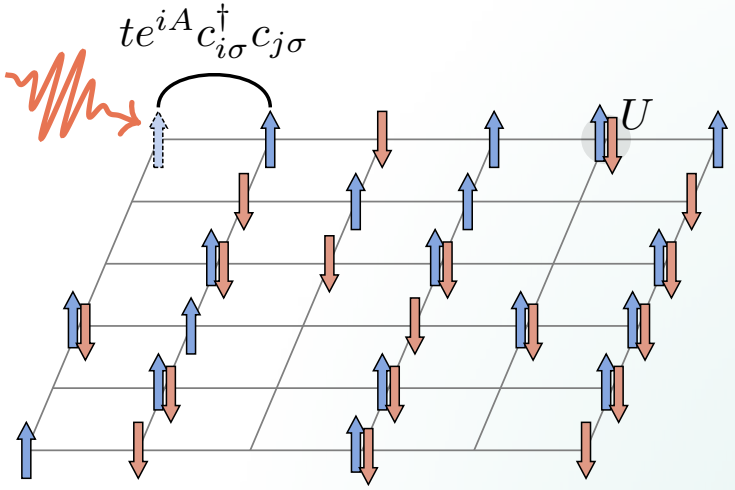
QUANTINUUM

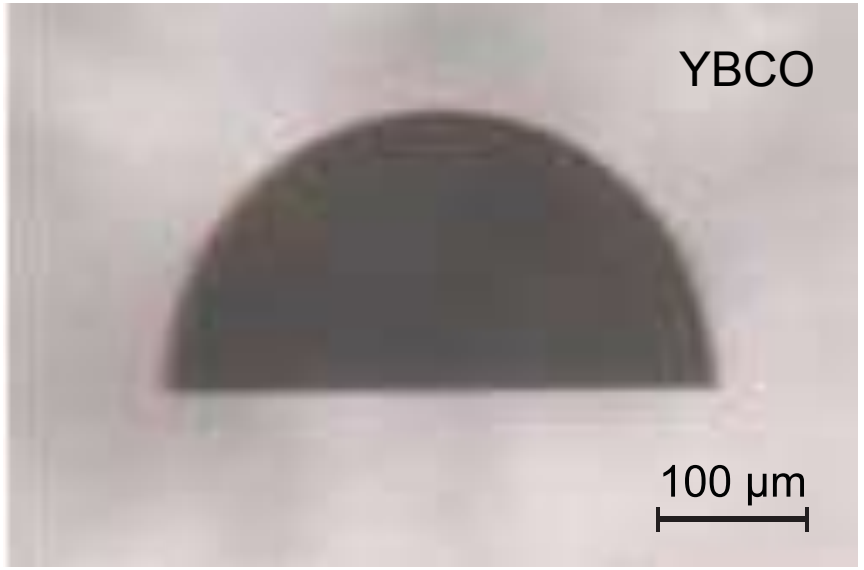
Superconducting pairing correlations on a trapped-ion quantum computer

arXiv:2511.02125

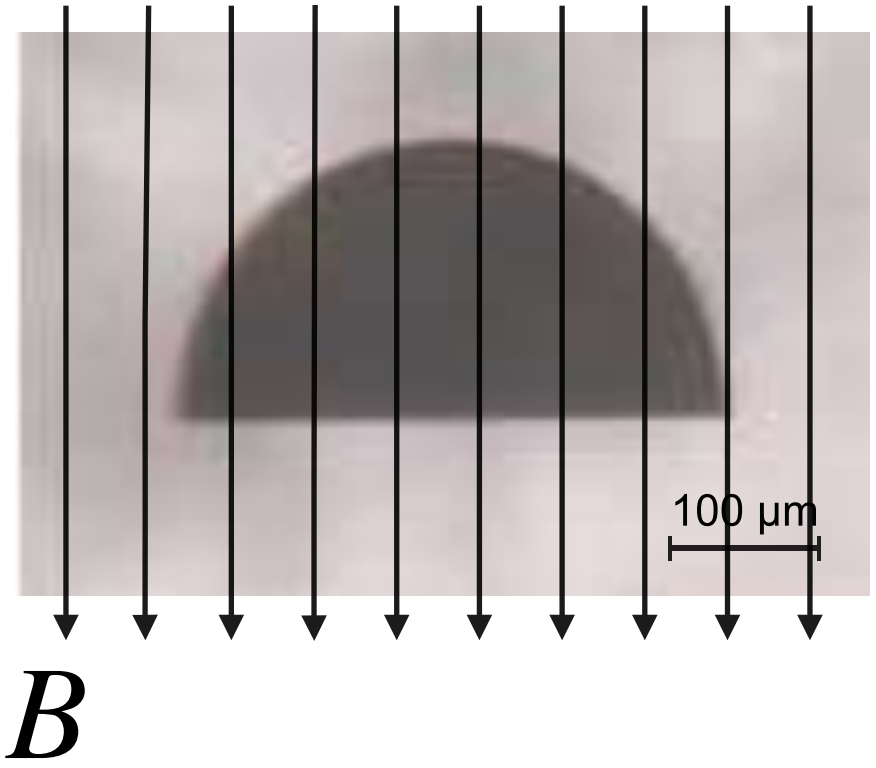
Henrik Dreyer
6 July 2026

Joint work with Etienne Granet, Sheng-Hsuan Lin, Kevin Hemery, Drew Potter, Mike Foss-Feig, Ramil Nigmatullin, Mohsin Iqbal & many others





S Fava et al., *Nature* (2024)



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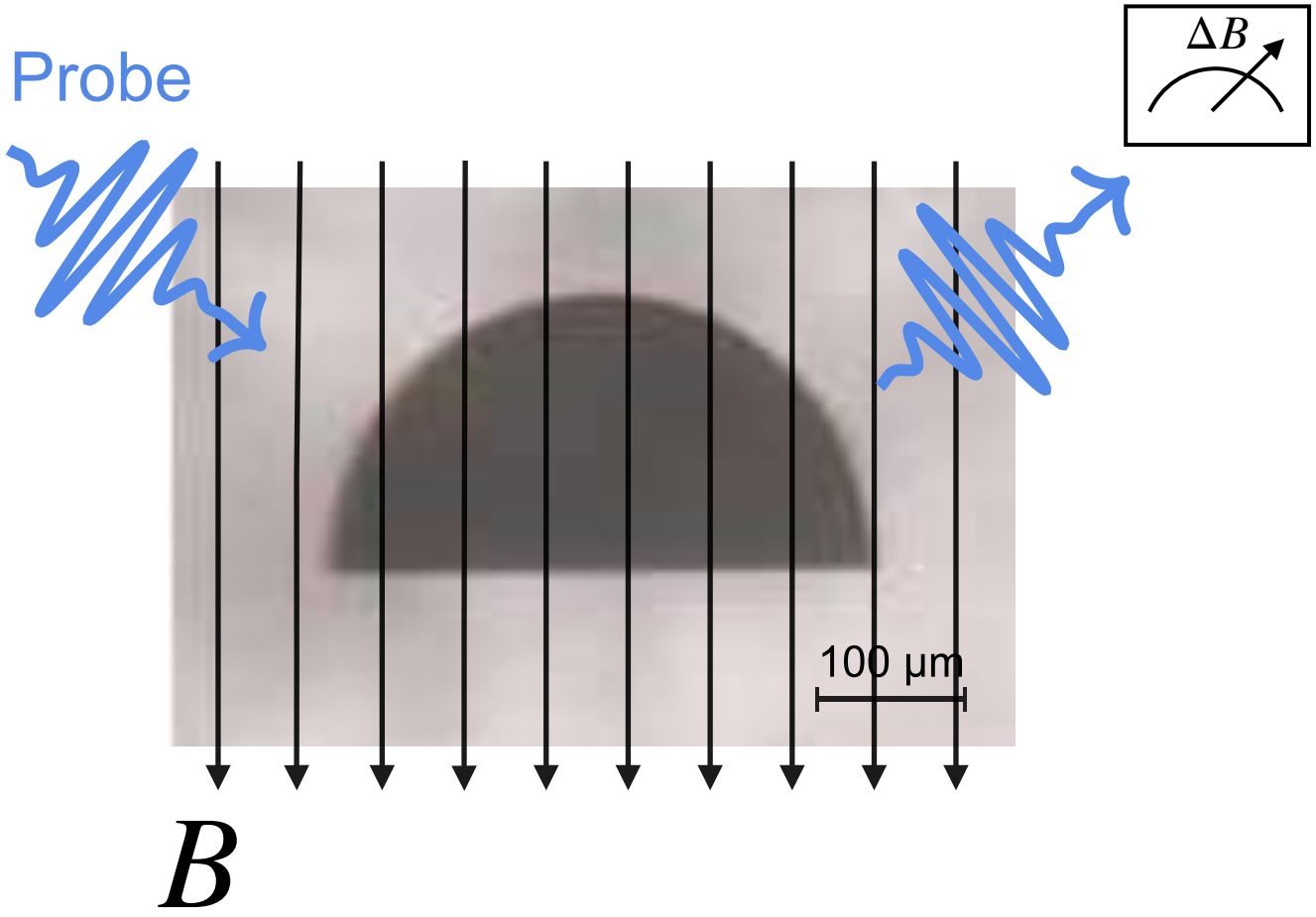

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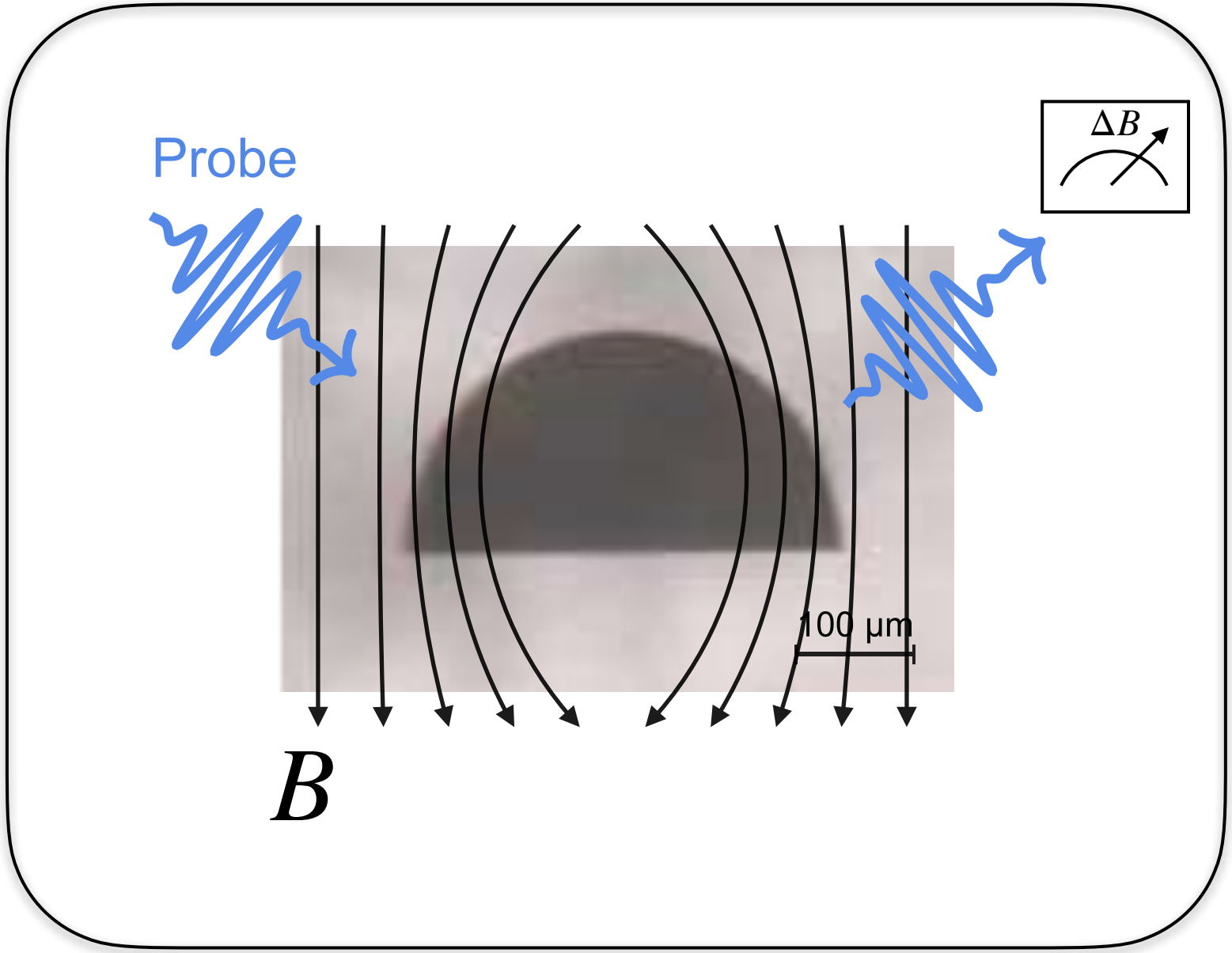

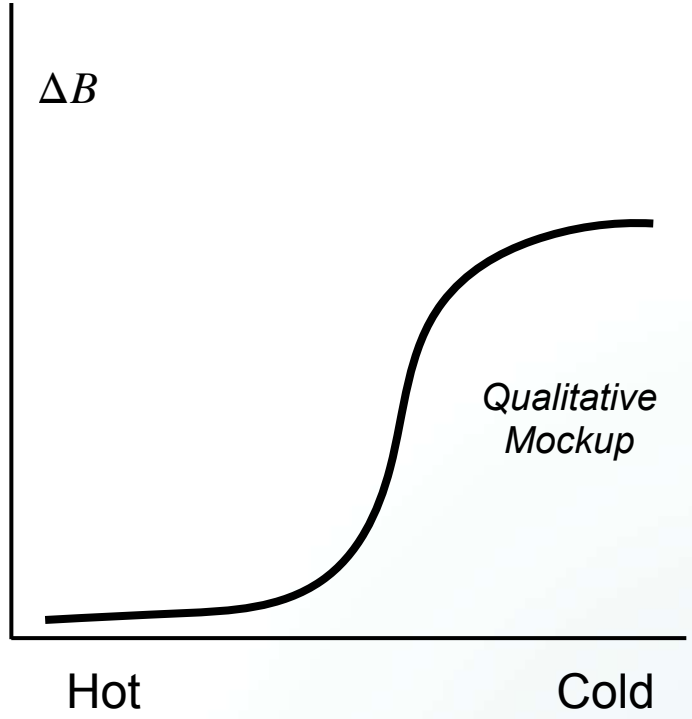

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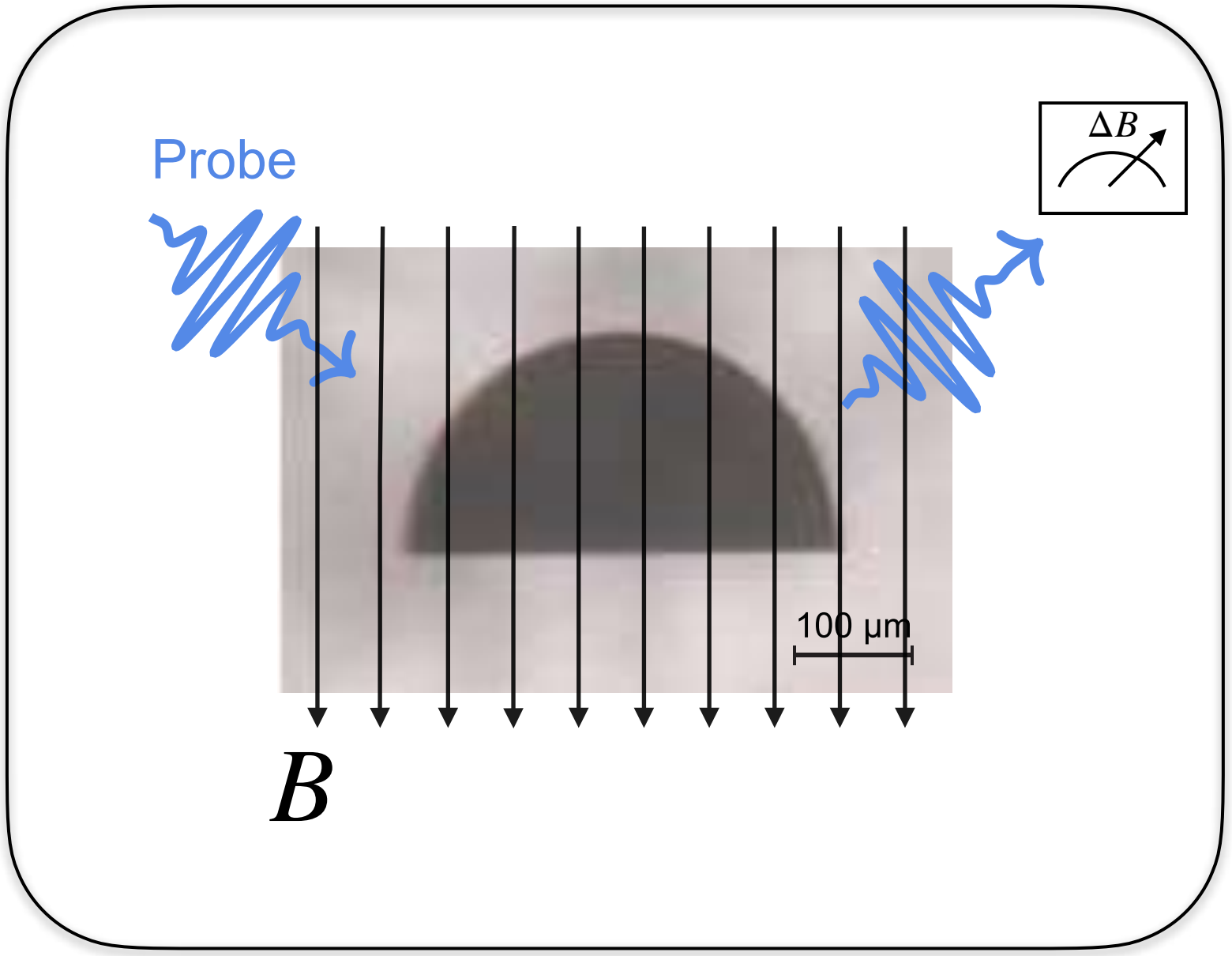

