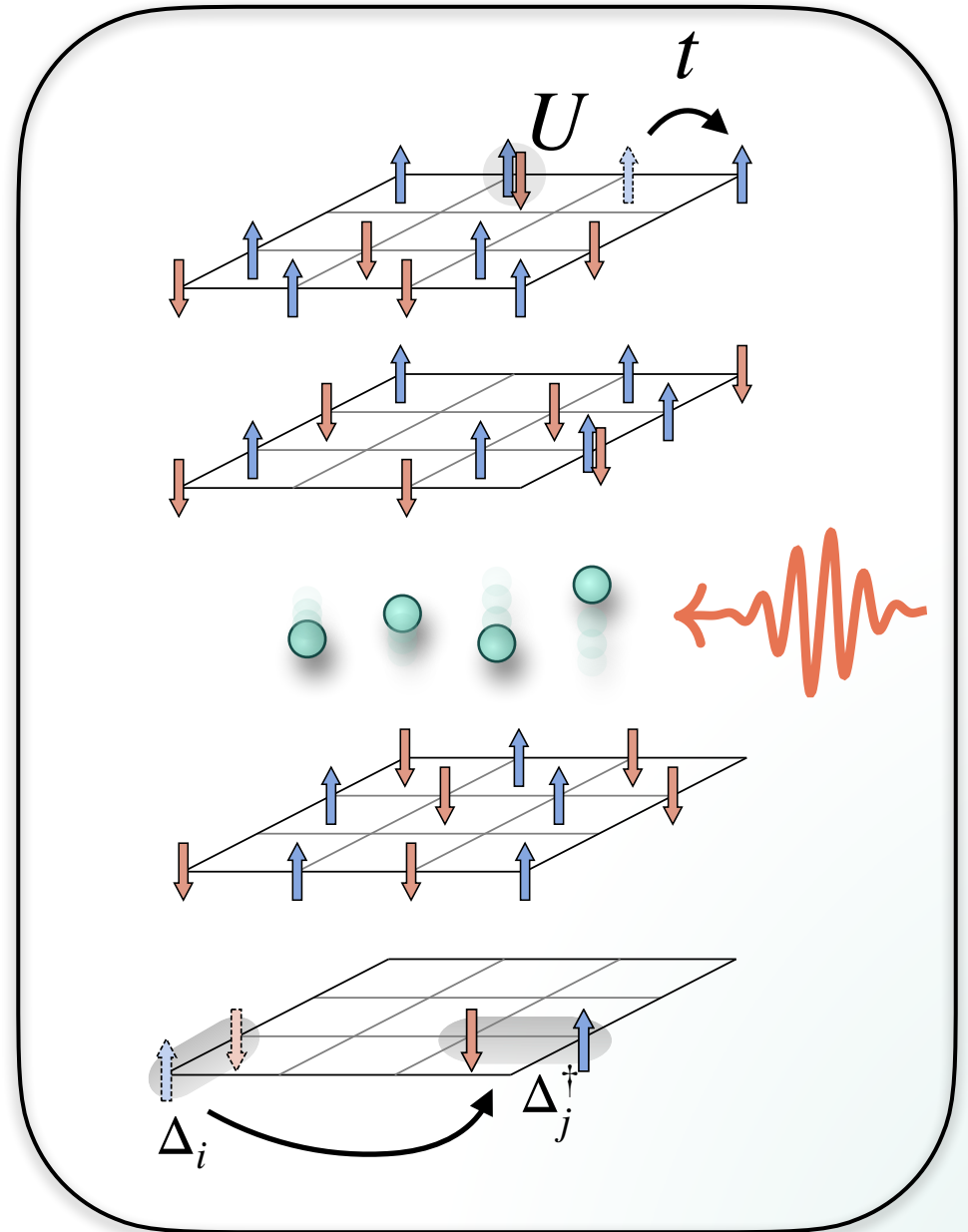
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Acknowledgements

EQUAHUMO
Efficient Quantum Algorithms
for the Hubbard Model



Gefördert durch



Bayerisches Staatsministerium für
Wirtschaft, Landesentwicklung und Energie

GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung



Etienne
Granet



Sheng-Hsuan
Lin



Kevin
Hémary



Ramil
Nigmatullin



Mohsin
Iqbal

Superconducting pairing correlations on a trapped-ion quantum computer

Etienne Granet,¹ Sheng-Hsuan Lin,¹ Kevin Hémary,¹ Reza Haghshenas,² Pablo Andres-Martinez,³ David T. Stephen,² Anthony Ransford,² Jake Arkinstall,³ M.S. Allman,² Pete Campora,² Samuel F. Cooper,² Robert D. Delaney,² Joan M. Dreiling,² Brian Estey,² Caroline Figgatt,² Cameron Foltz,² John P. Gaebler,² Alex Hall,² Ali Husain,⁴ Akhil Isanaka,² Colin J. Kennedy,² Nikhil Kotibhaskar,⁵ Ivaylo S. Madjarov,² Michael Mills,² Alistair R. Milne,⁵ Annie J. Park,² Adam P. Reed,² Brian Neyenhuis,² Justin G. Bohnet,² Michael Foss-Feig,² Andrew C. Potter,² Ramil Nigmatullin,³ Mohsin Iqbal,¹ and Henrik Dreyer^{1,*}

¹Quantinuum, Leopoldstrasse 180, 80804 Munich, Germany

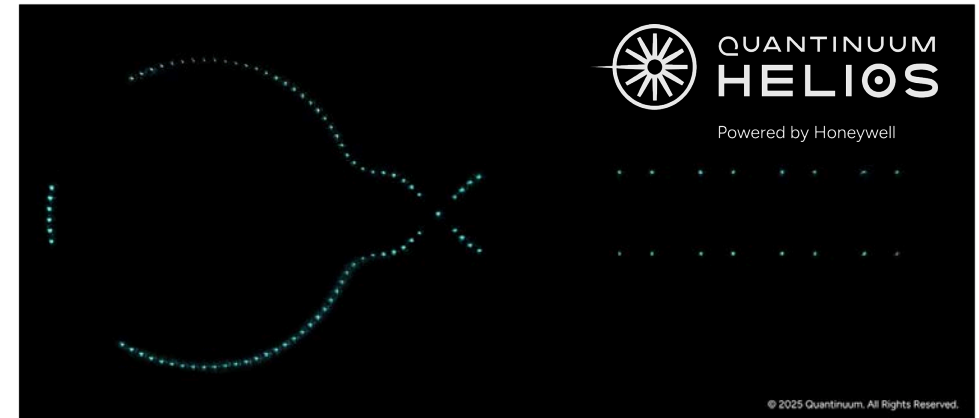
²Quantinuum, 303 S Technology Ct, Broomfield, CO 80021, USA

³Quantinuum, Terrington House, 13-15 Hills Road, Cambridge CB2 1NL, UK

⁴Quantinuum, 8799 Brooklyn Boulevard, Brooklyn Park, MN 55428, USA

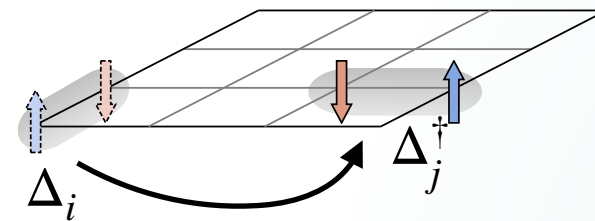
⁵Quantinuum, Partnership House, Carlisle Place, London SW1P 1BX, UK

(Dated: December 19, 2025)



