



Turun yliopisto  
University of Turku

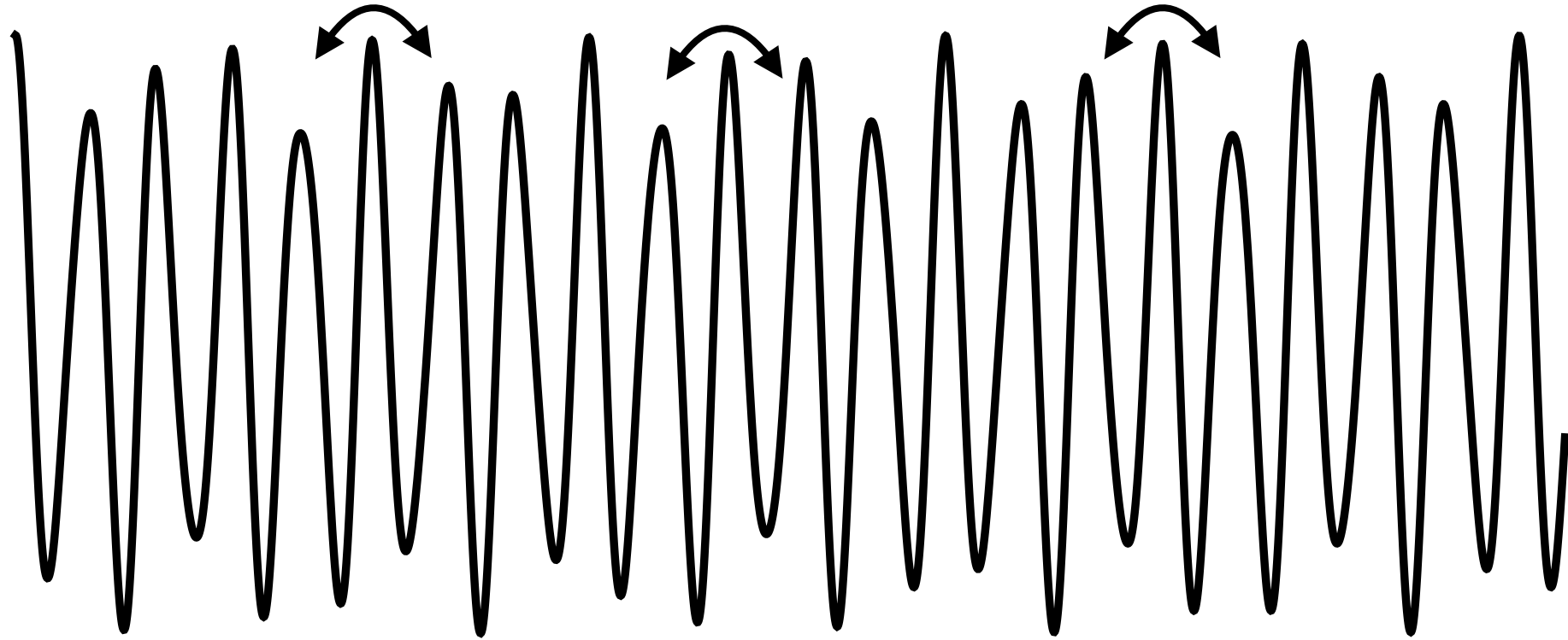


# PROBING STATISTICAL ORTHOGONALITY CATASTROPHE IN A QUASI-PERIODIC SYSTEM

EML, Francesco Cosco, Massimo Borrelli, Sabrina Maniscalco  
John Gool, ICTP, Italy