100 K
300 K

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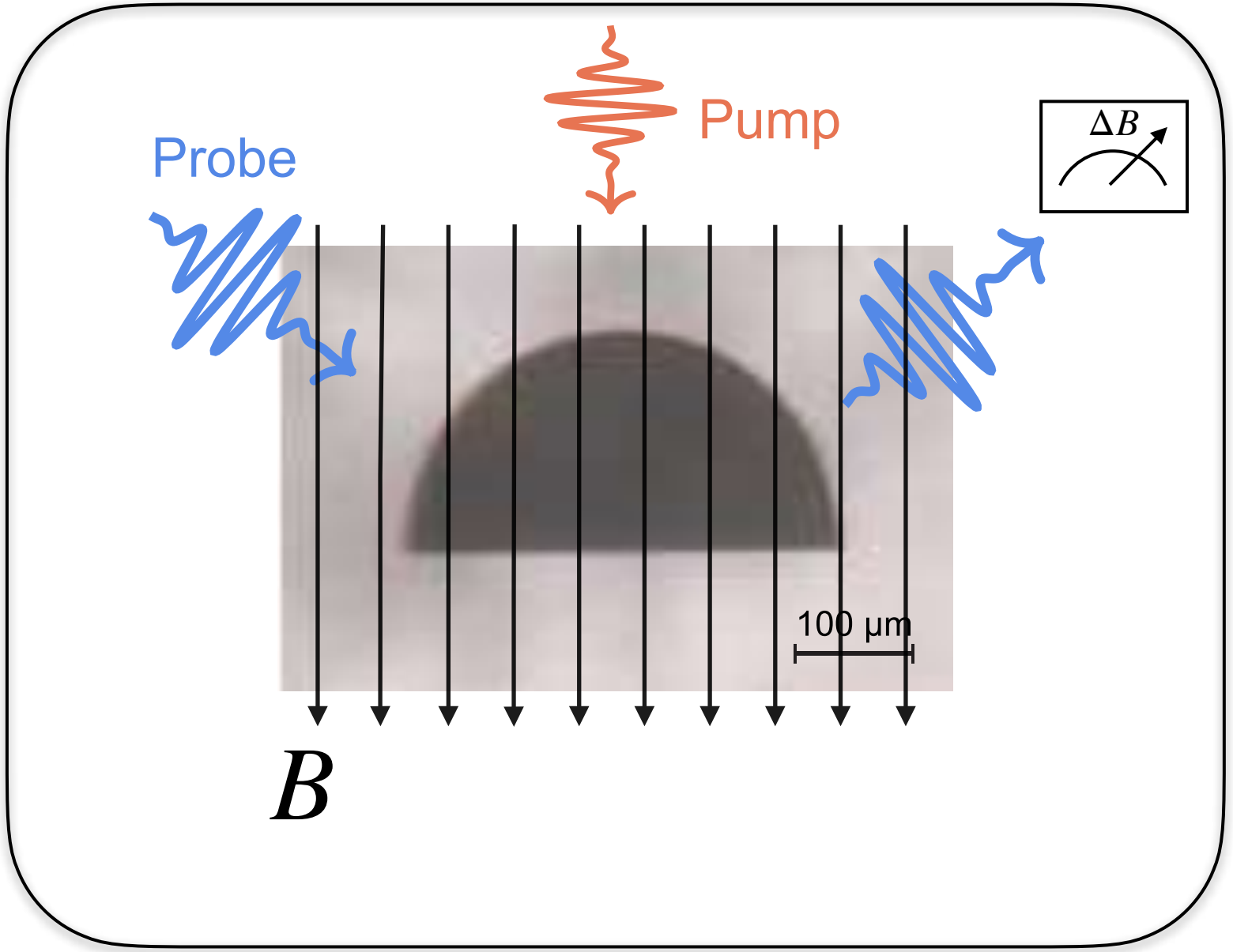

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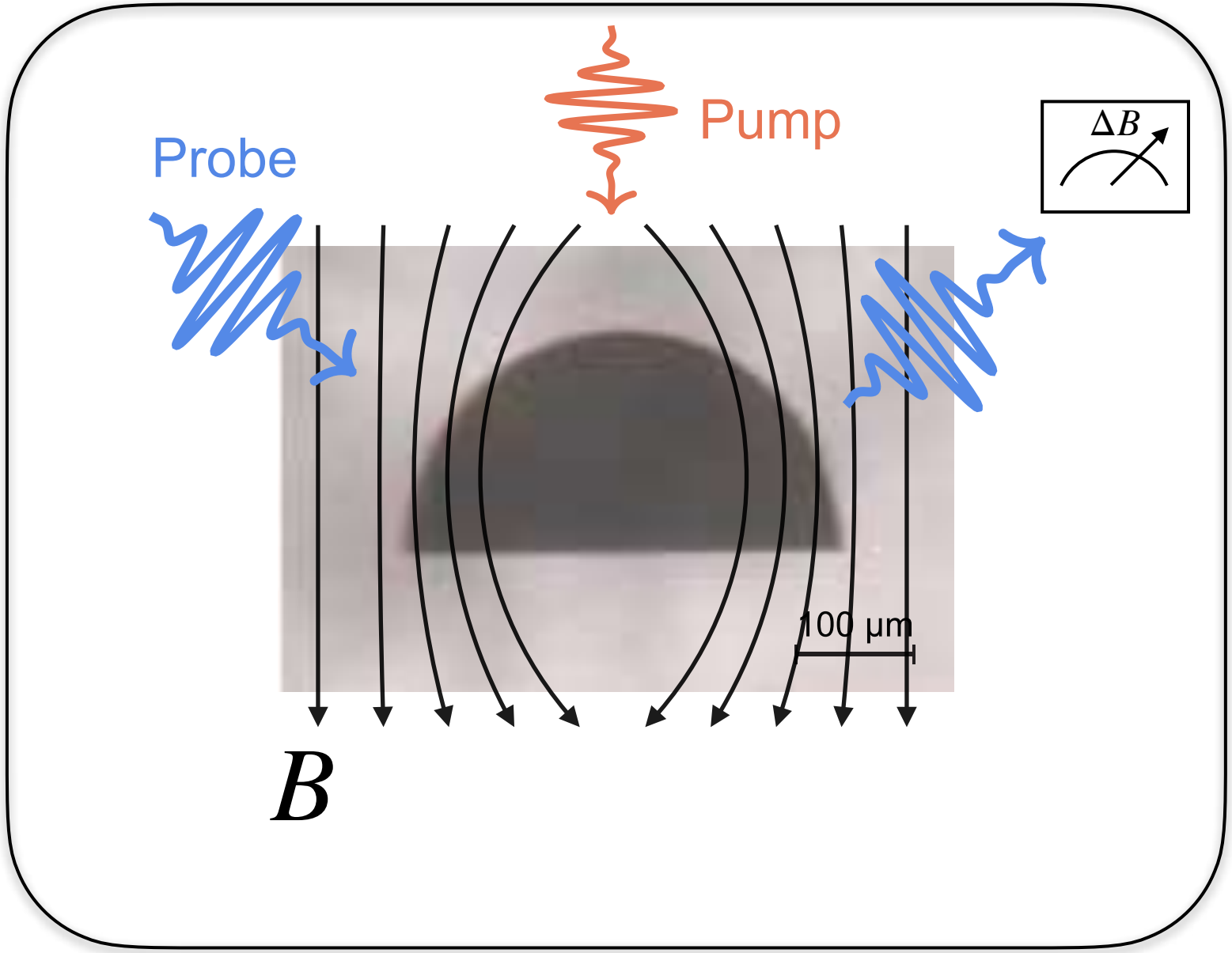

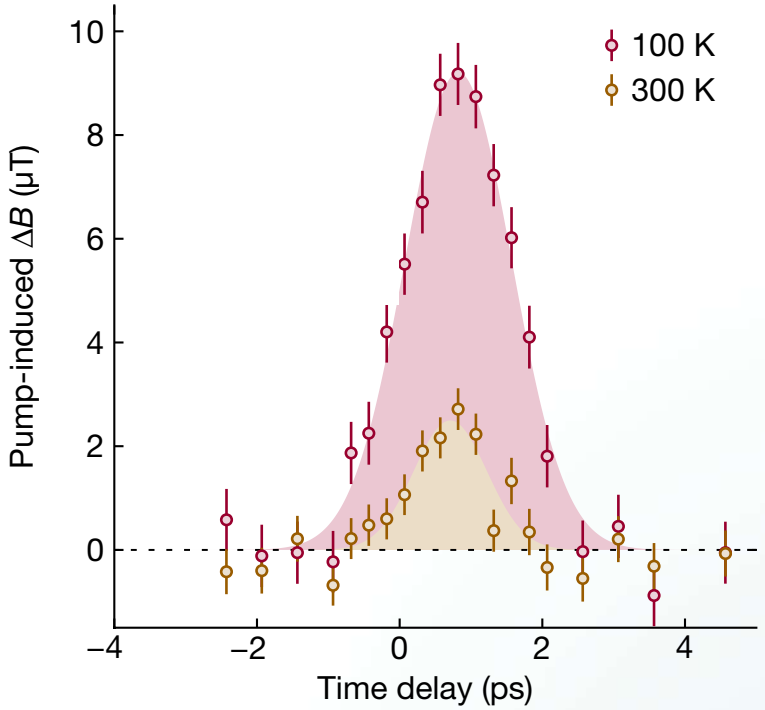

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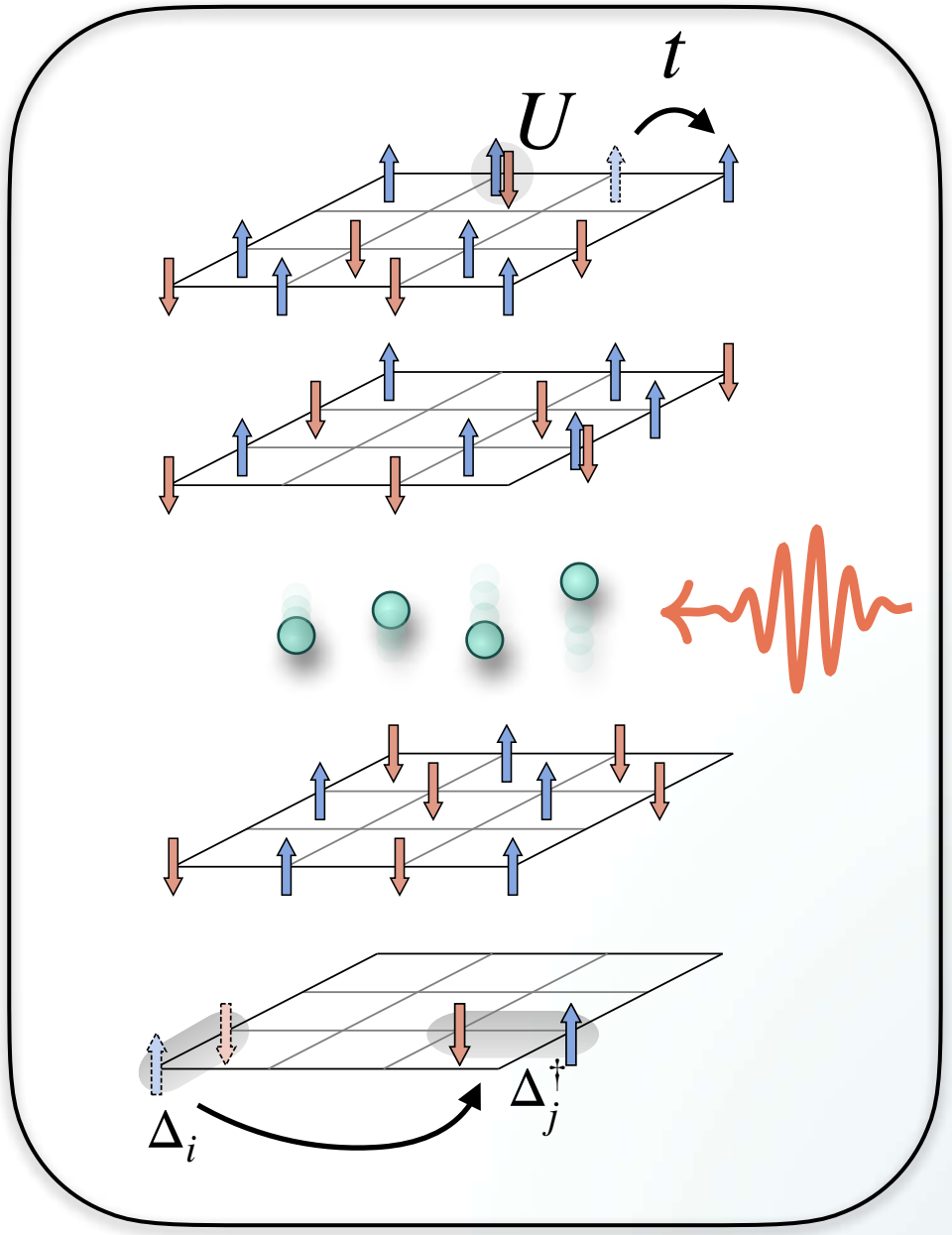
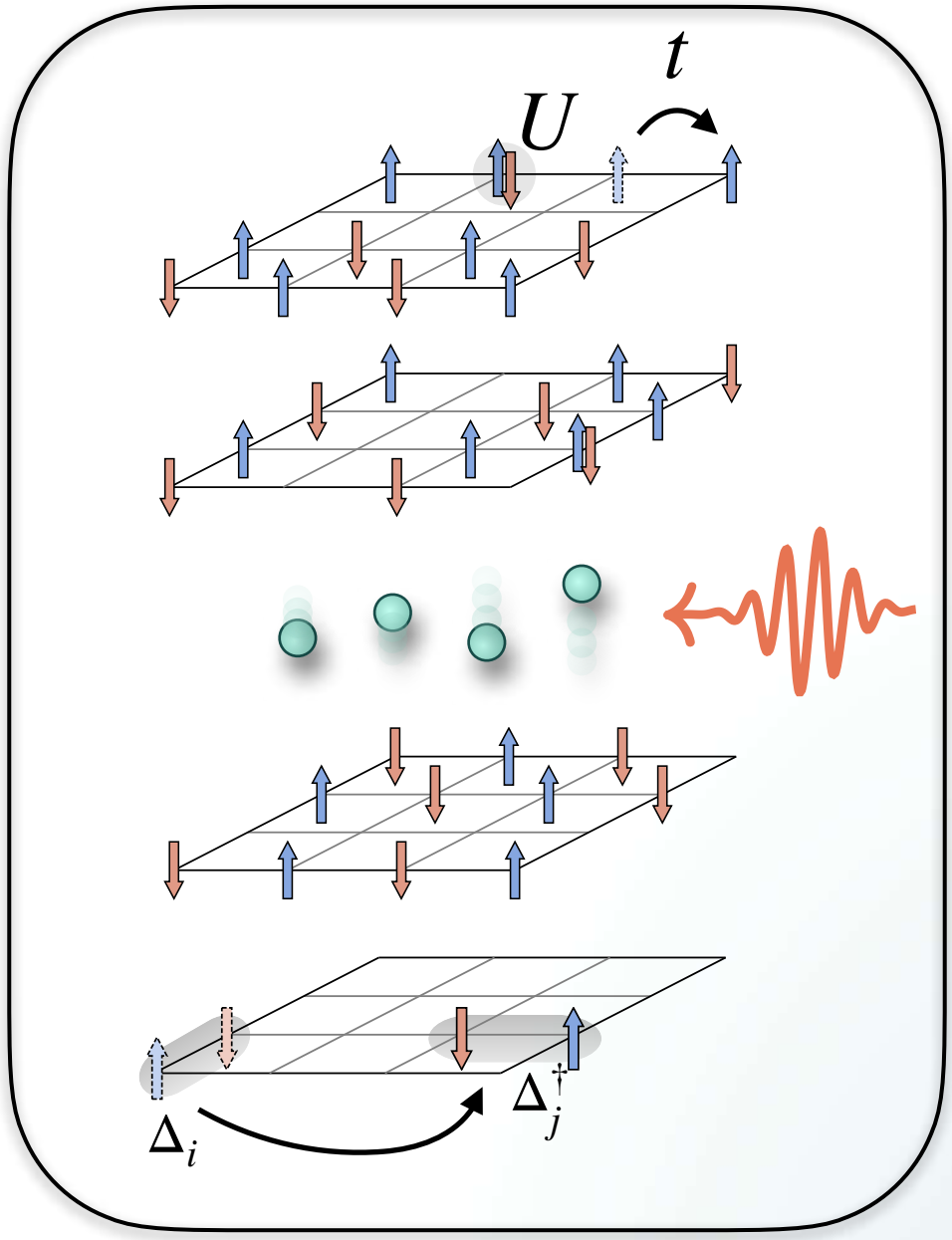