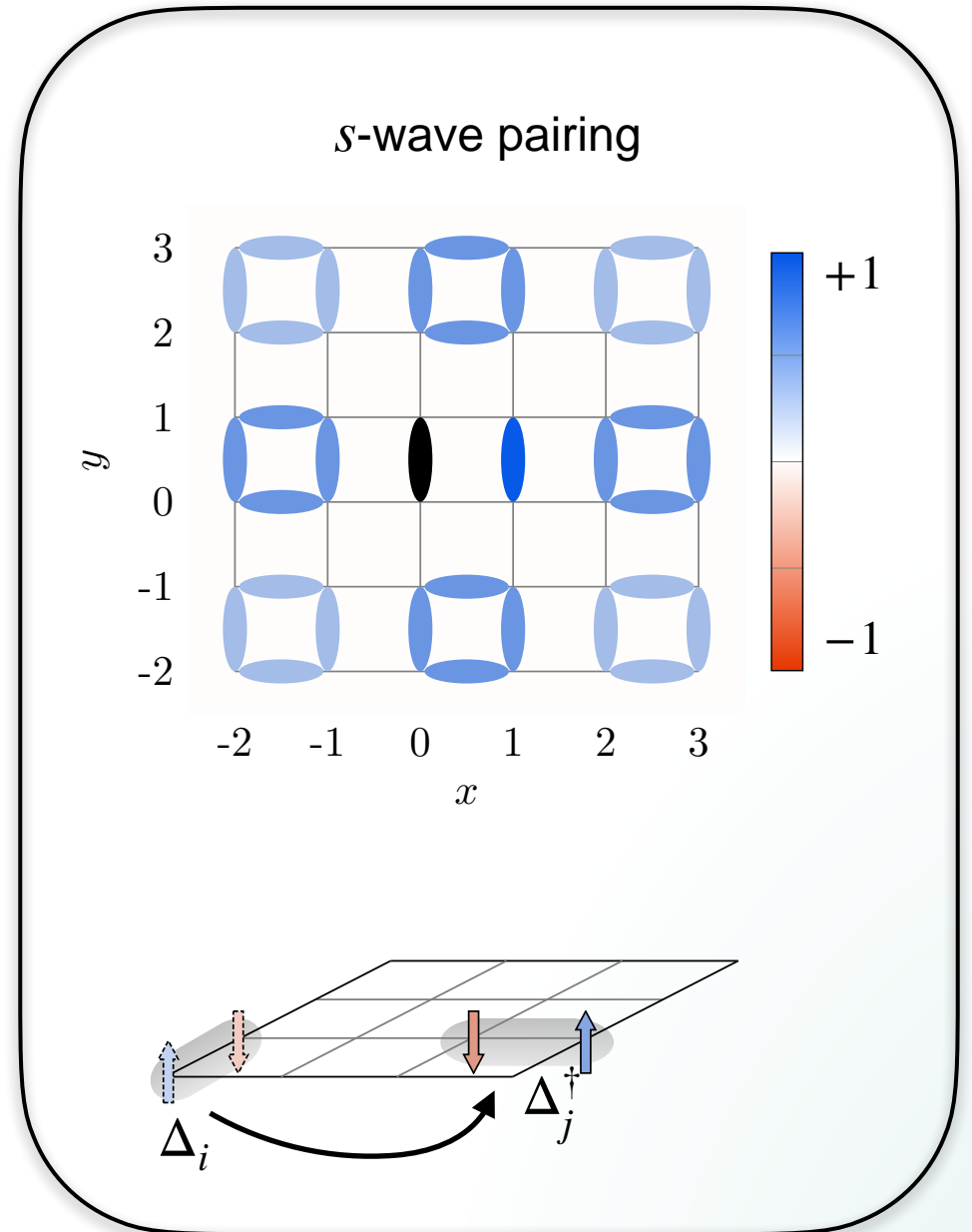
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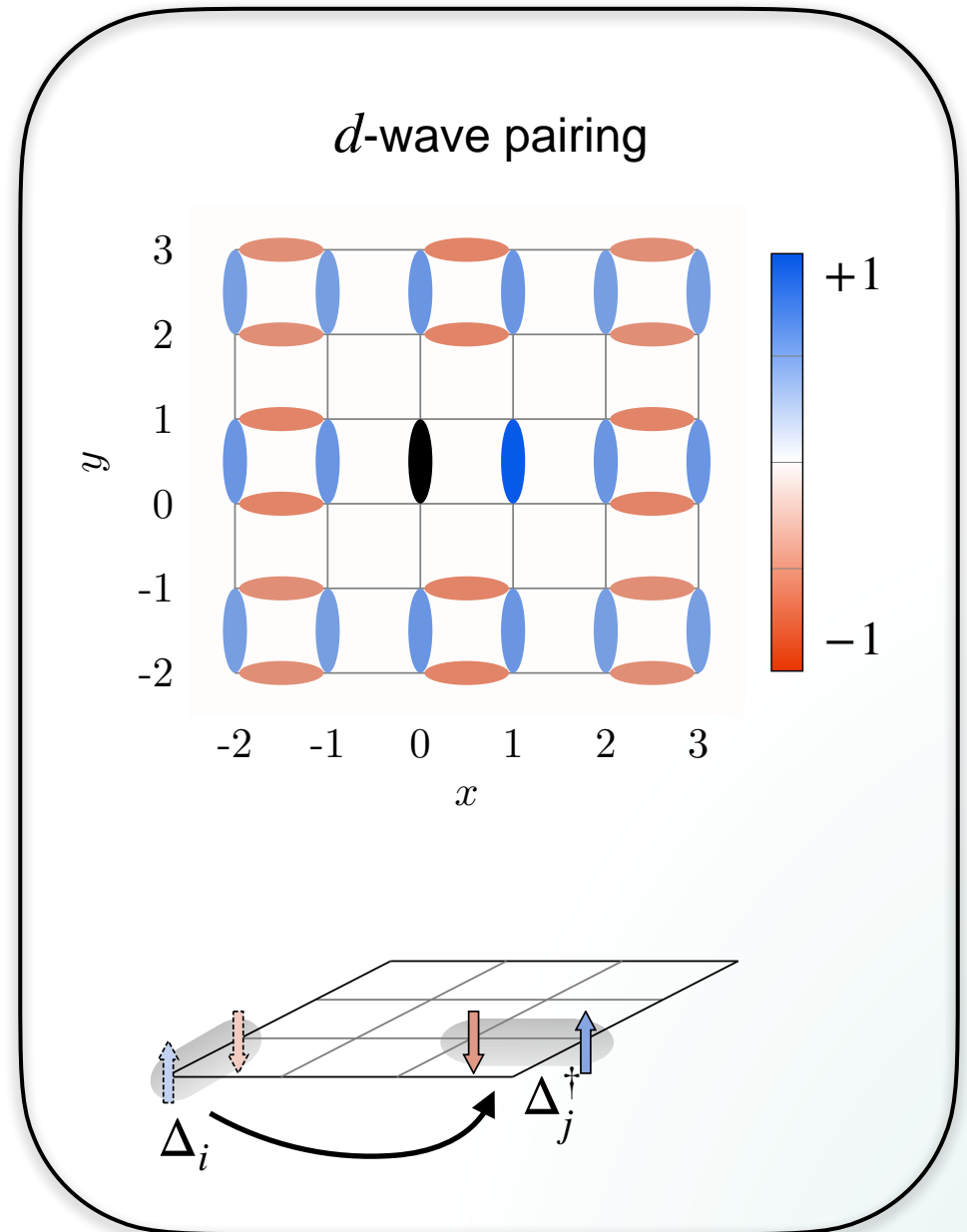
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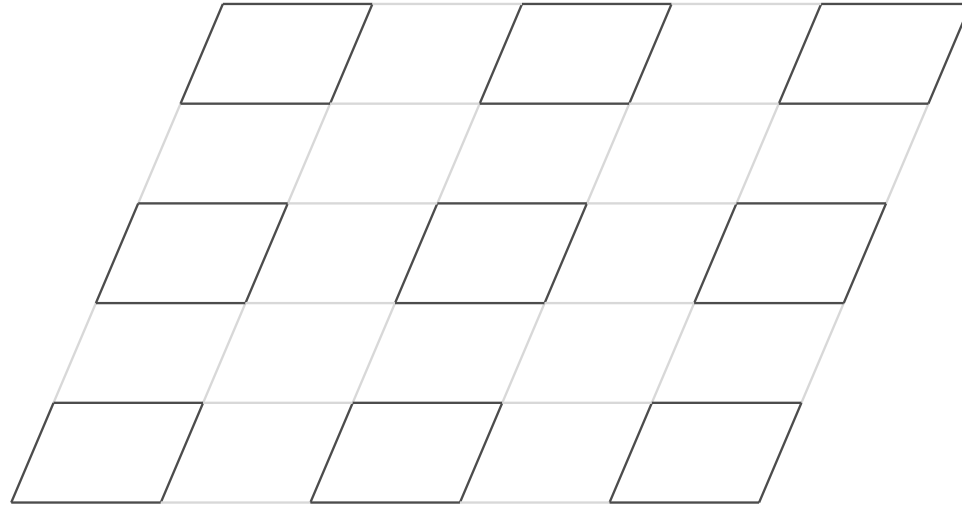