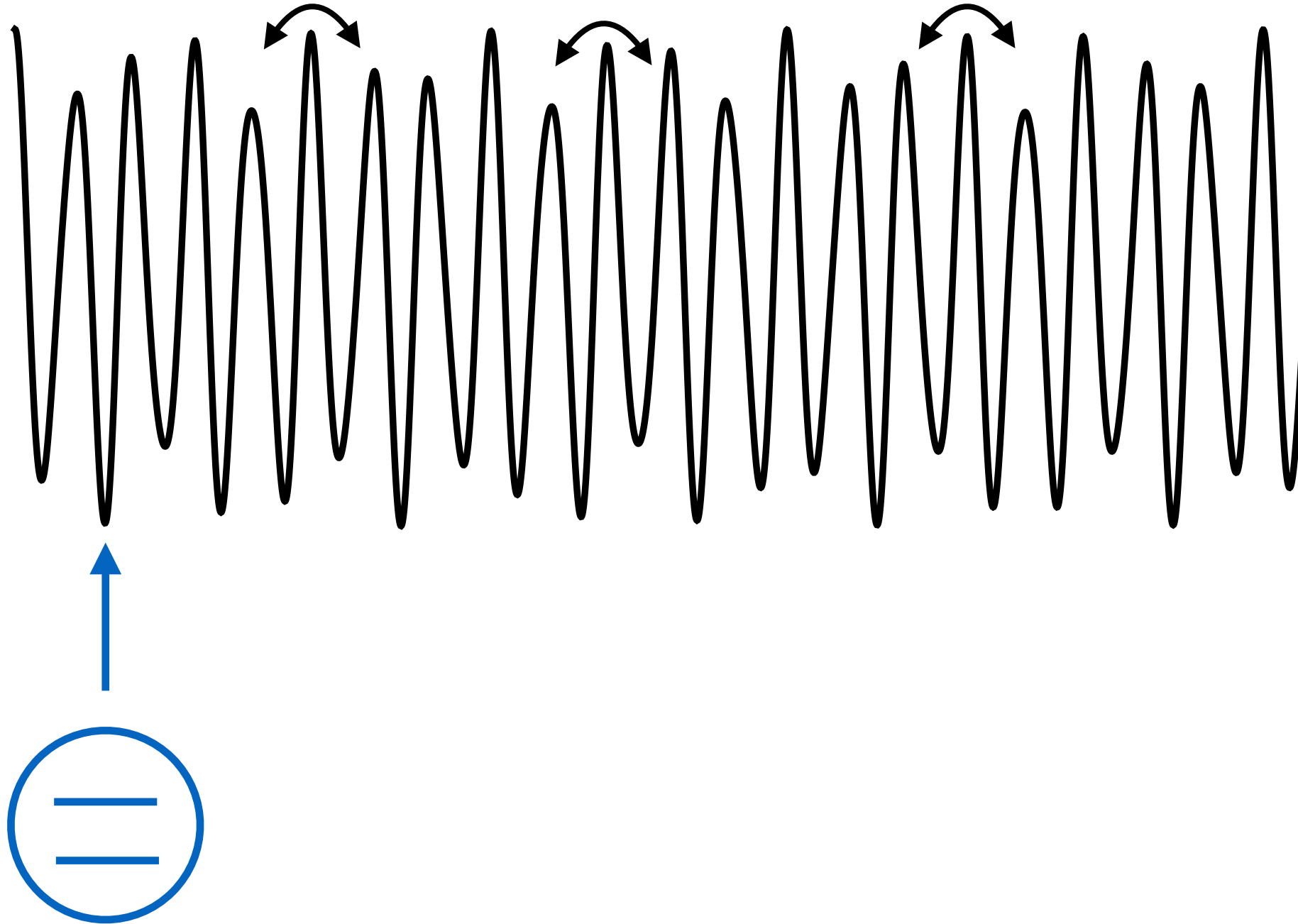
QuProCS Meeting, Palma, April 7th 2017

# Setup



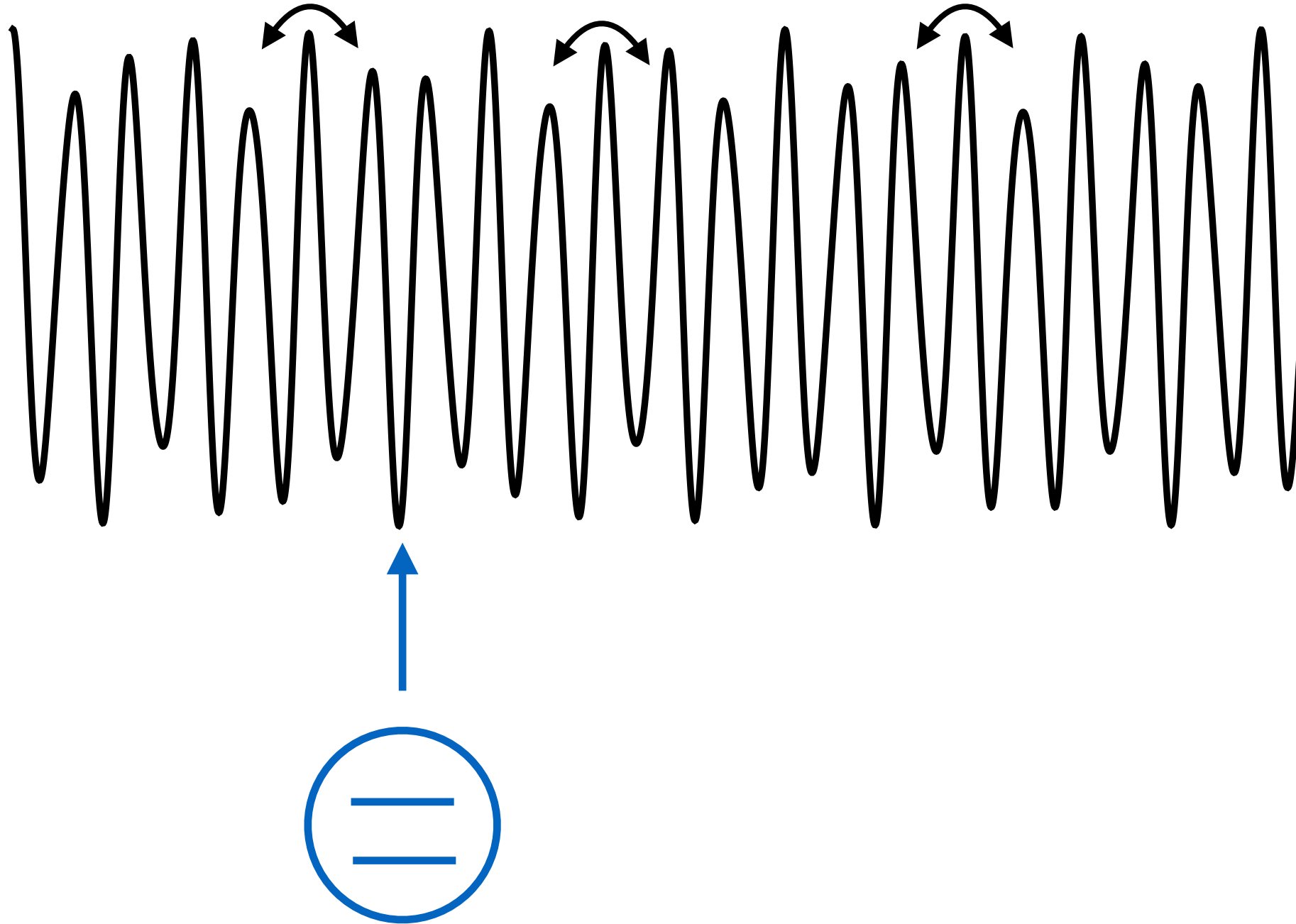
- ♣ Incommensurate lattice partially filled with fermions.