Features of a microscopic model

Strong Electronic Correlation

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



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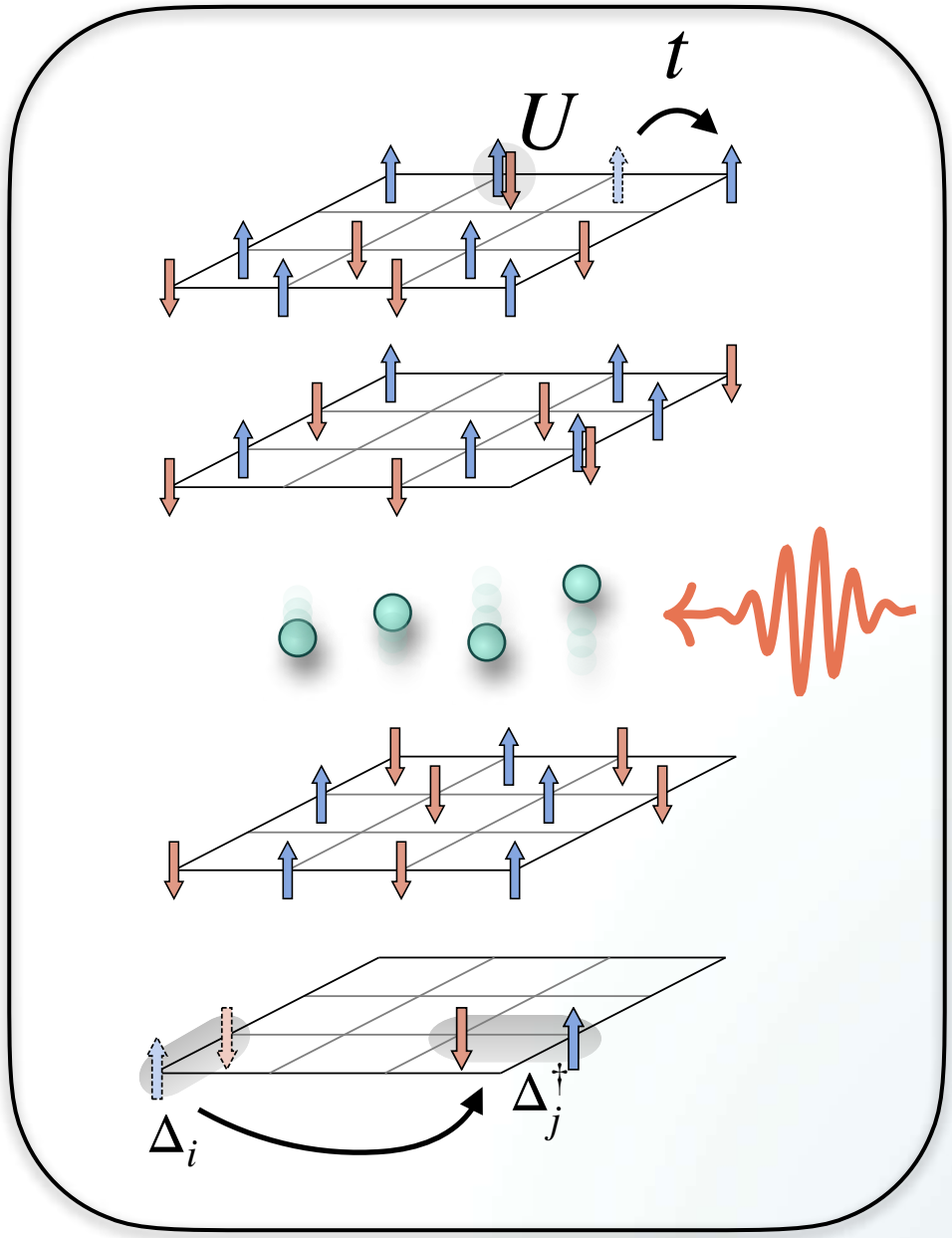
Non-Equilibrium Drive

$$H = H(\tau)$$



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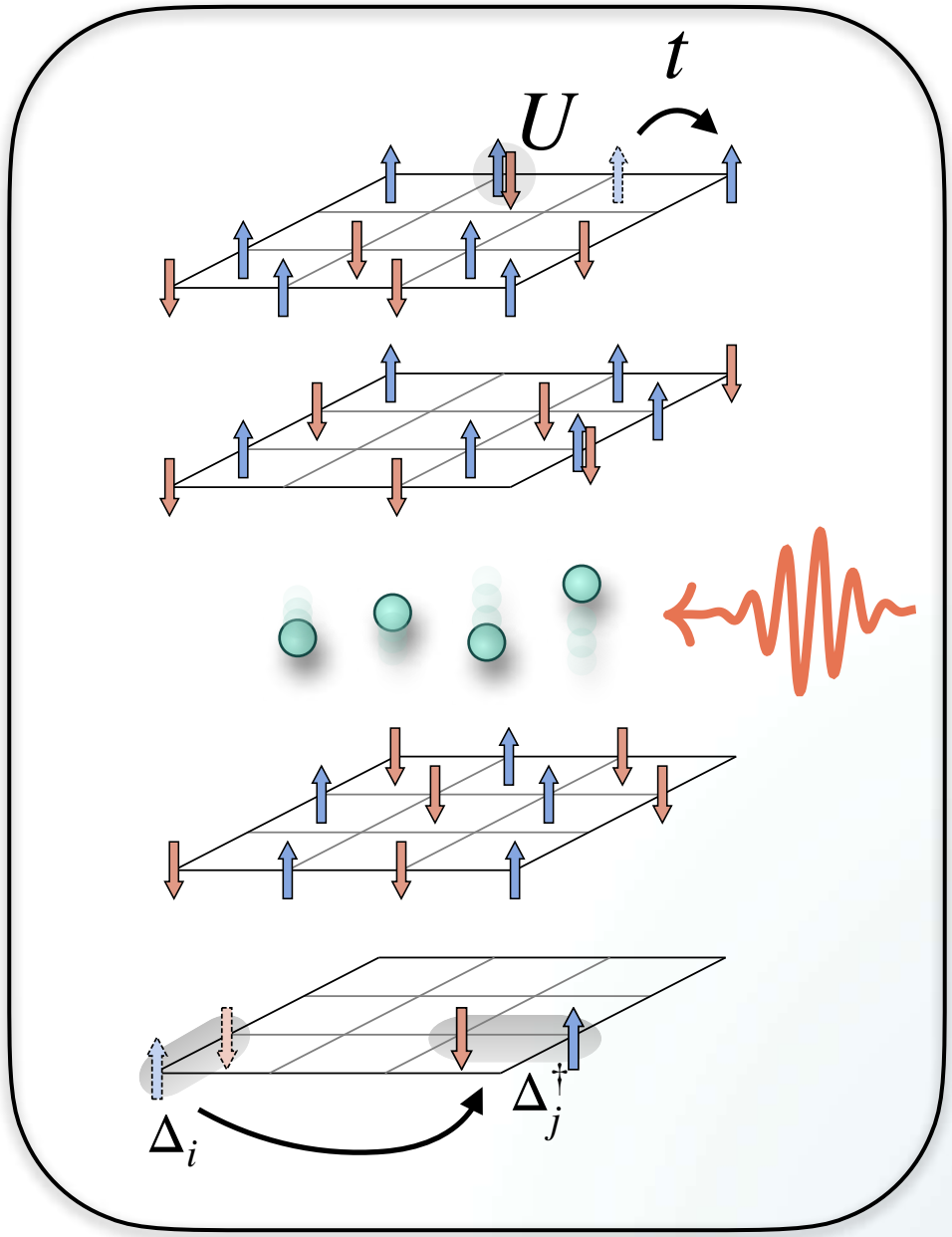
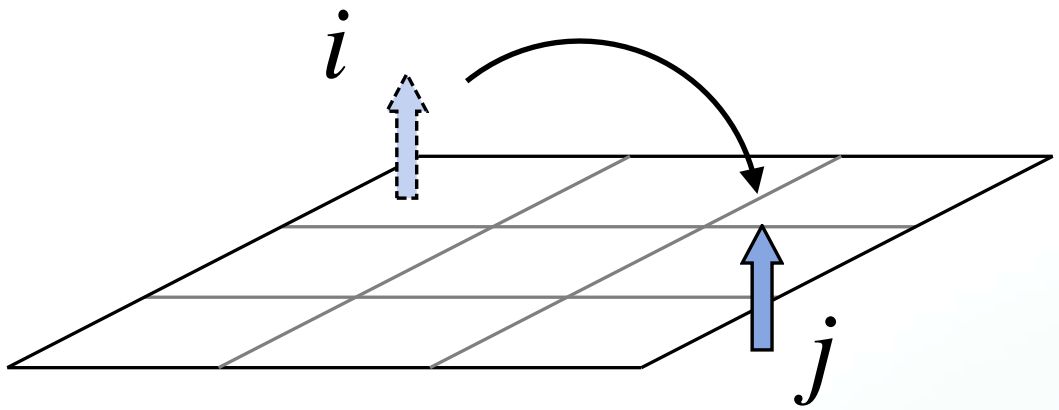
Superconducting Pairing Correlation Measurement

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



Superconducting Pairing Correlations

$$\langle c^{\dagger}_{j\uparrow} c_{i\uparrow} \rangle$$



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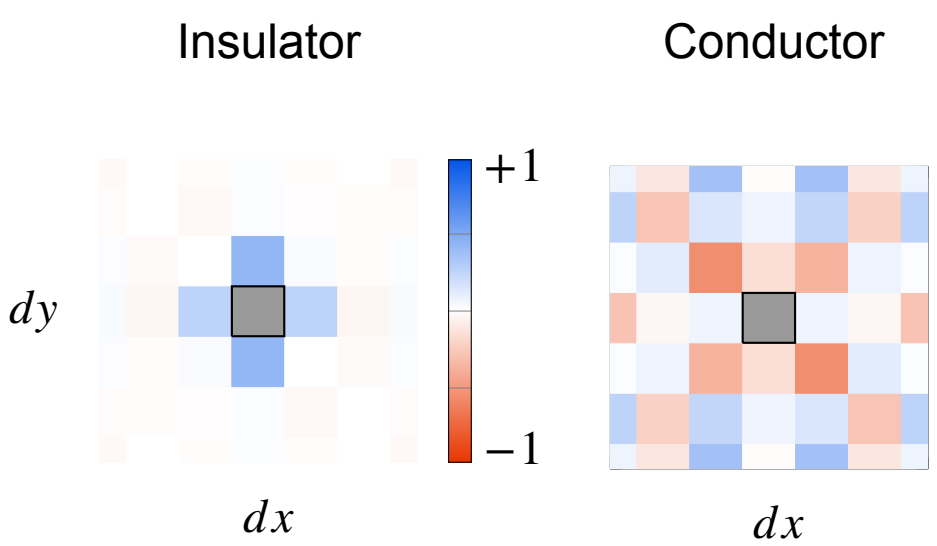

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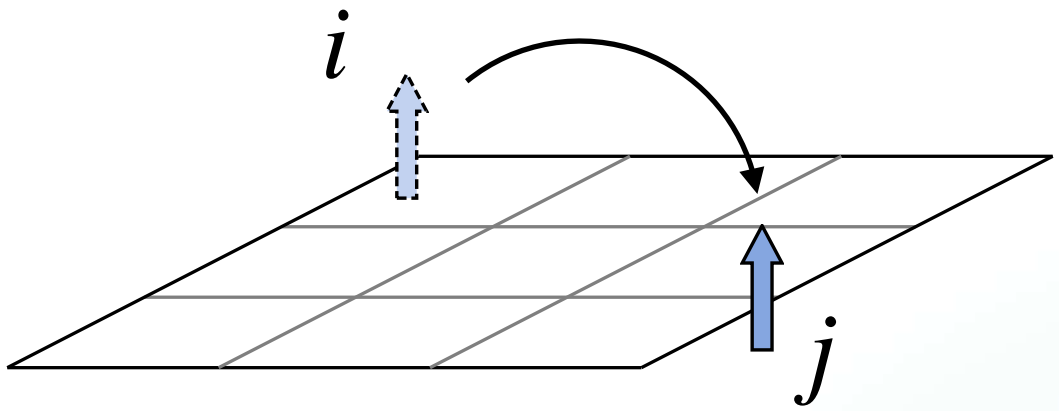

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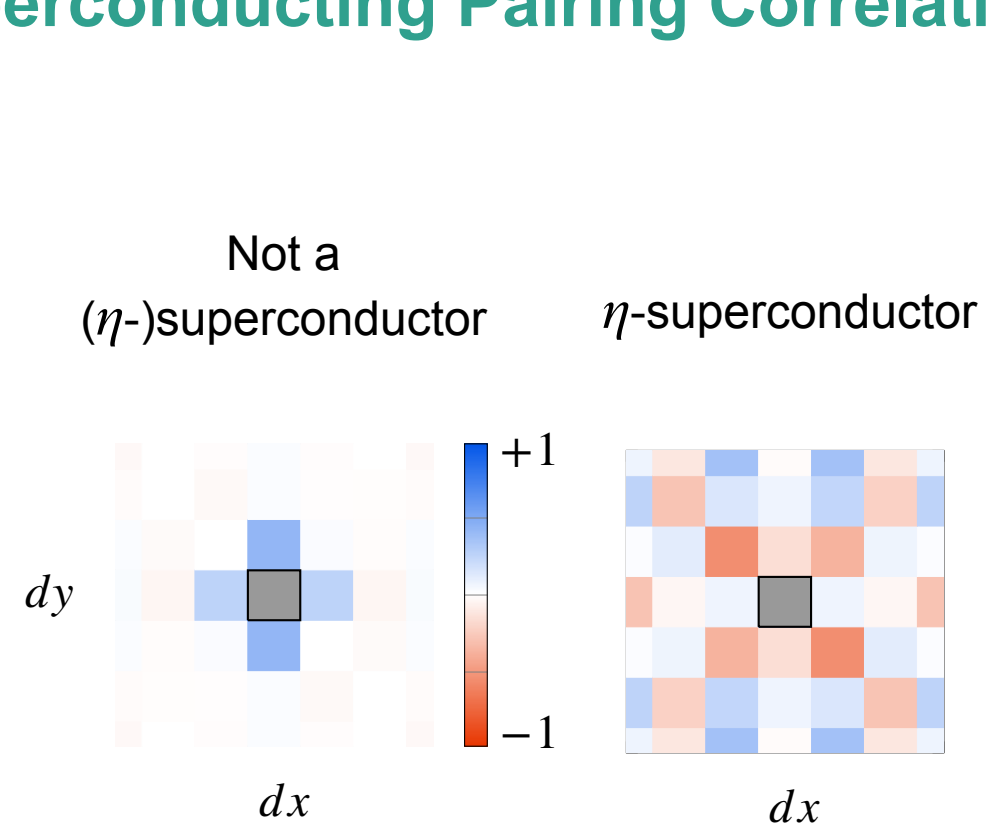
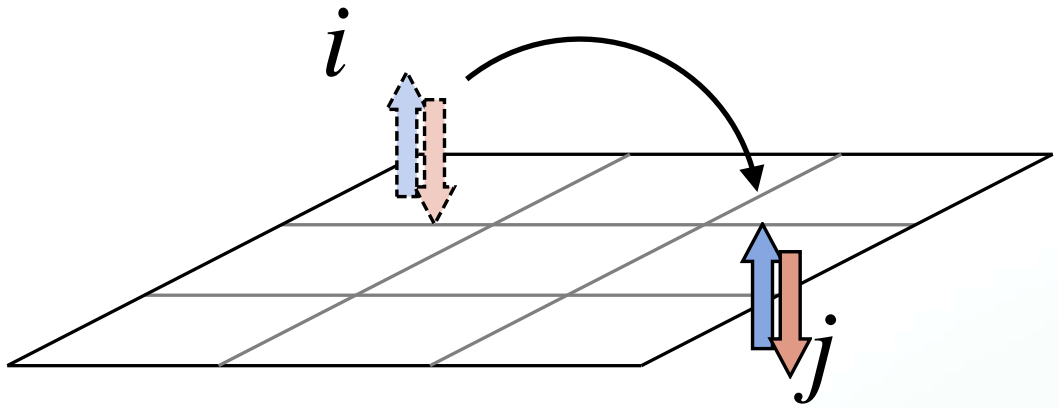