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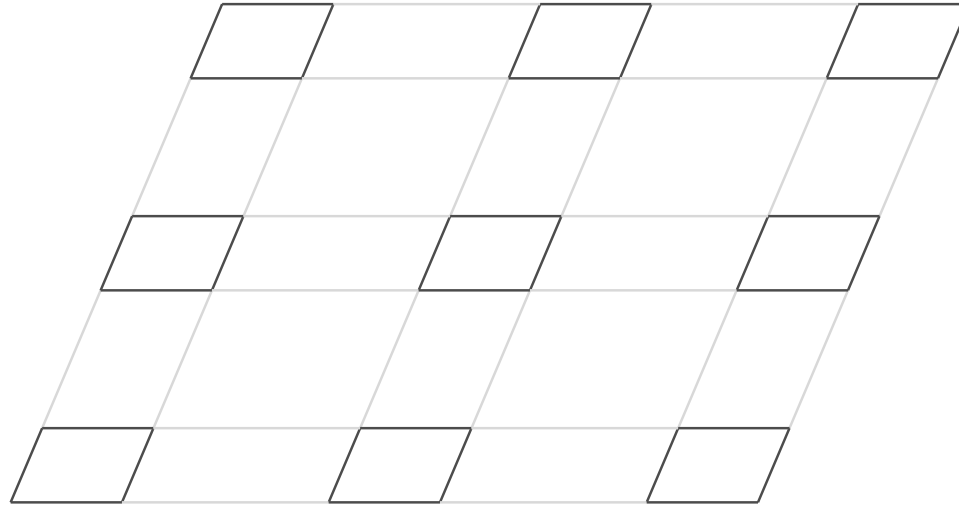


D-Wave Pairing



W-F Tsai & S Kivelson, *PRB* (2006), S Trebst et al, *PRL* (2006),
W-F Tsai et al., *PRB* (2008), AM Rey et al, *EPL* (2009)

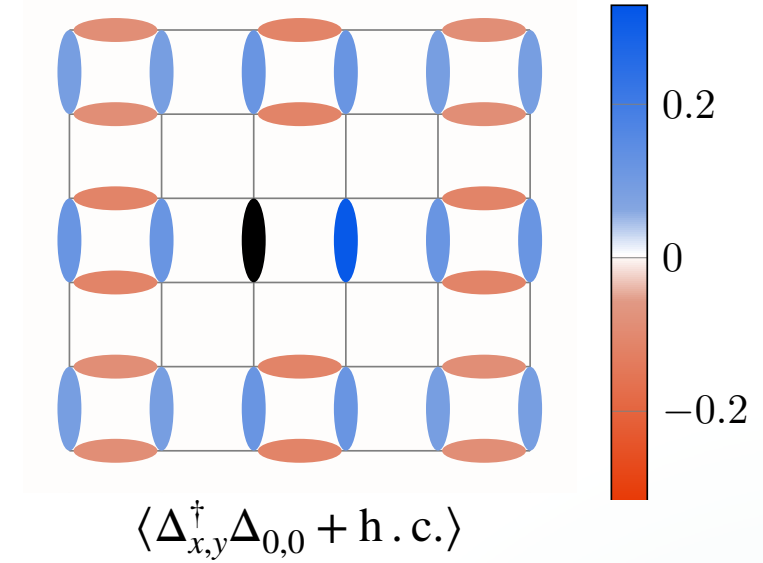
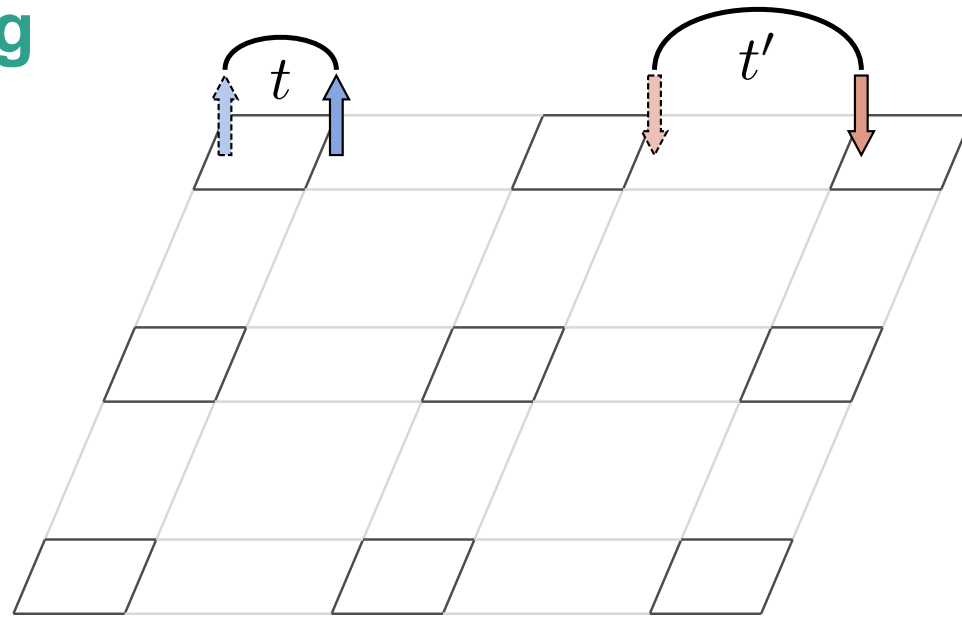
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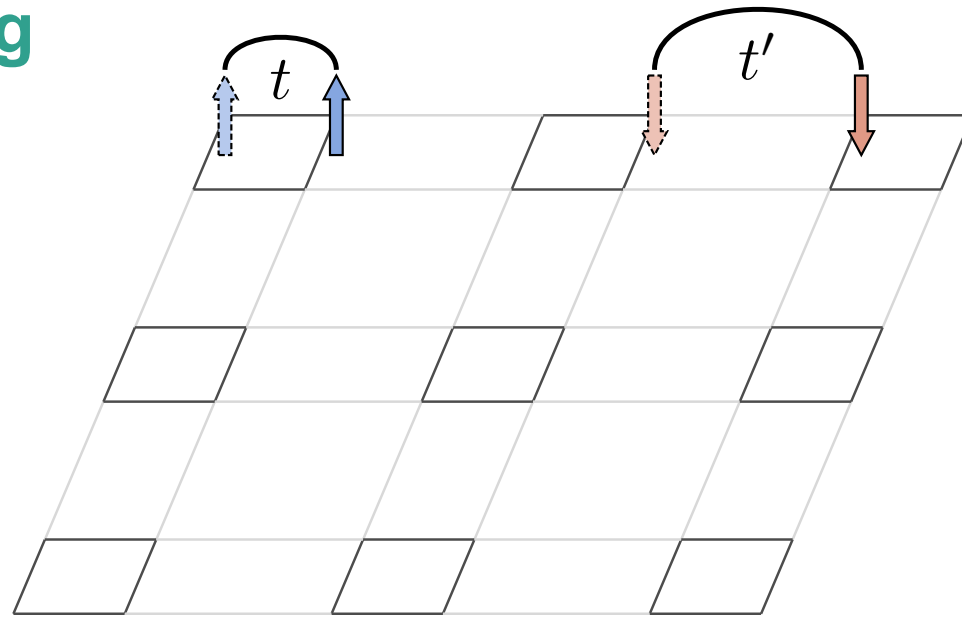
D-Wave Pairing