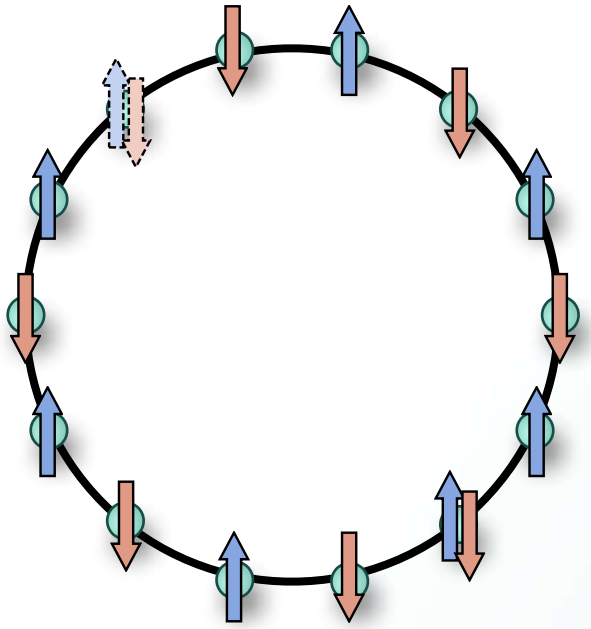
$$\Delta_i$$
$$\langle c^\dagger_{j\downarrow} c^\dagger_{j\uparrow} \overbrace{c_{i\uparrow} c_{i\downarrow}} \rangle$$



Classical State of the Art

$(U/t = 8)$

$$H = -t \sum_{\langle ij \rangle \sigma} c^{\dagger}_{i\sigma} c_{j\sigma} + U \sum_{i} n_{i\uparrow} n_{i\downarrow}$$



T Kaneko et al., *Phys. Rev. Lett.* (2019)

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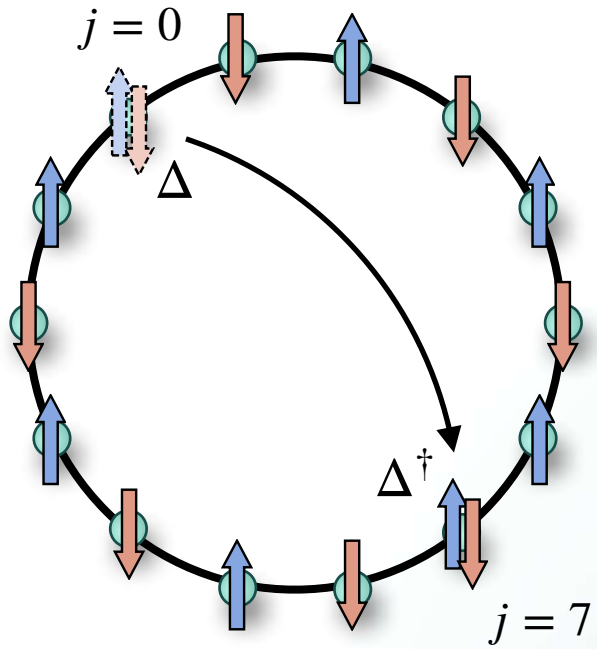

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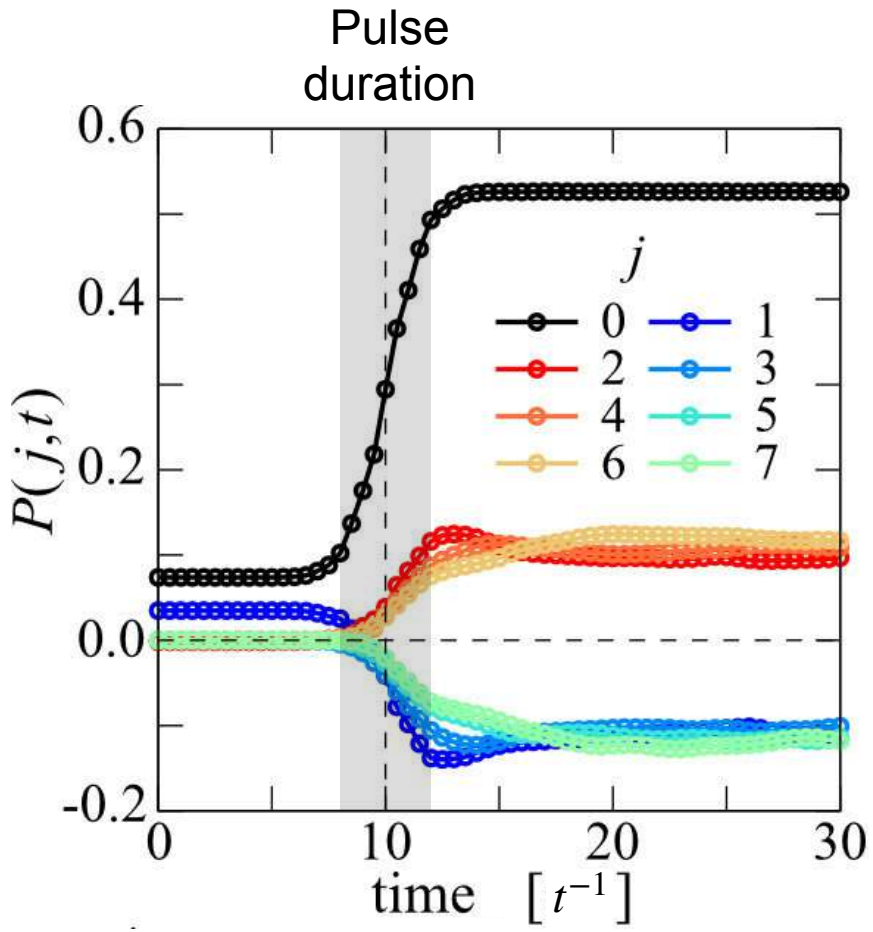

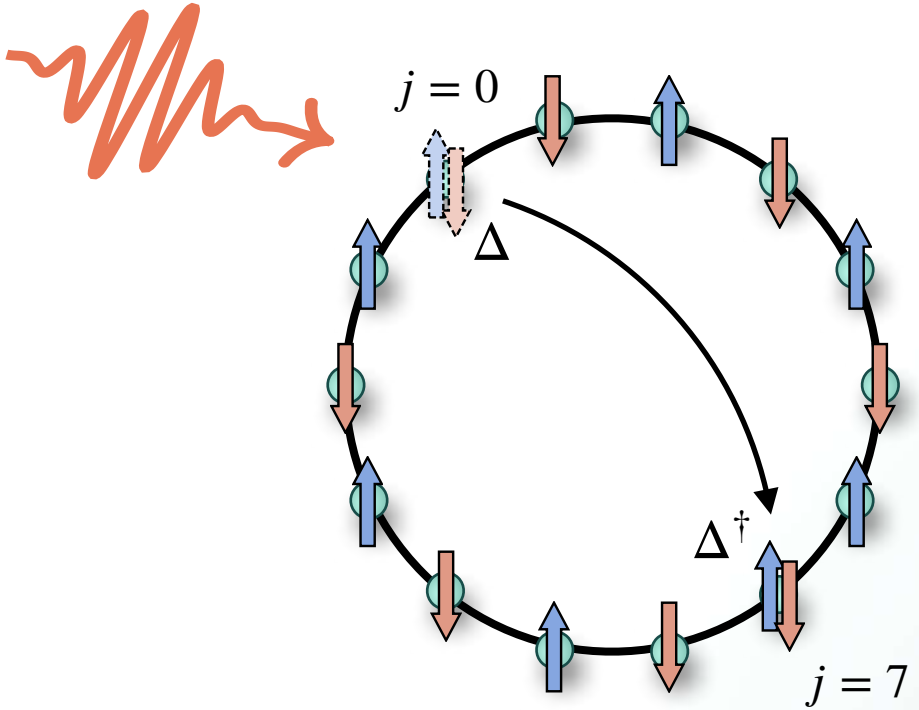

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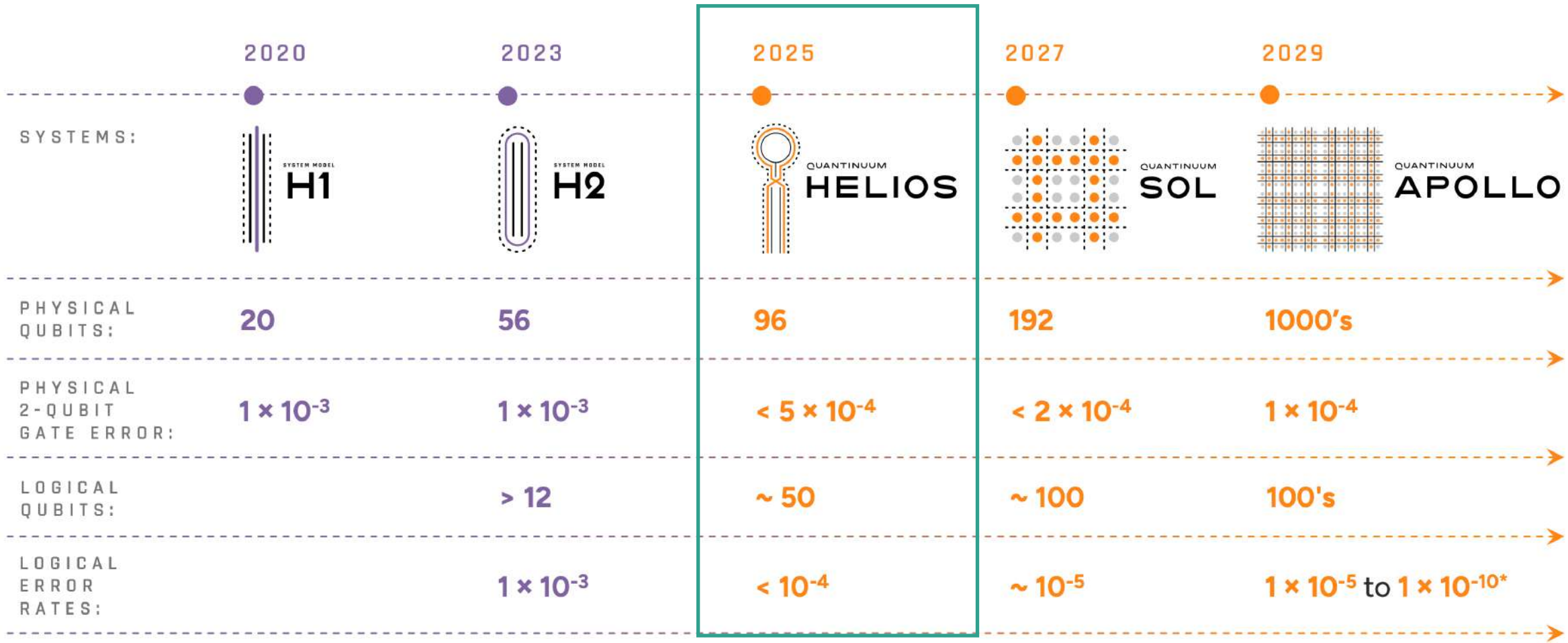
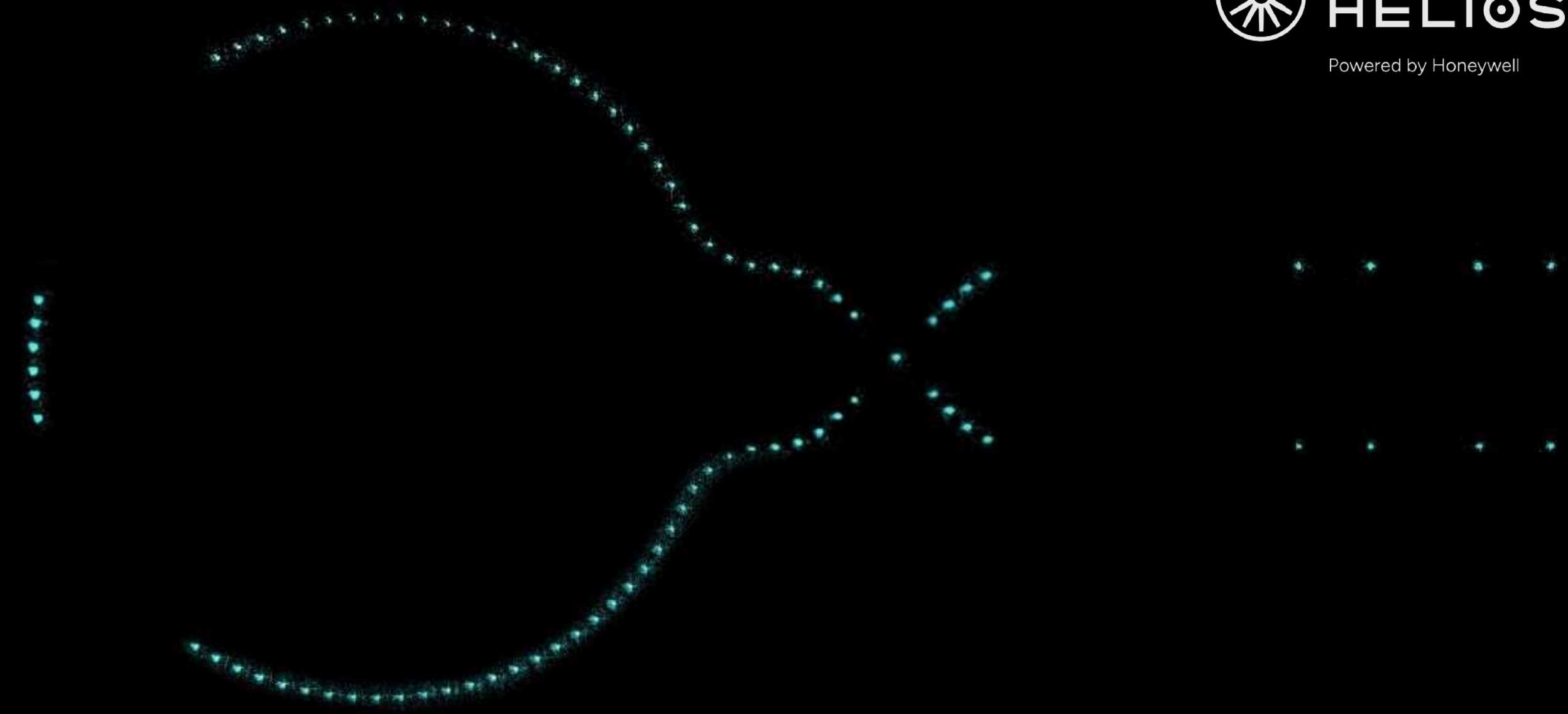


*analysis based on recent literature in new, novel error correcting codes predict that error could be as low as 1E-10 in Apollo (ref: arXiv:2403.16054, arXiv:2308.07915)



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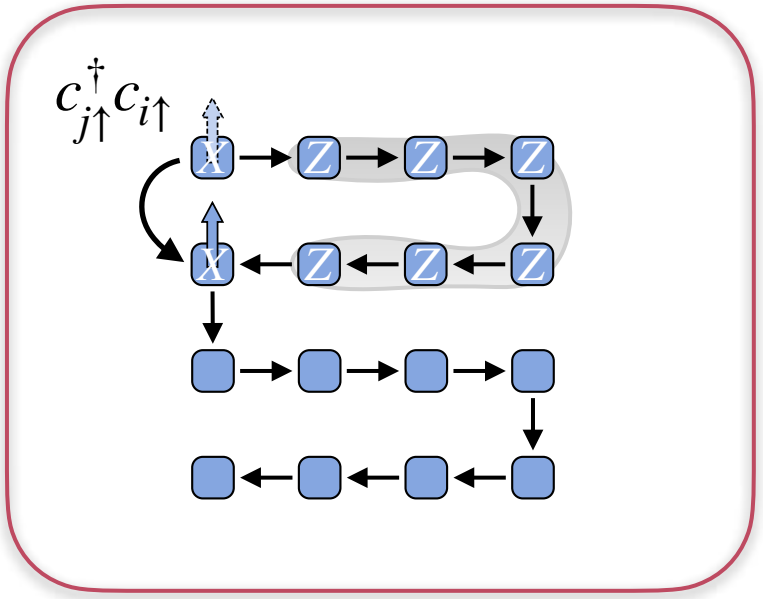
HELIOS