($U/t = 2$)

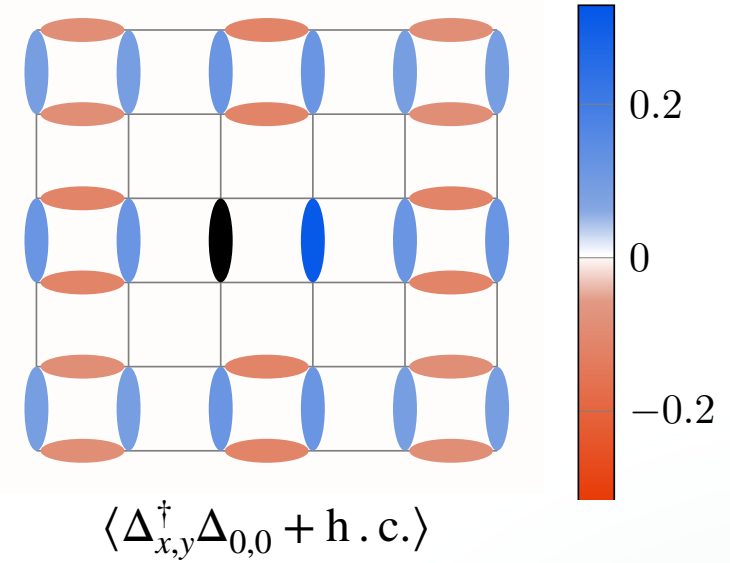


D-Wave Pairing

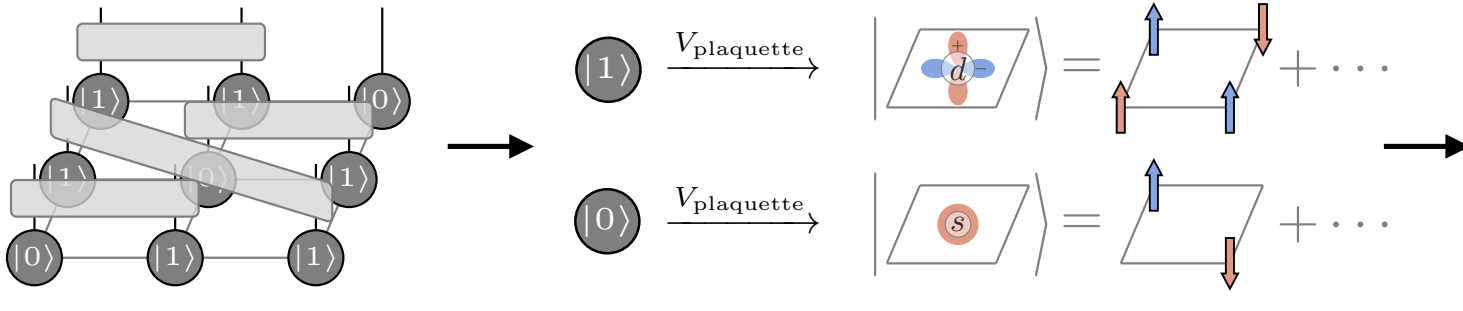
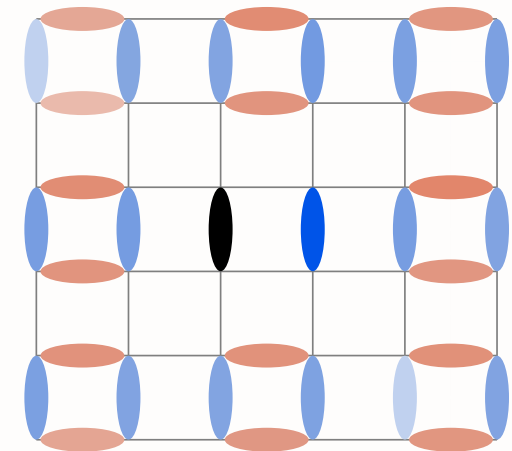
$(U/t = 2)$