Powered by Honeywell

Fermionic Encodings

Jordan-Wigner



C Derby & J Klassen, *Phys. Rev. B 104, 035118 (2021),*
L Clinton, T Cubitt et al., *Nat. Comm 15, 211 (2024),*
"Dilution of Error" E Granet & H Dreyer, *PRX Quantum (2025),* E Chertkov et al*, arXiv:2410.10794,*
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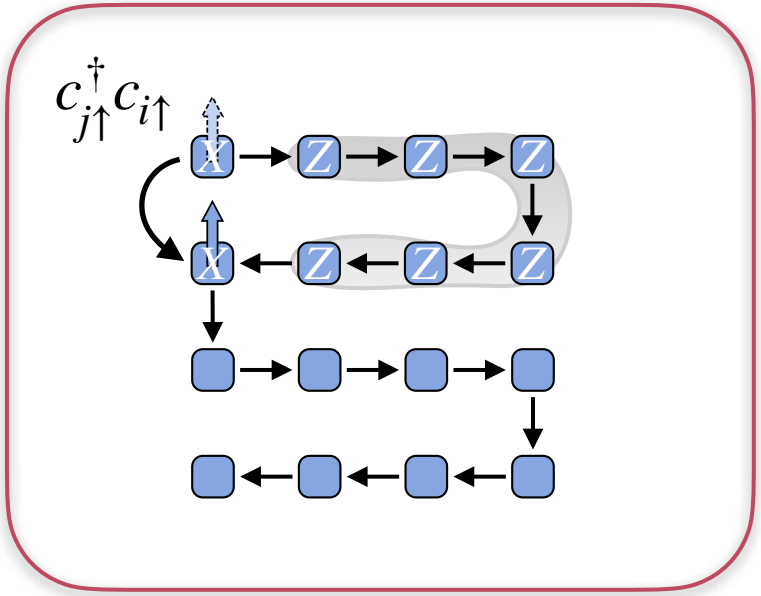
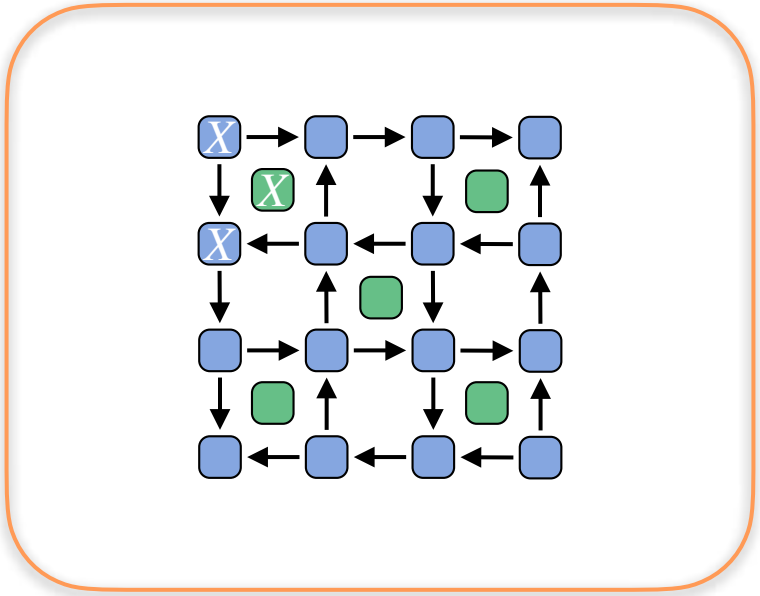


Compact



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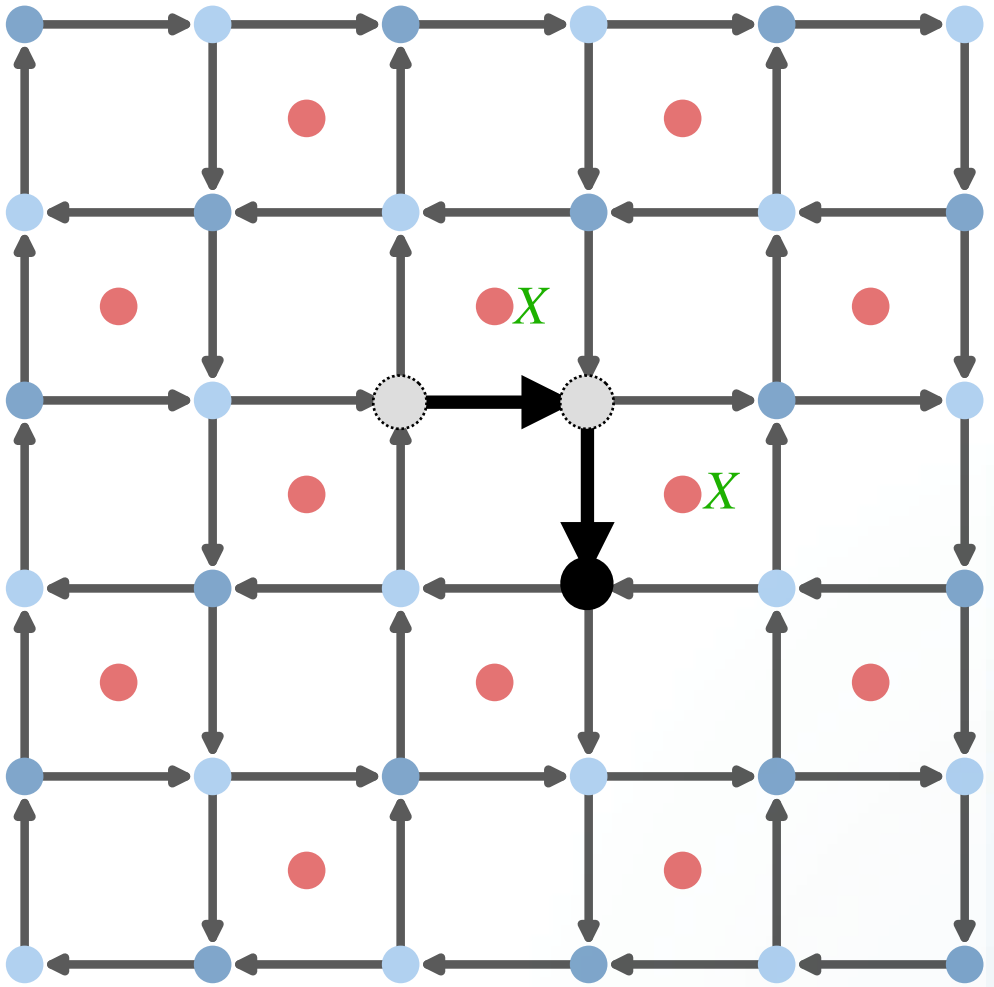

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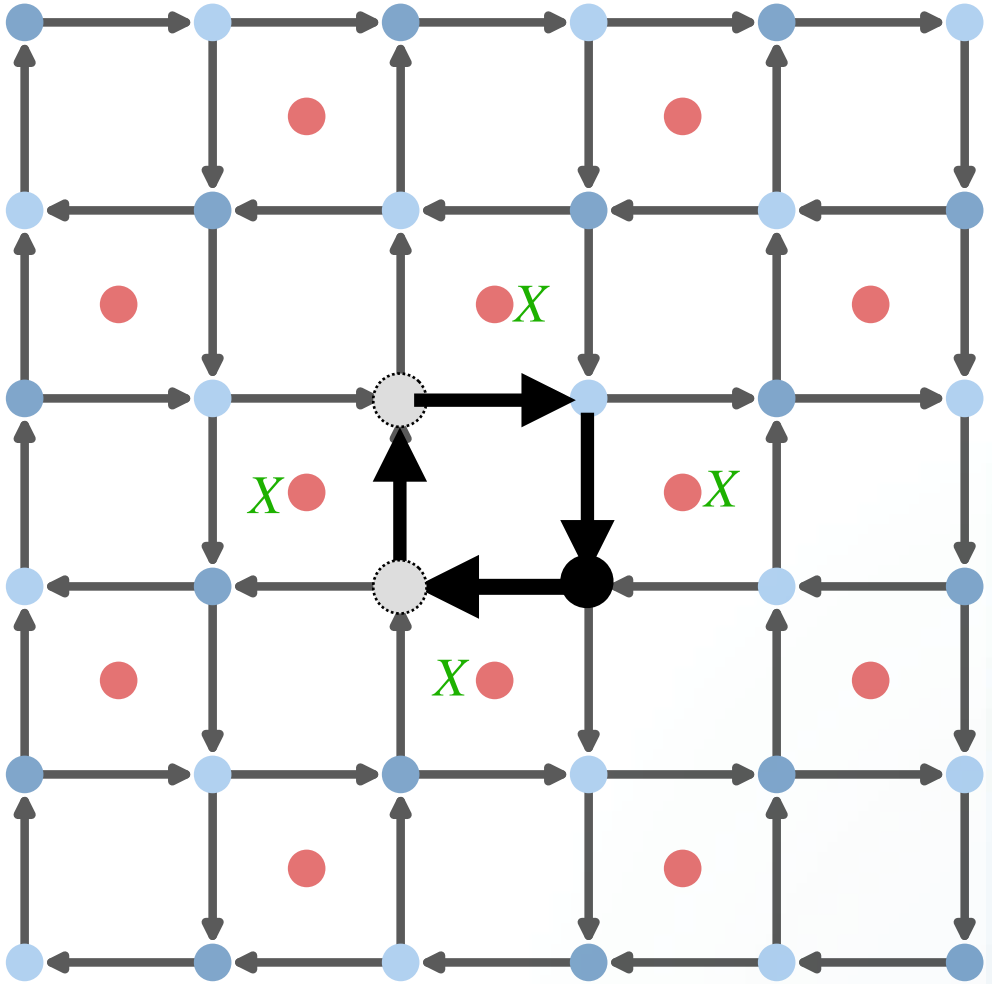

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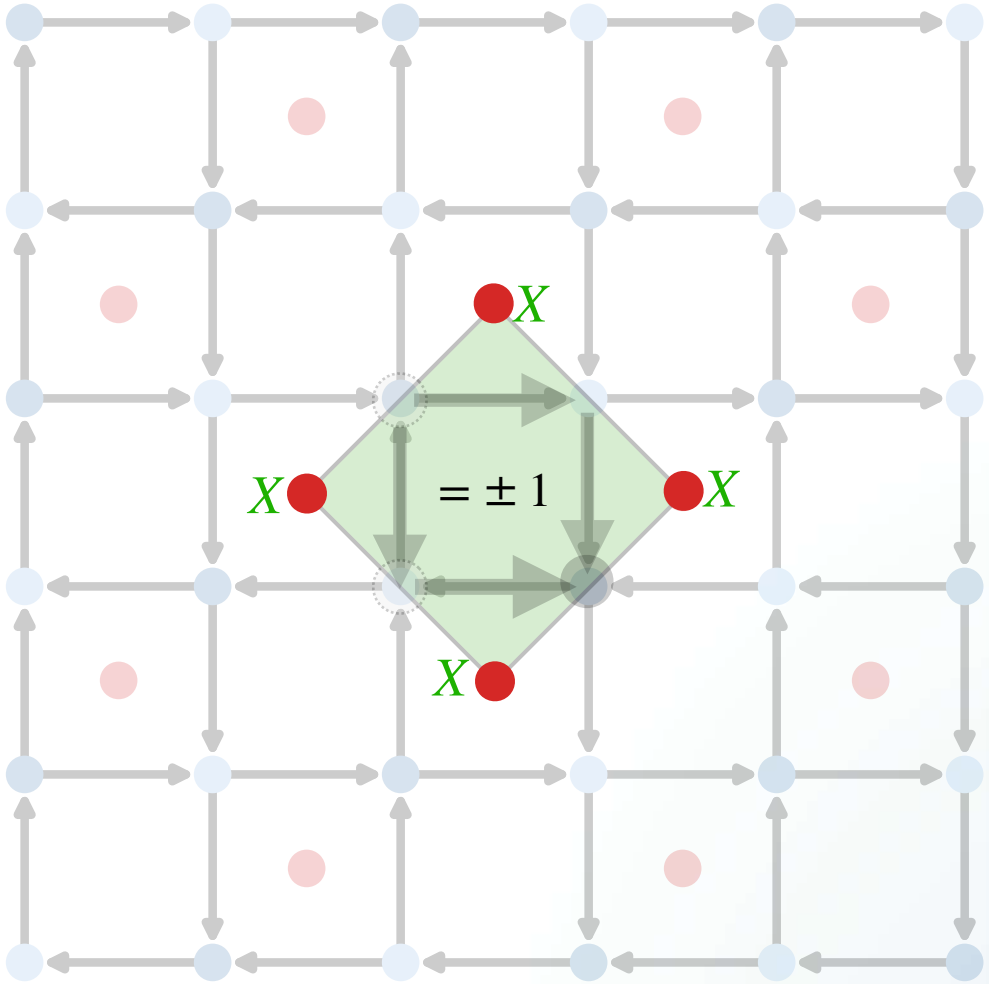

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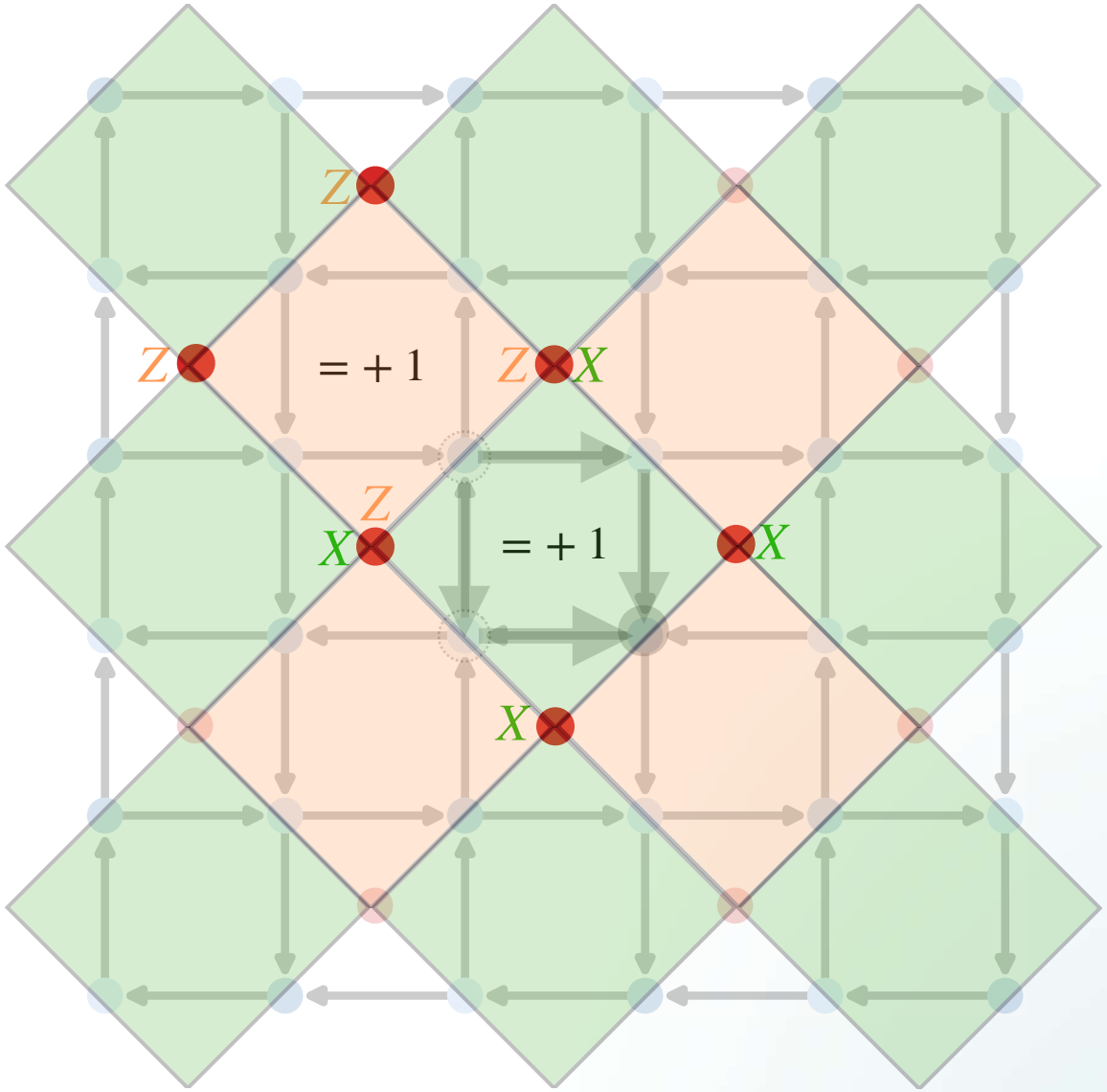