Theory



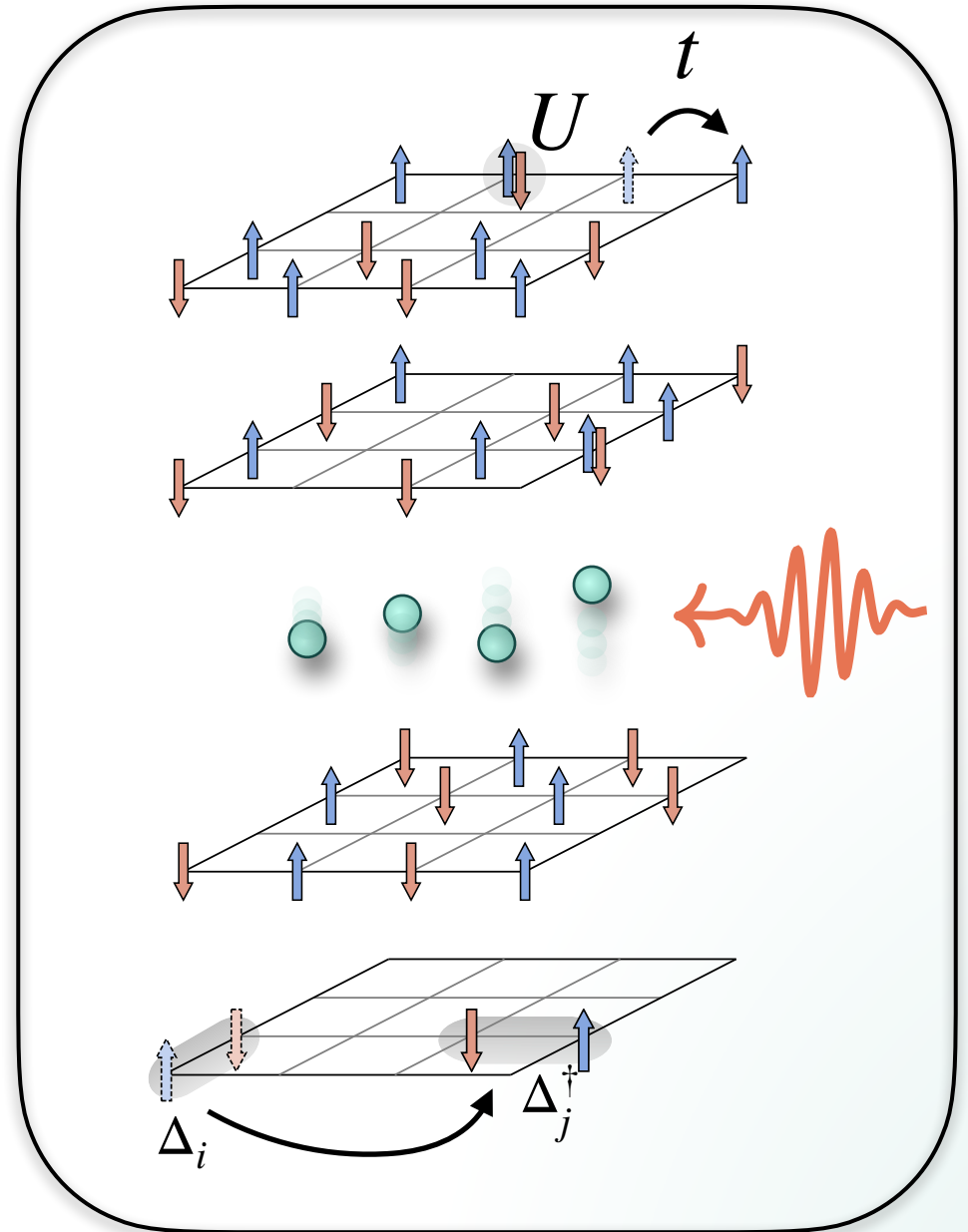
Experiment



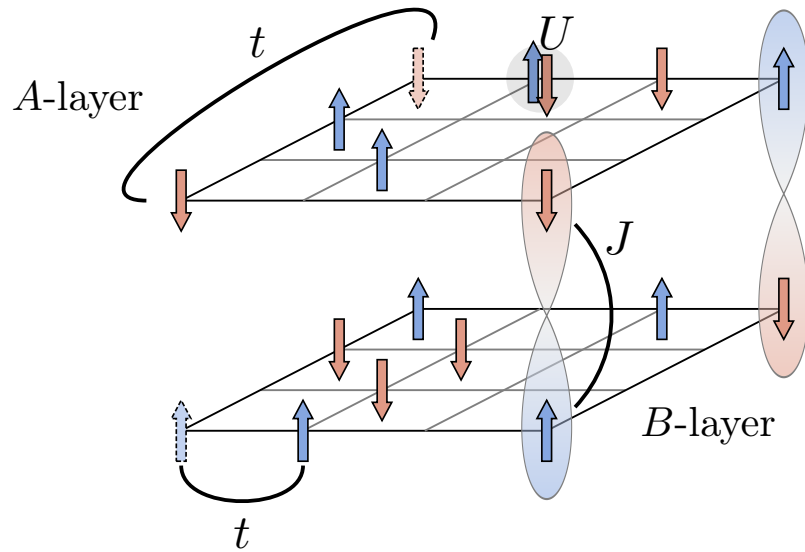
Superconducting pairing correlations on a trapped-ion quantum computer,
E Granet, SH Lin, K Hemery et al., *arXiv:2511.02125*

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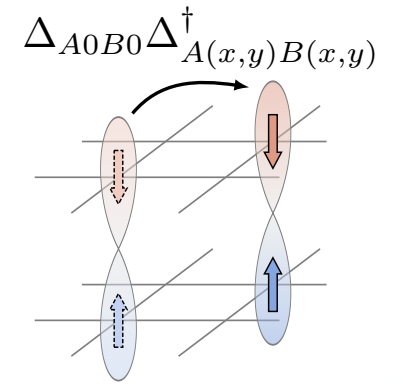
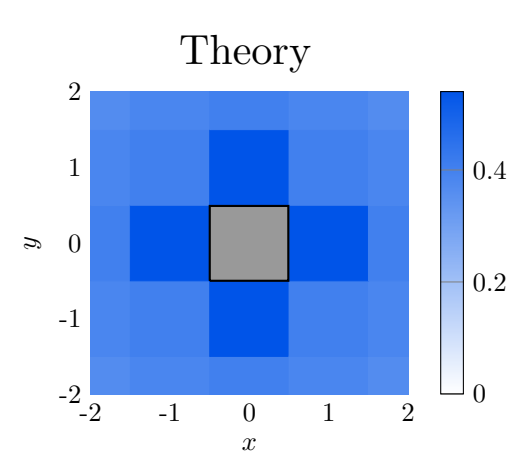
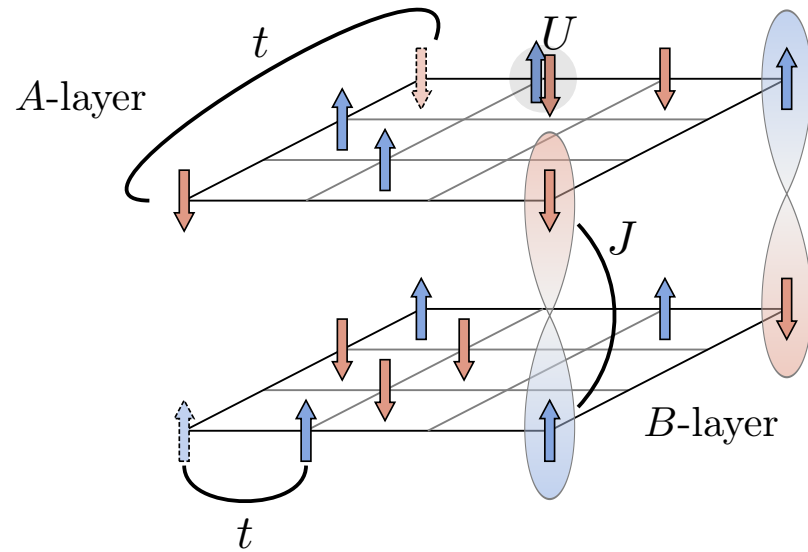
A Bilayer Hubbard Model



$$H = -t \sum_{\langle ij \rangle \sigma} c_{i\sigma}^\dagger c_{j\sigma} + U \sum_i n_{i\uparrow} n_{i\downarrow} + J \sum_i \mathbf{S}_i^A \mathbf{S}_i^B$$

H Sun et al, *Nature* (2023), C Lu et al, *PRL* (2024),
H Schlömer et al., *Nature Comm. Phys.* (2024),