M Iqbal et al, *Nat Comm Phys 7, 205 (2024)*
M Foss-Feig et al, *arXiv:2302.03029*

Fermionic Encodings

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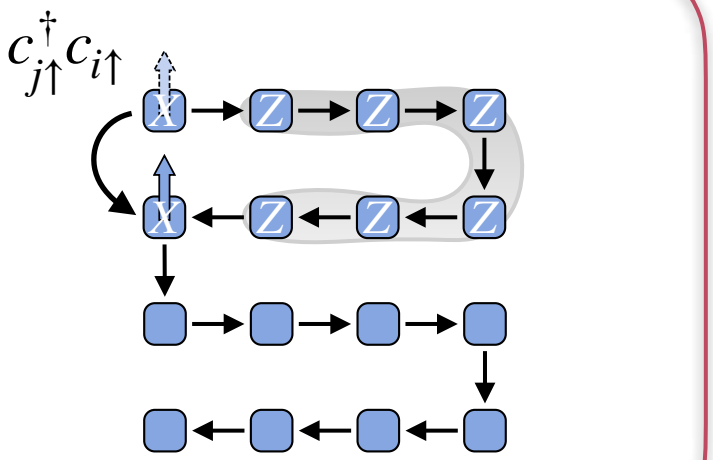

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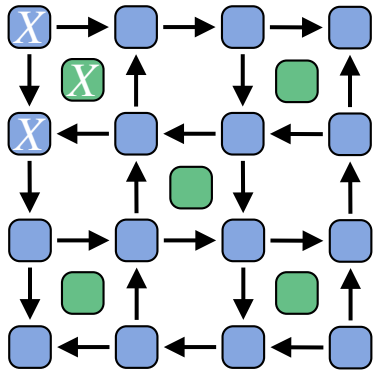

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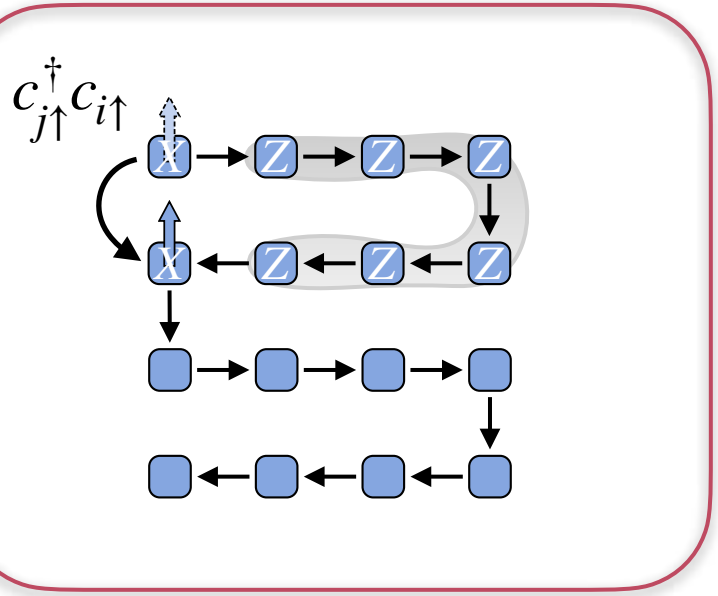

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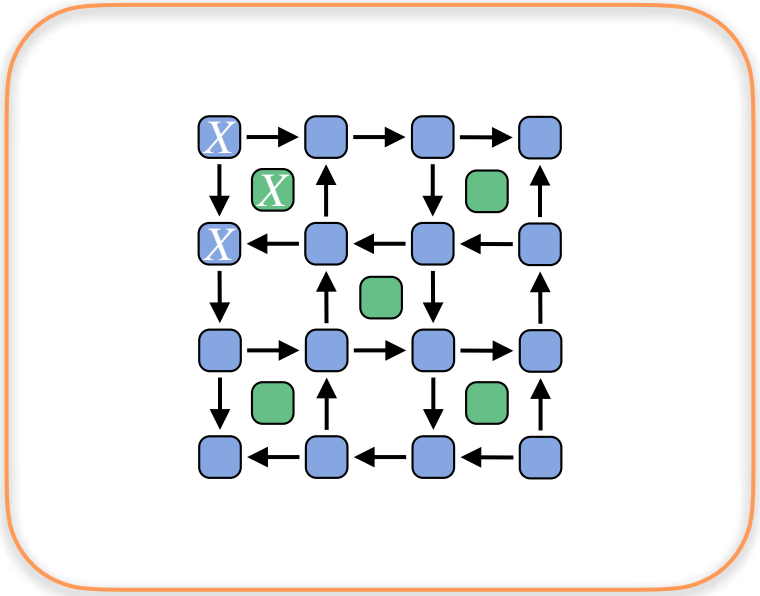
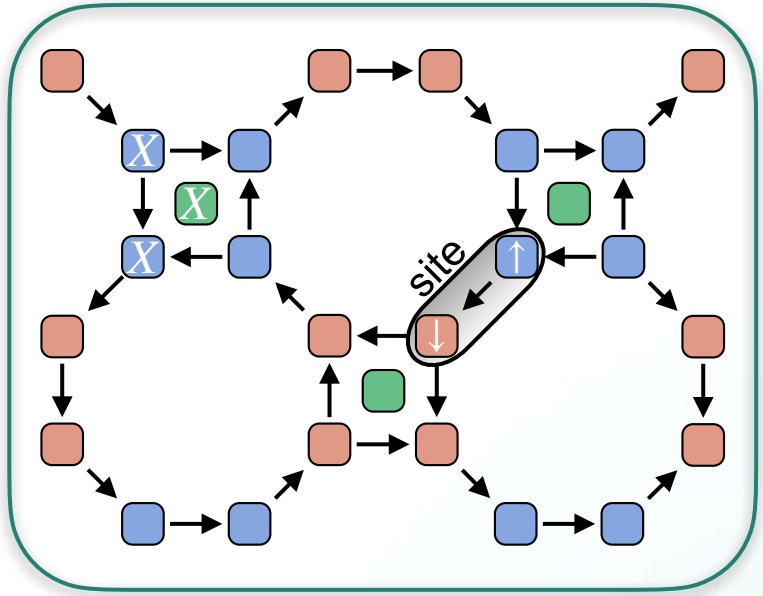


Octagon



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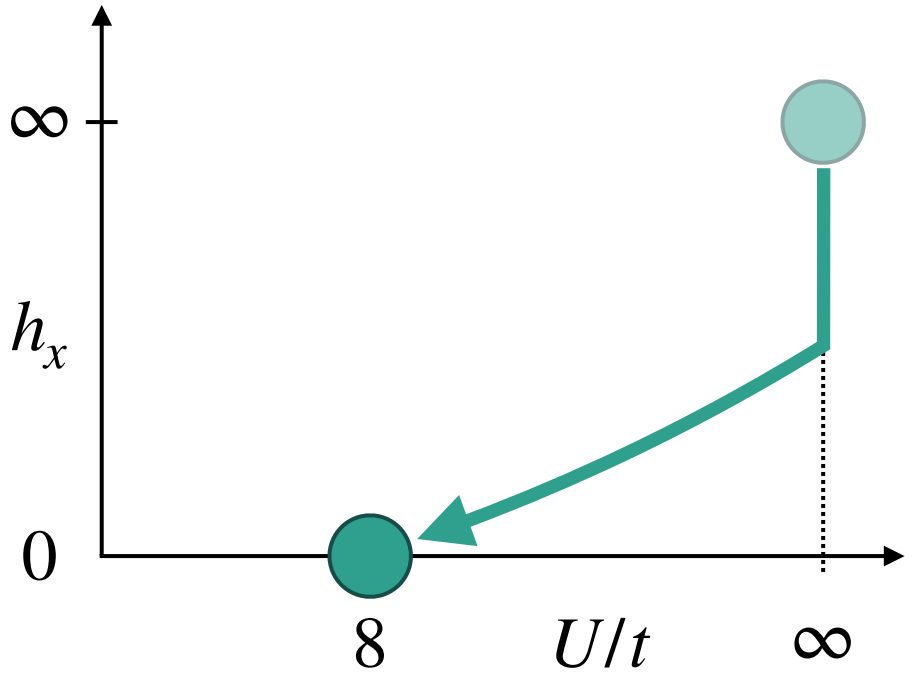
Low energy state preparation

6×6 half-filled periodic Fermi-Hubbard model $U = 8t$



$$H_{\text{Hubbard}} = -t \sum_{\langle ij \rangle \sigma} c_{i\sigma}^{\dagger} c_{j\sigma} + U \sum_{i} n_{i\uparrow} n_{i\downarrow} + h_x \sum (-1)^j S_j^x$$

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

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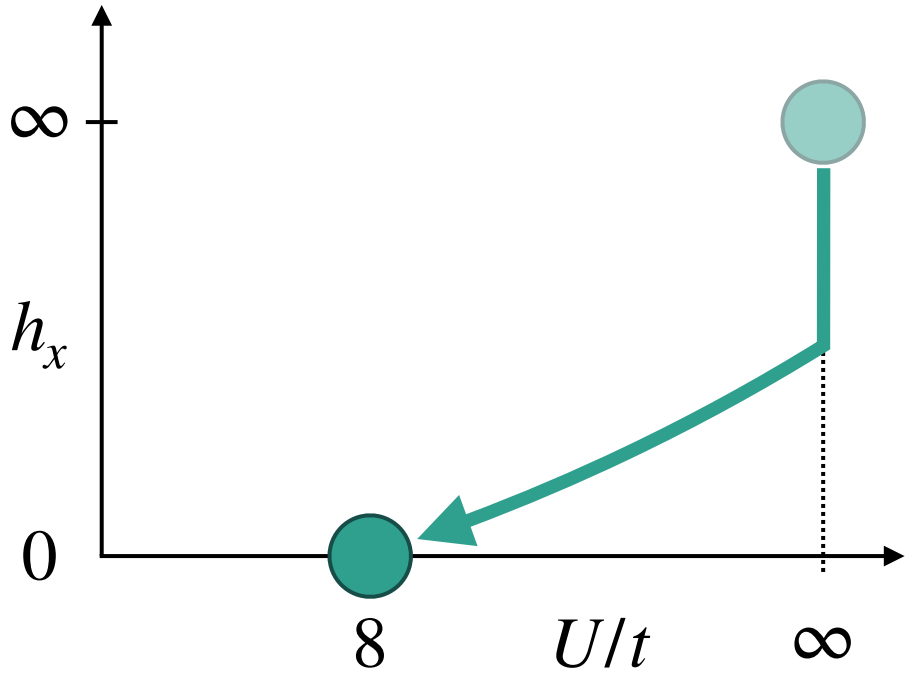

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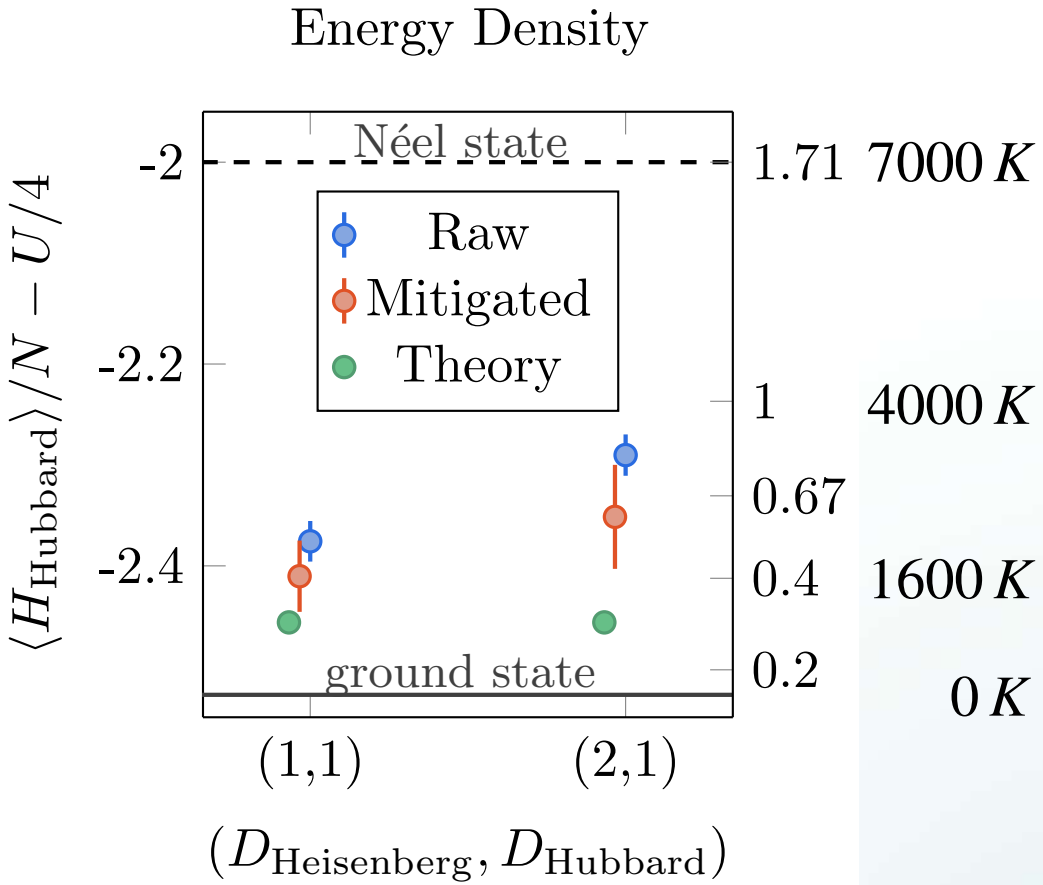