A Bilayer Hubbard Model

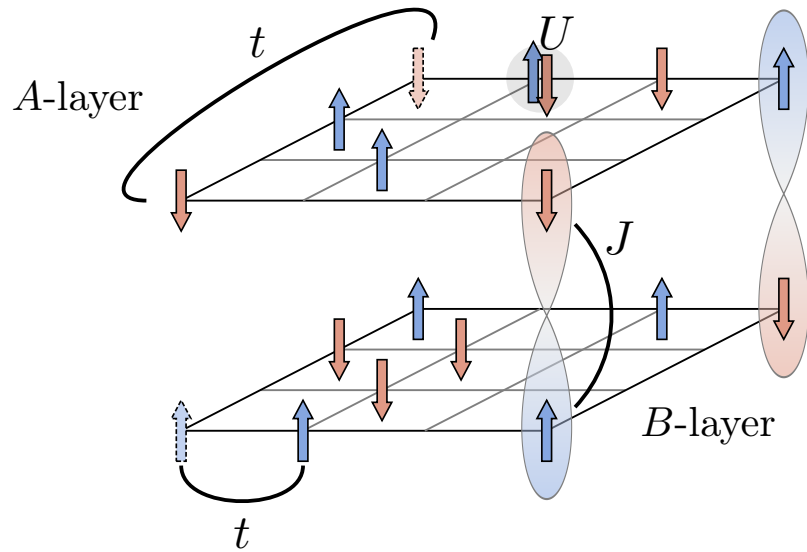


$$H = -t \sum_{\langle ij \rangle \sigma} c_{i\sigma}^\dagger c_{j\sigma} + U \sum_i n_{i\uparrow} n_{i\downarrow} + J \sum_i \mathbf{S}_i^A \mathbf{S}_i^B$$

$$\xrightarrow{J \gg t} \sum_{\langle ij \rangle} X_i X_j + Y_i Y_j + \Delta Z_i Z_j$$

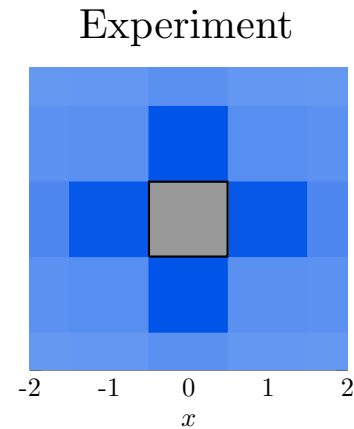
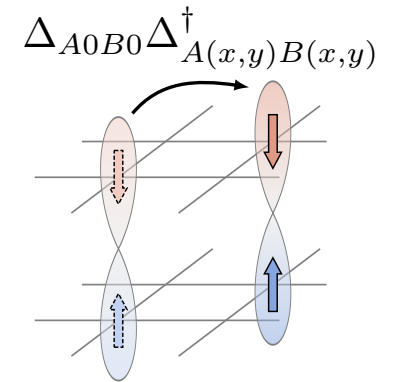
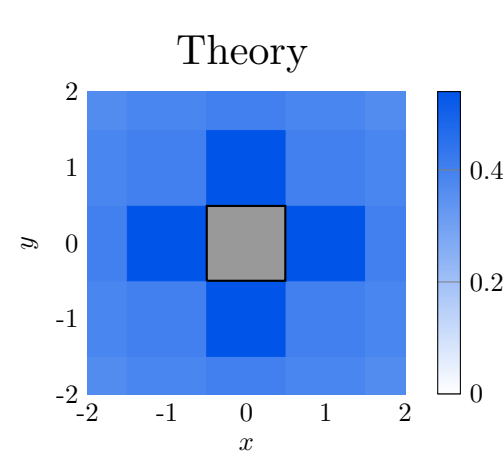
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A Bilayer Hubbard Model



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 E Granet, SH Lin, K Hemery et al., *arXiv:2511.02125*

Classical Difficulty

Sparse Pauli Dynamics

$$O = \sum_P c_P P$$

Classical Difficulty

Sparse Pauli Dynamics

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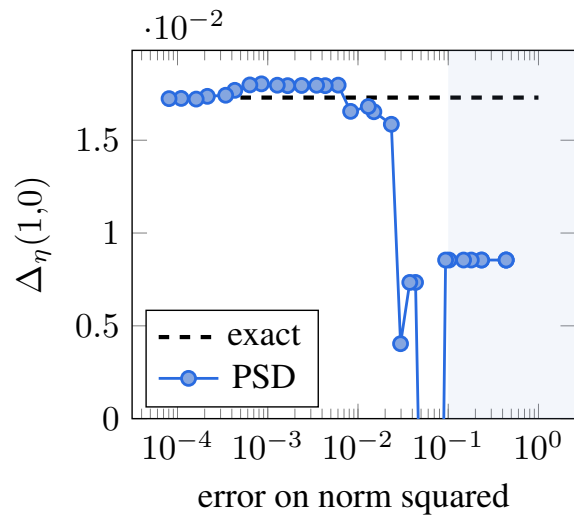
$$\text{Norm squared} = \sum_P |c_P|^2$$

Classical Difficulty

Sparse Pauli Dynamics

$$O = \sum_P c_P P$$

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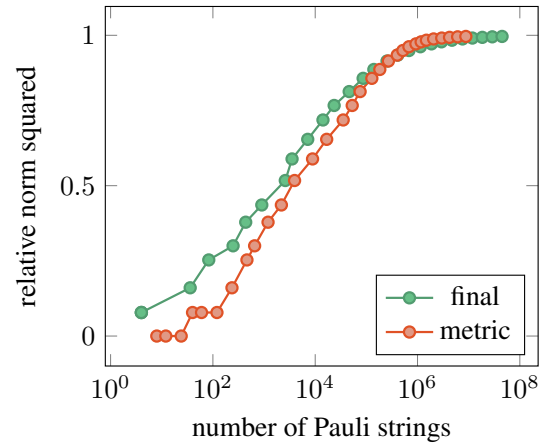
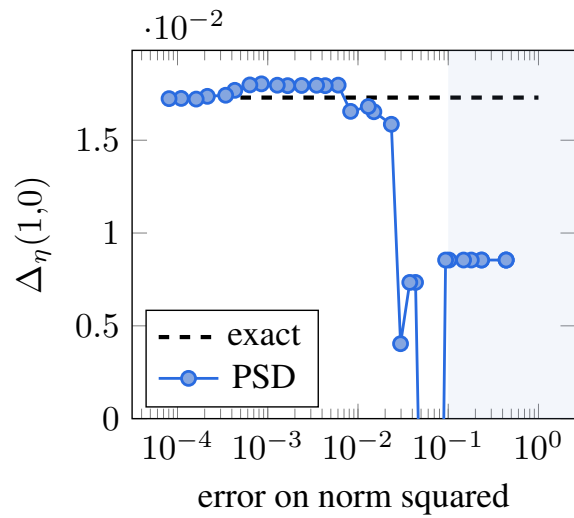
L Broers, R-Y Sun, S Yunoki, , *arXiv:2506.13241*
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Classical Difficulty

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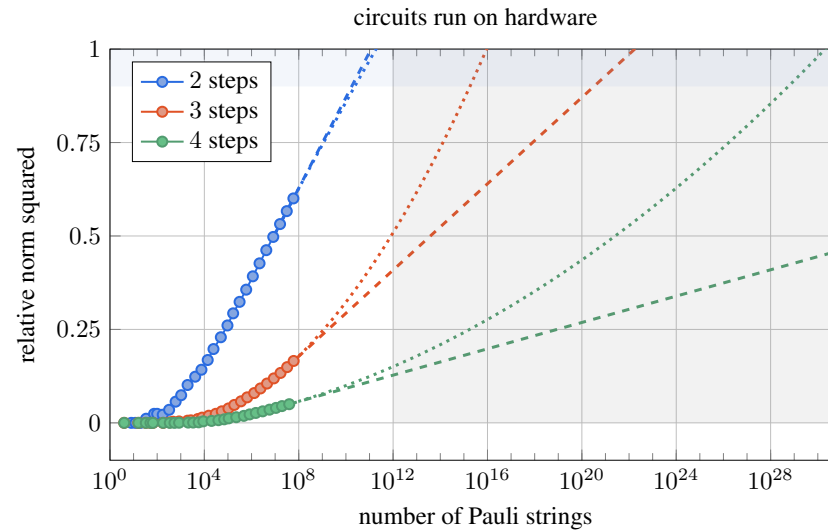
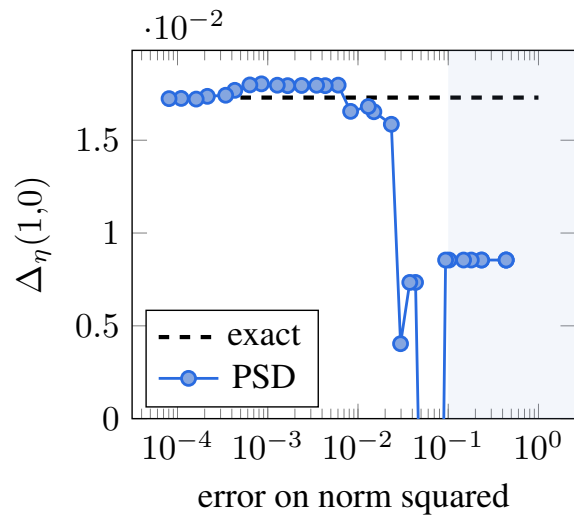
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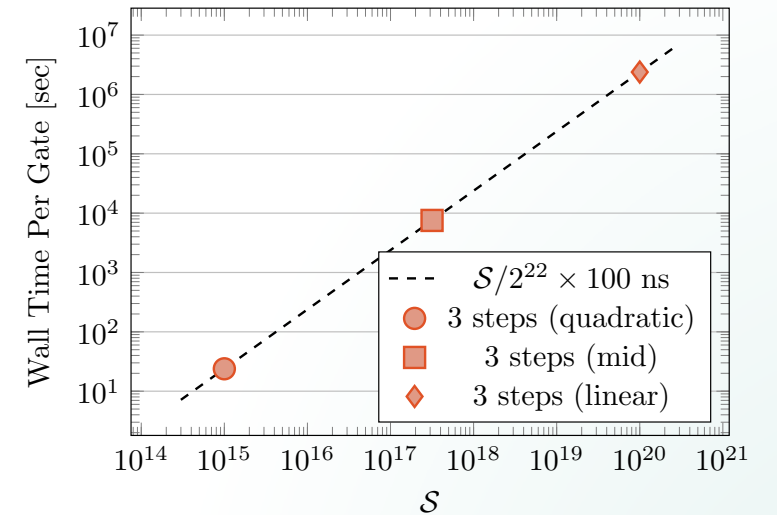
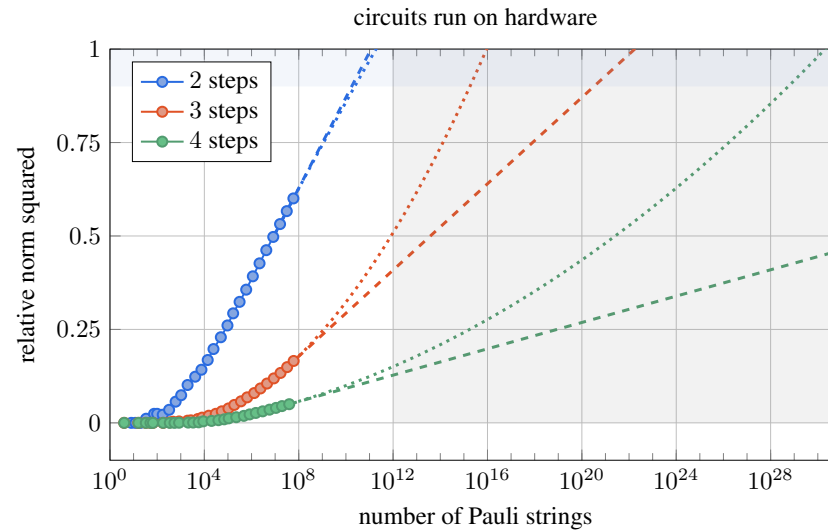
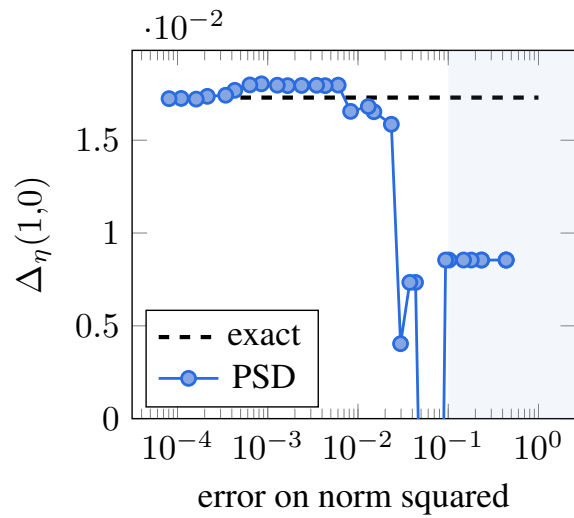
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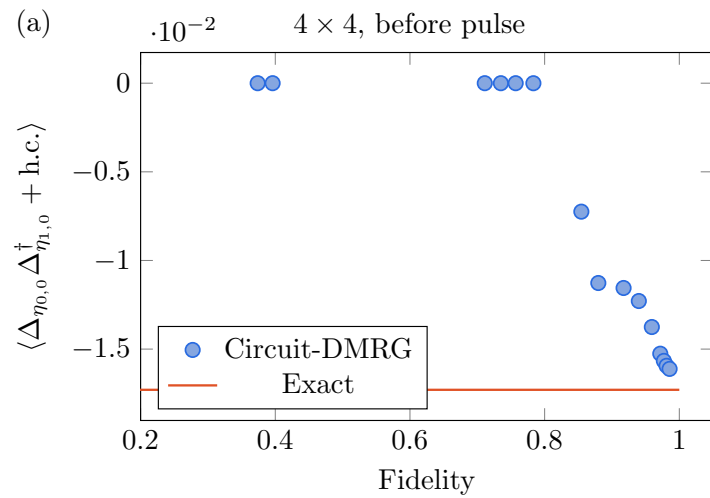
$$\text{Norm squared} = \sum_P |c_P|^2$$



L Broers, R-Y Sun, S Yunoki, , *arXiv:2506.13241*
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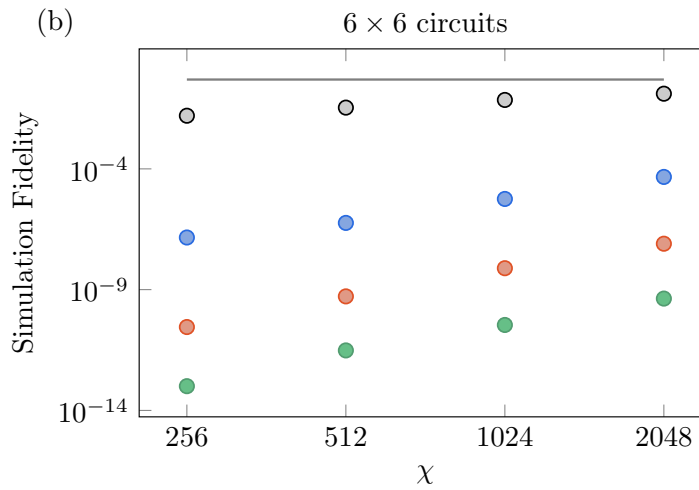
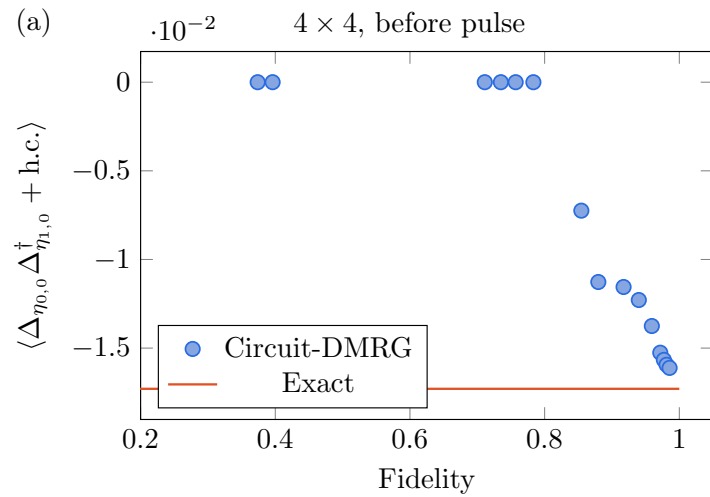
Classical Difficulty