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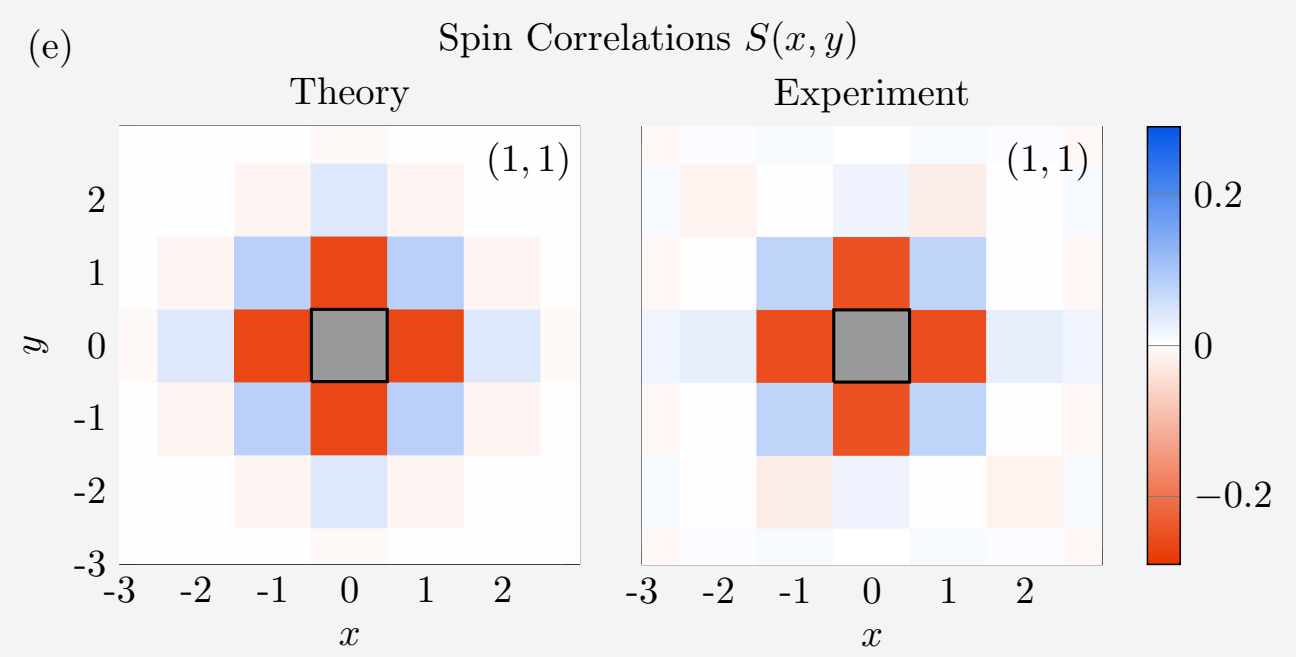
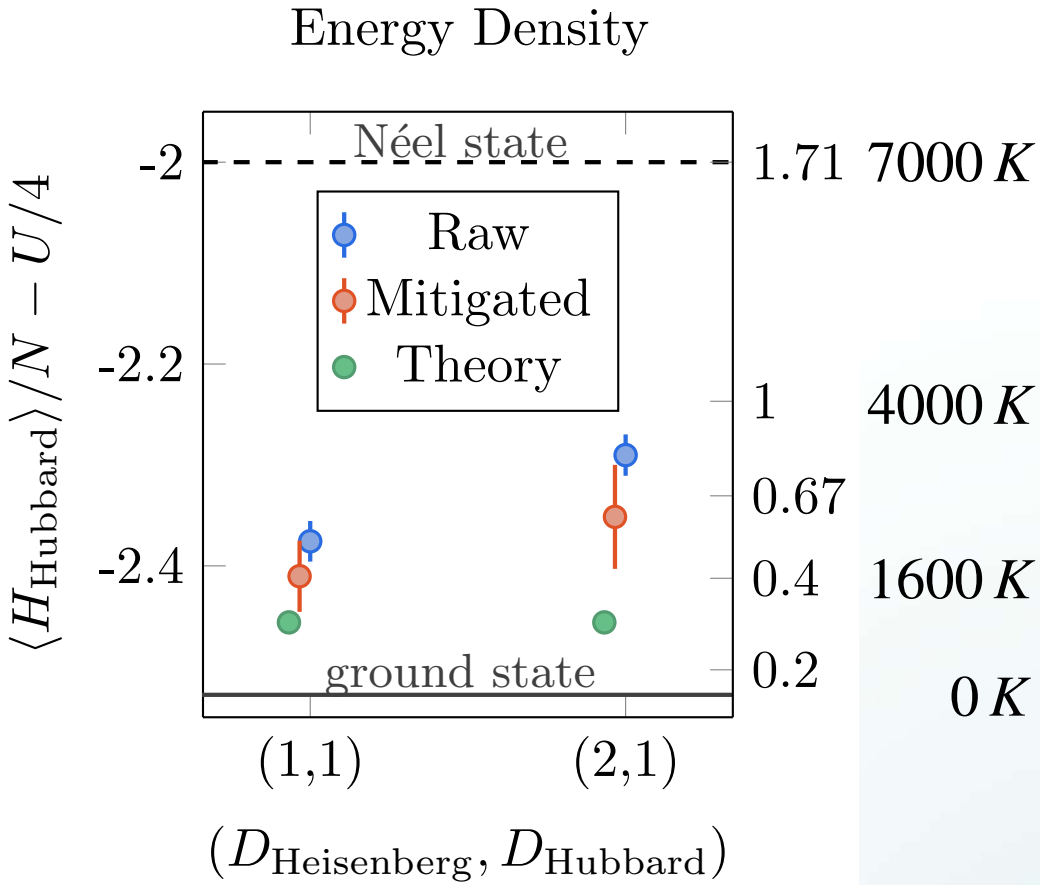
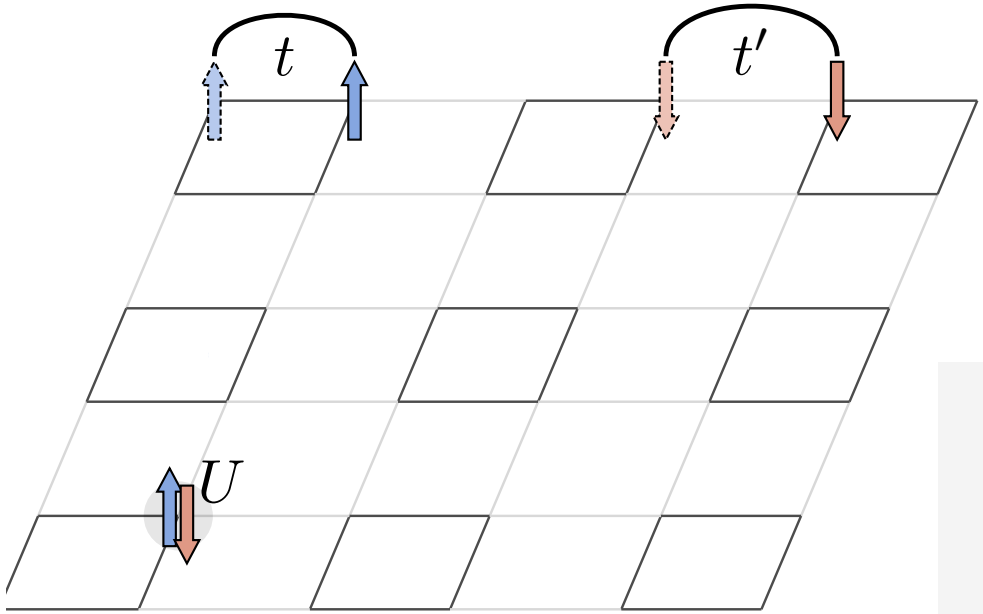


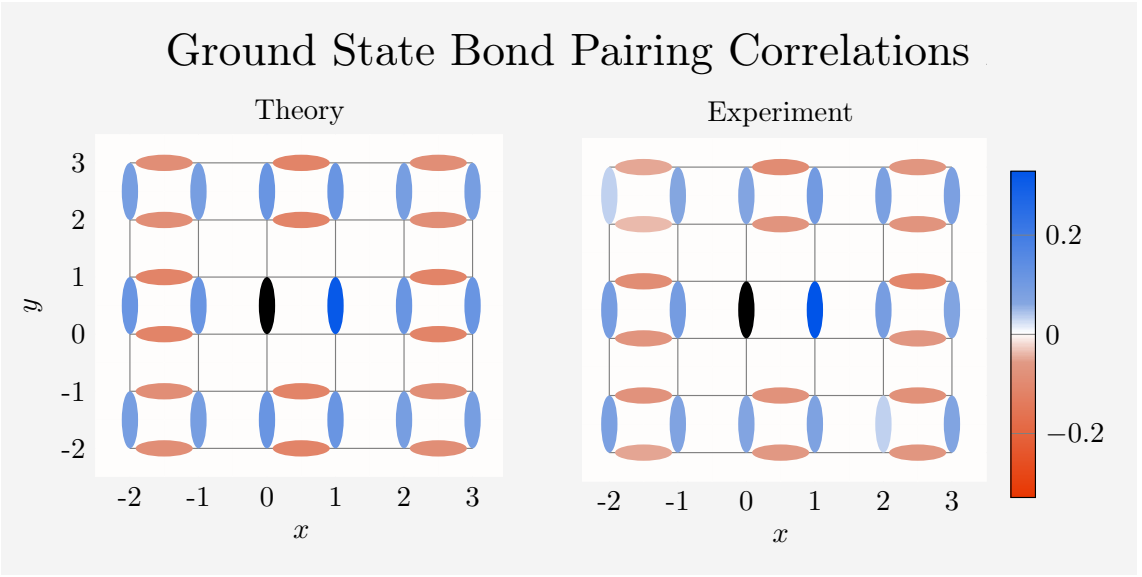


Superconducting pairing correlations on a trapped-ion quantum computer,
E Granet, SH Lin, K Hemery et al., *arXiv:2511.02125*

Sidenote: Anisotropic limit of the Hubbard model ($t' \ll t$)



S Trebst, U Schollwoeck, M Troyer, P Zoller
Phys. Rev. Lett. 96, 250402 (2006)



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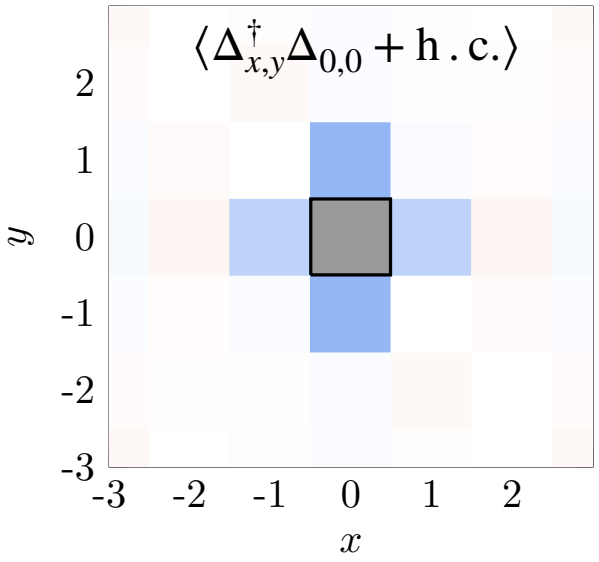
η-correlations
$(U/t = 8)$



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η-correlations after light pulse
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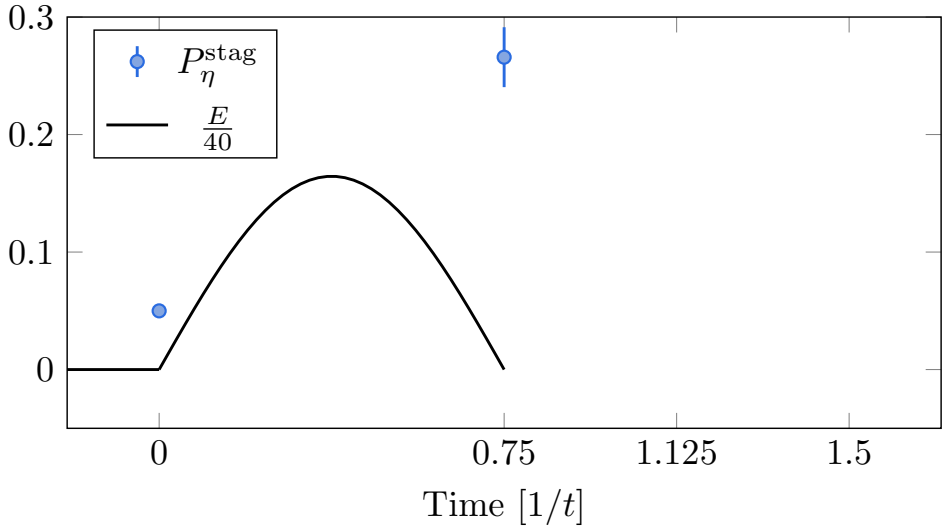

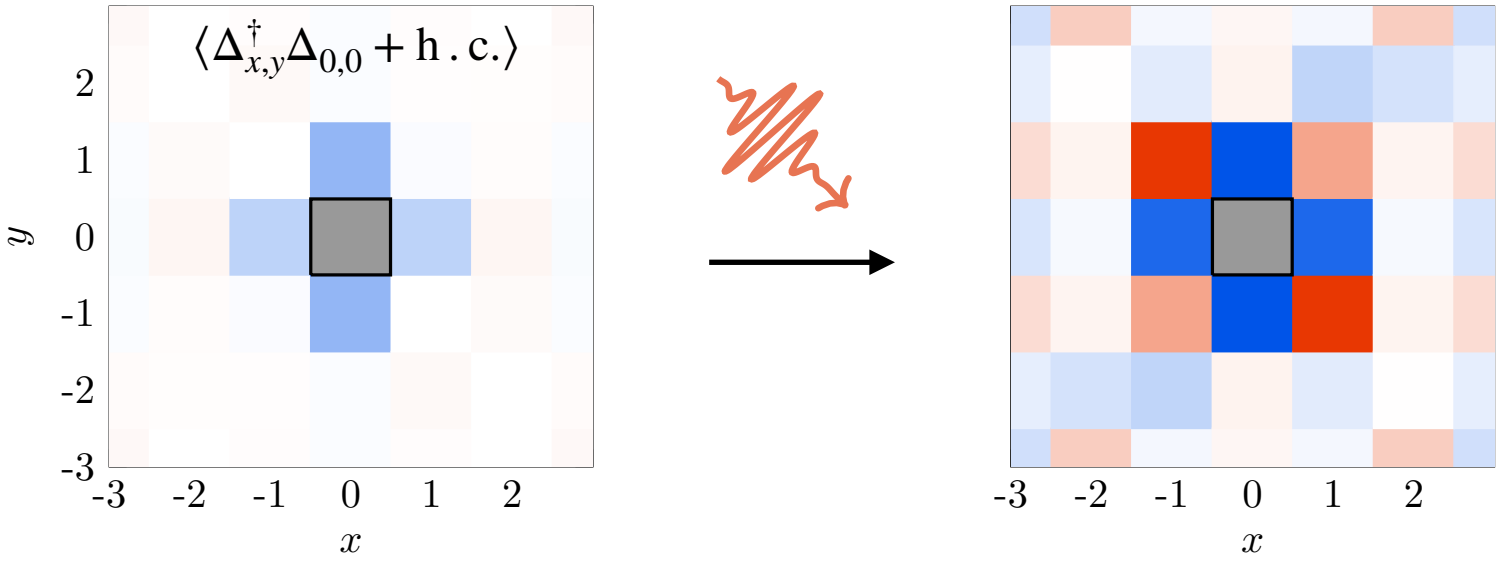

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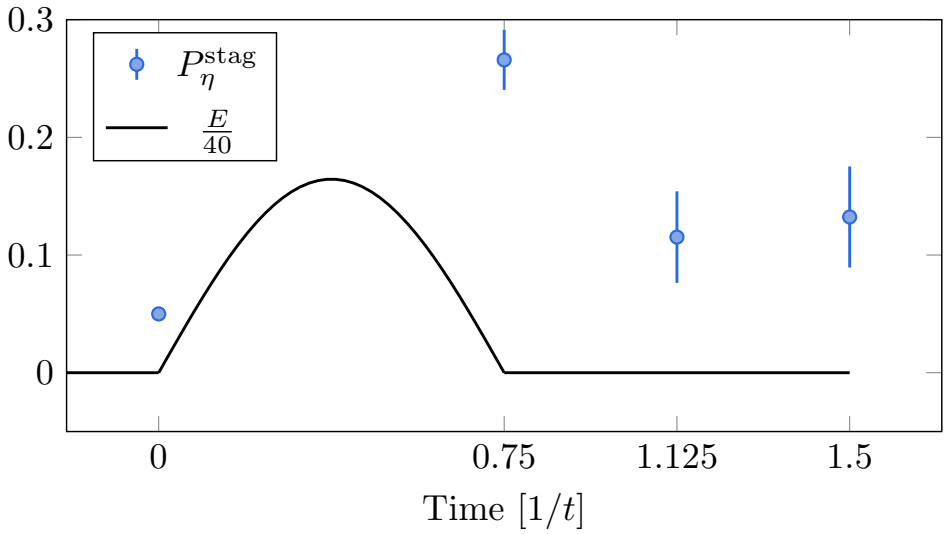
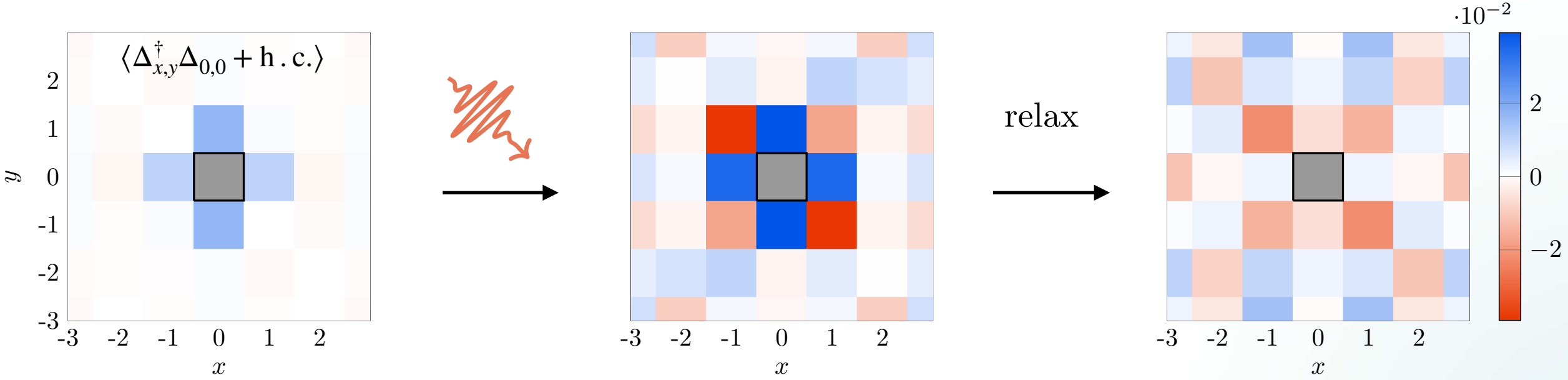
η-correlations after light pulse