MPS



Classical Difficulty

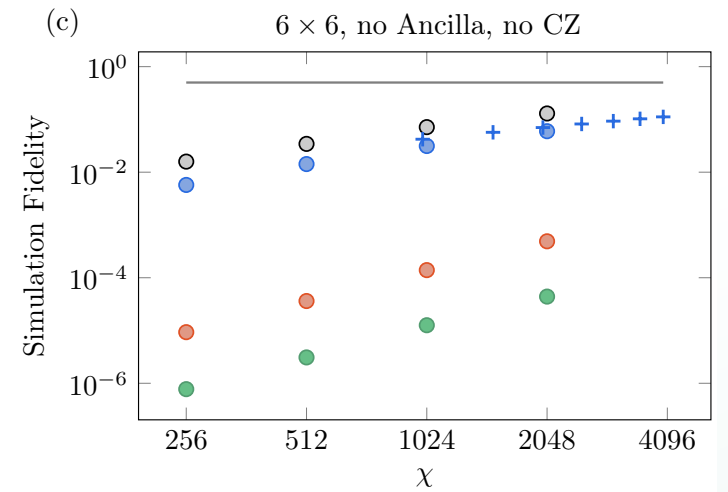
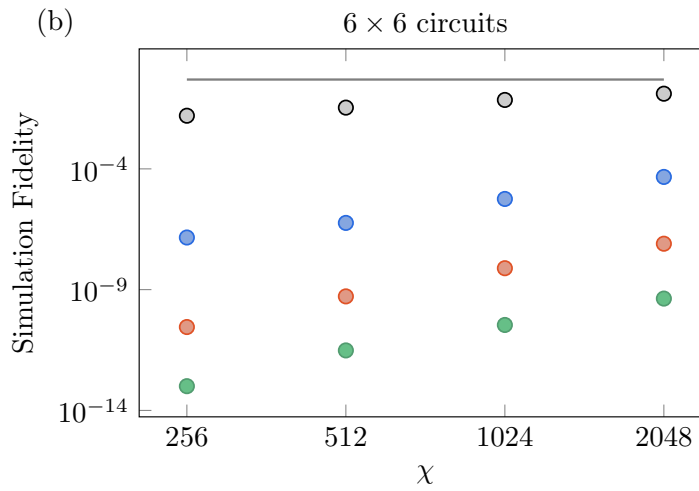
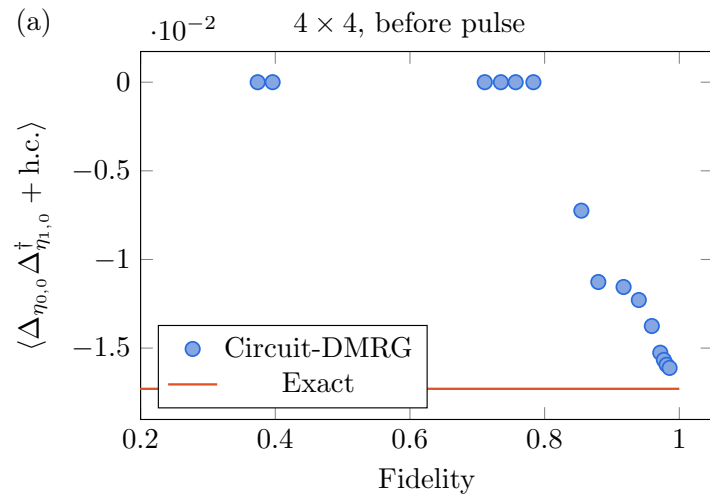
MPS



○ $s = 20$ Ising Quench ● 2 steps ● 3 steps ● 4 steps + 2 steps (JW) — 50%

Classical Difficulty

MPS



○ $s = 20$ Ising Quench
 ● 2 steps
 ● 3 steps
 ● 4 steps
 + 2 steps (JW)
 — 50%

Classical Difficulty

PEPS/MPO

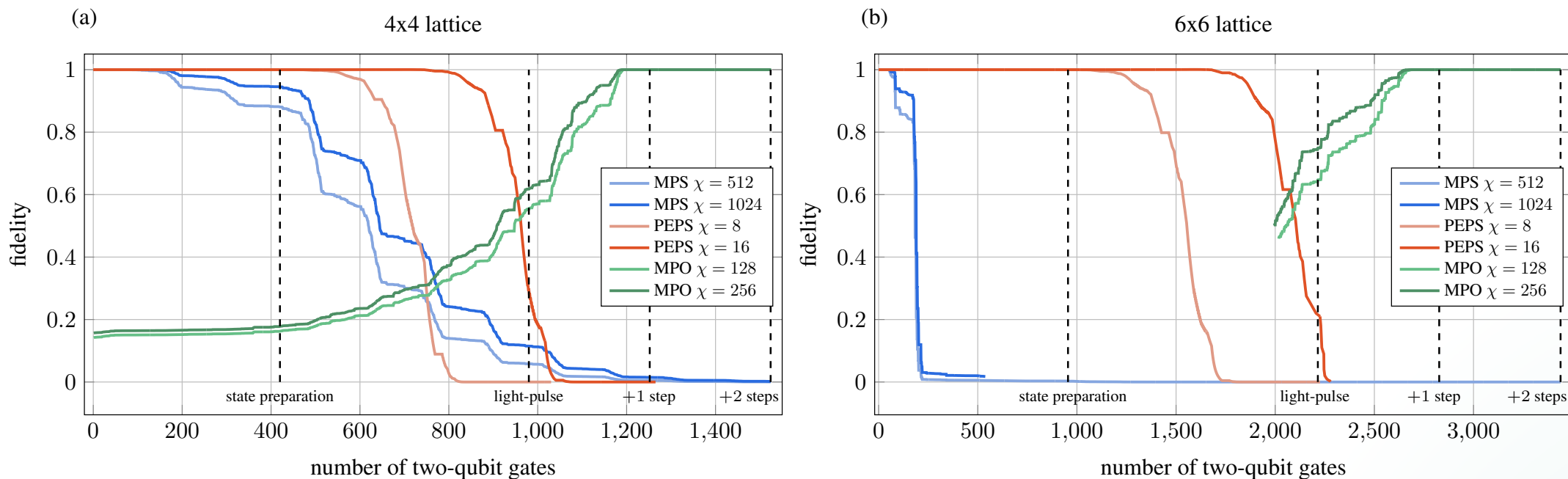


FIG. S27. Fidelity versus two-qubit gate count for simulating light-pulse dynamics (+2 extra steps) in 4×4 and 6×6 systems using MPS, PEPS, and MPO methods.