$(U/t = 8)$





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

Classical Difficulty

Sparse Pauli Dynamics

$$O = \sum_P c_P P$$

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

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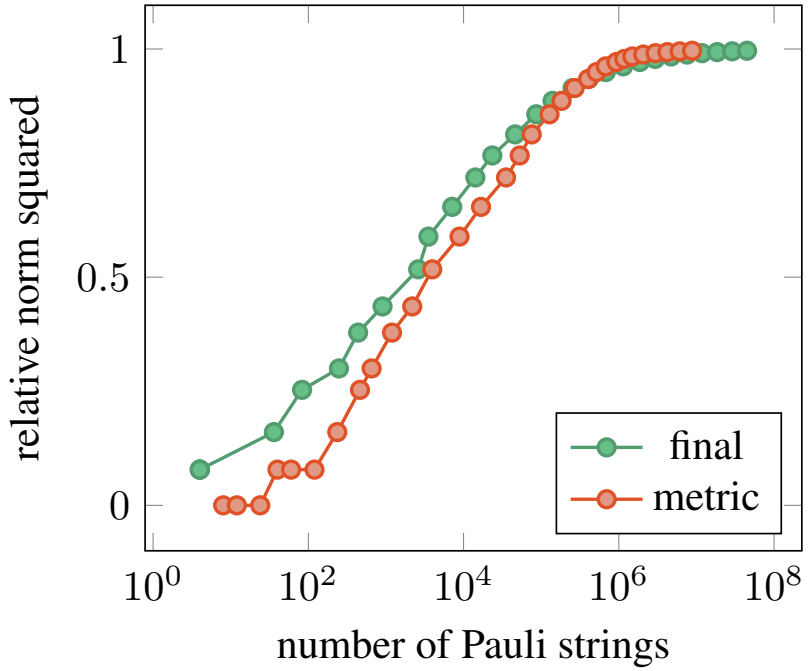

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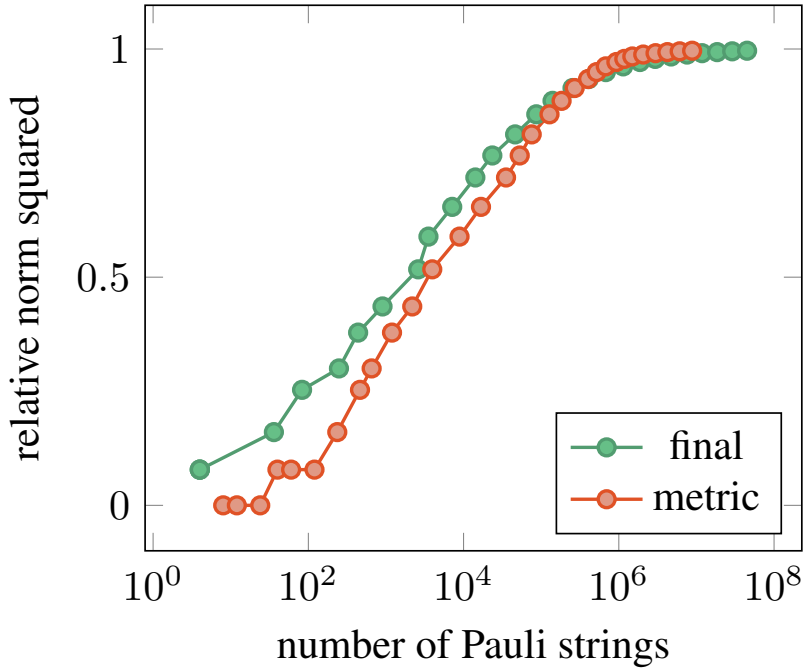

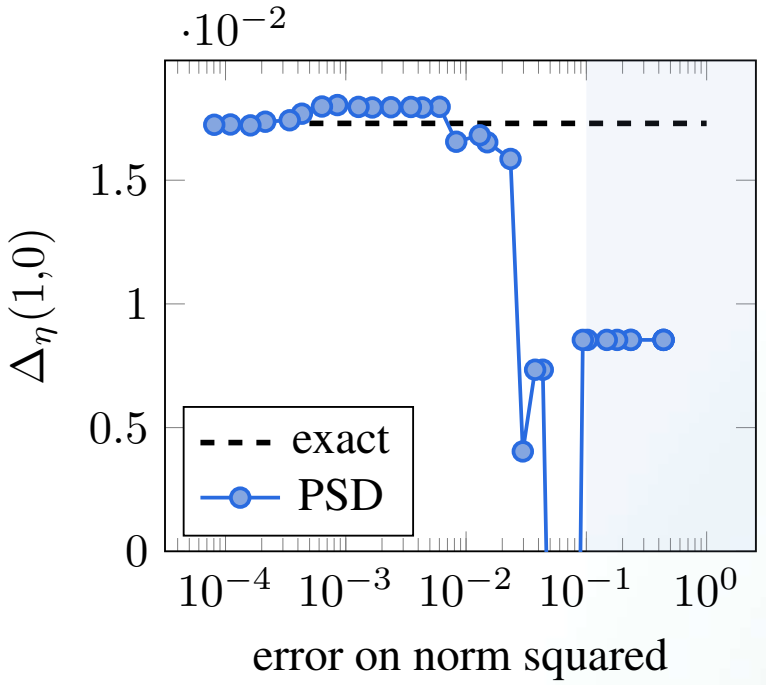

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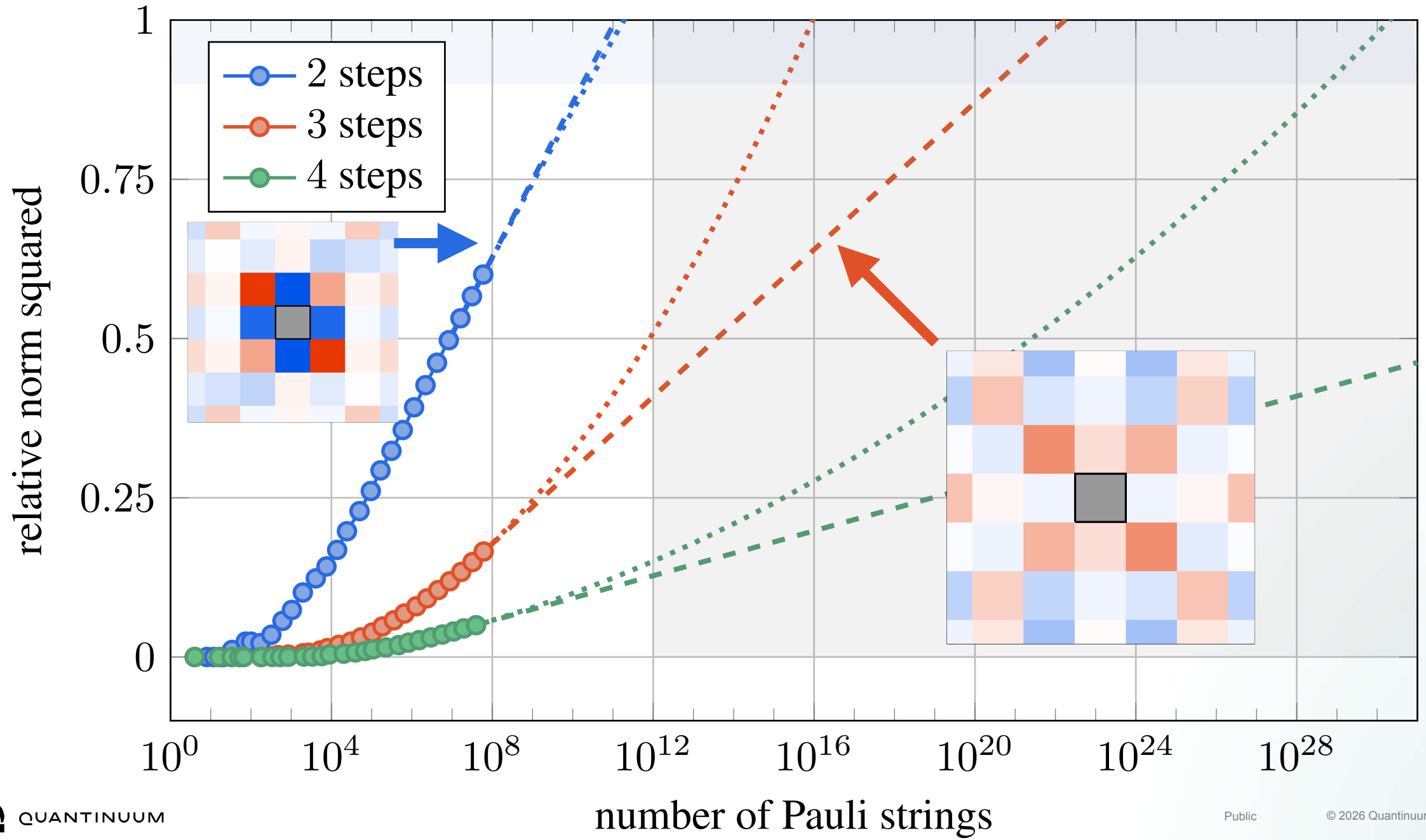

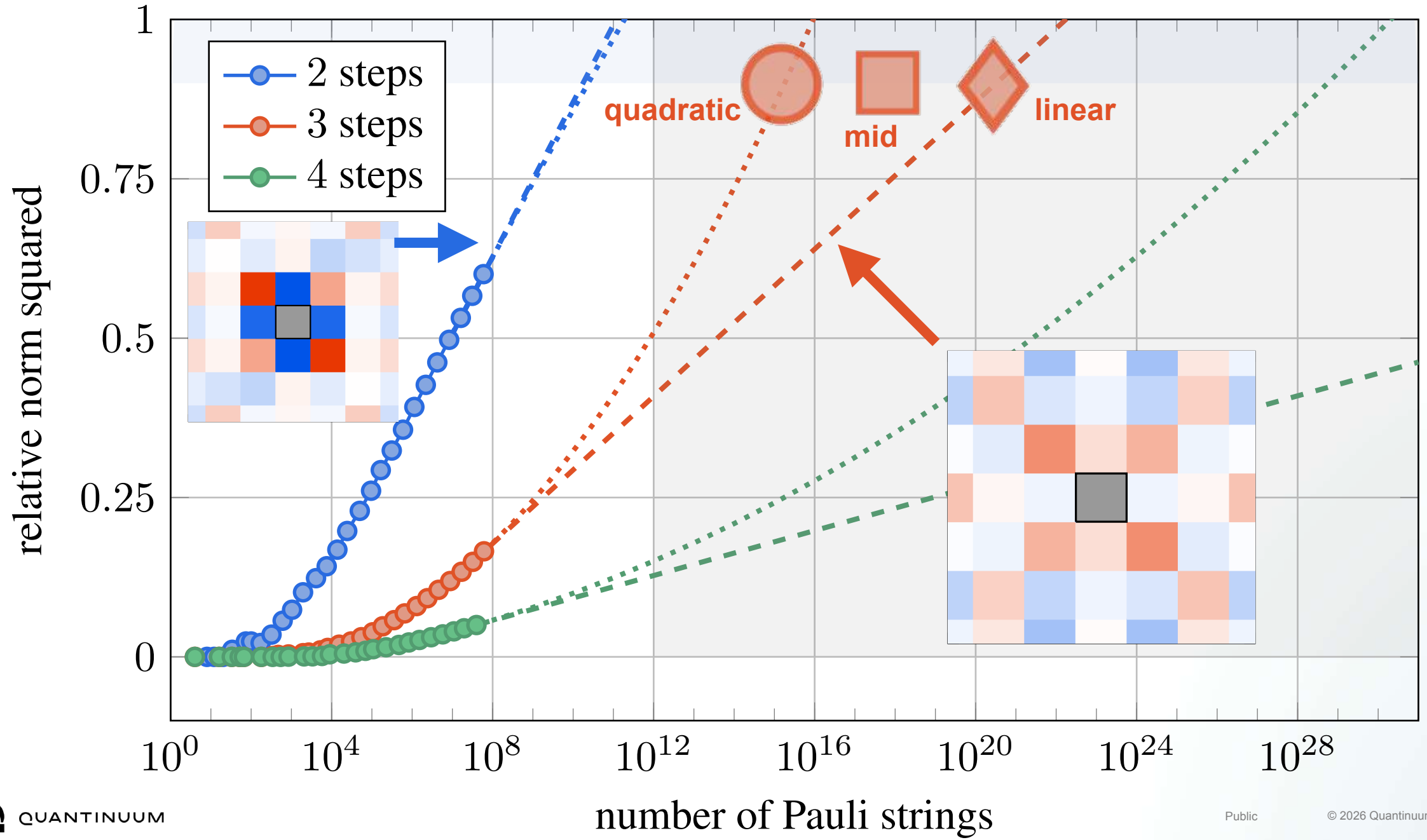

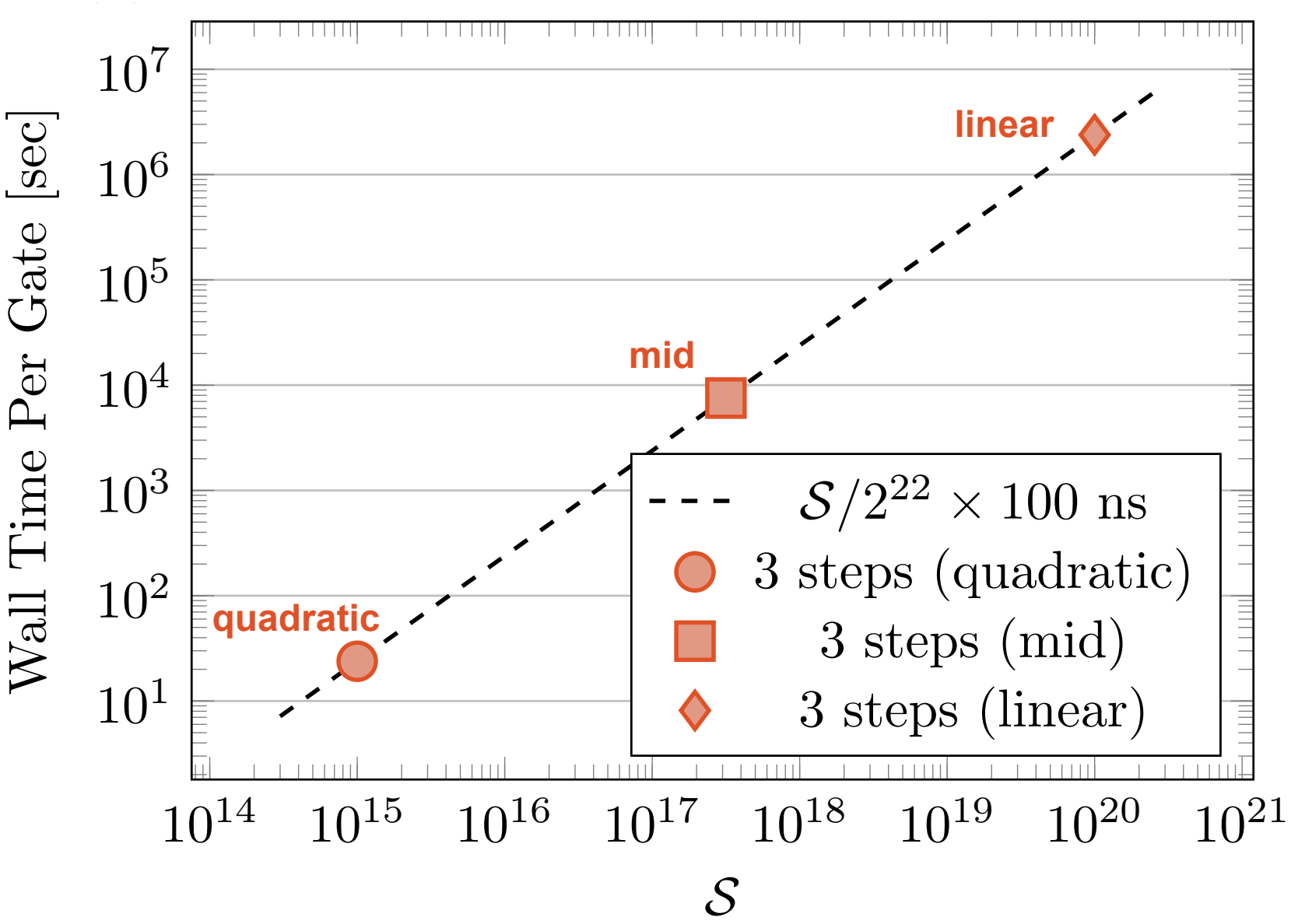

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