# Setup



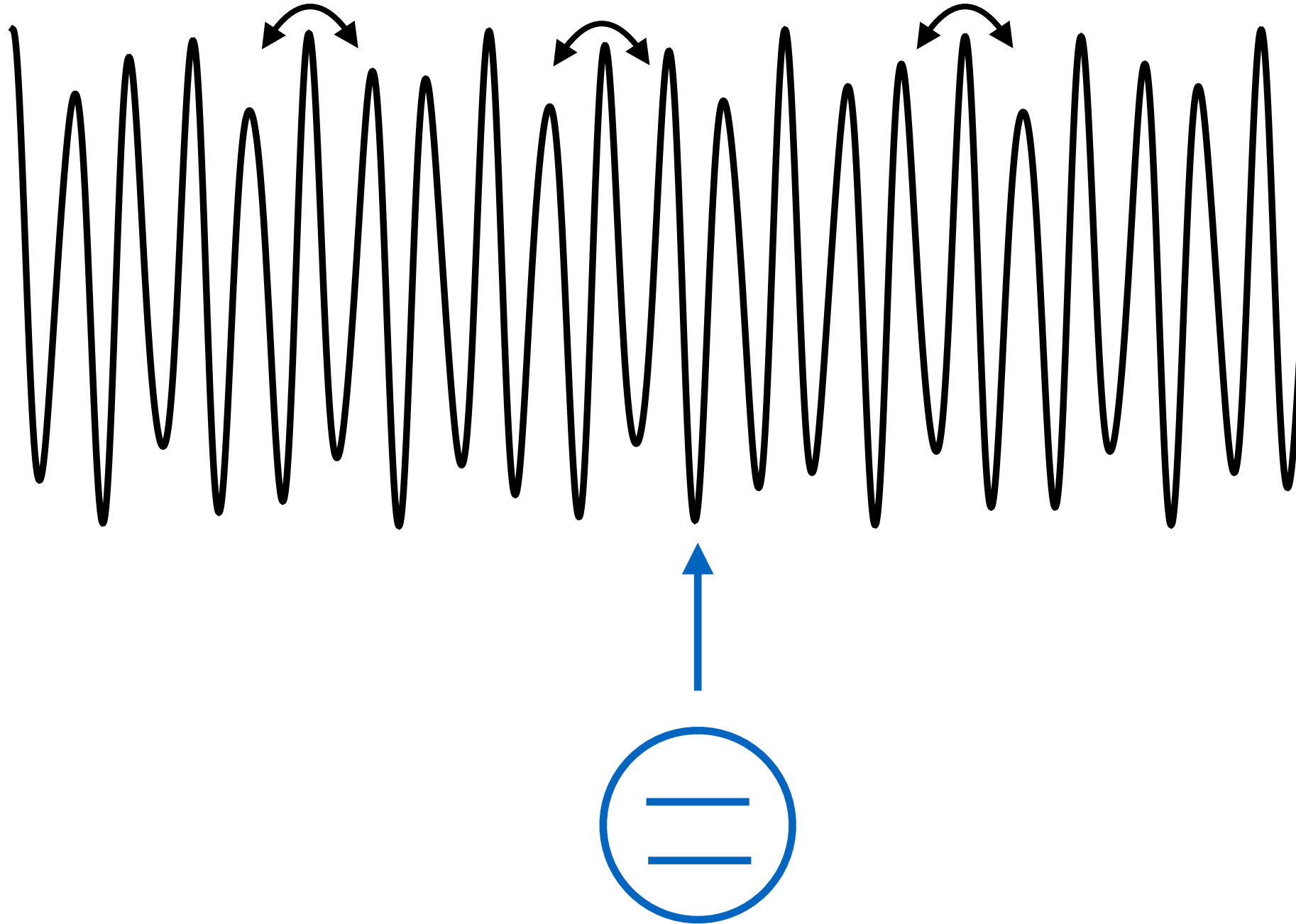
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# Setup



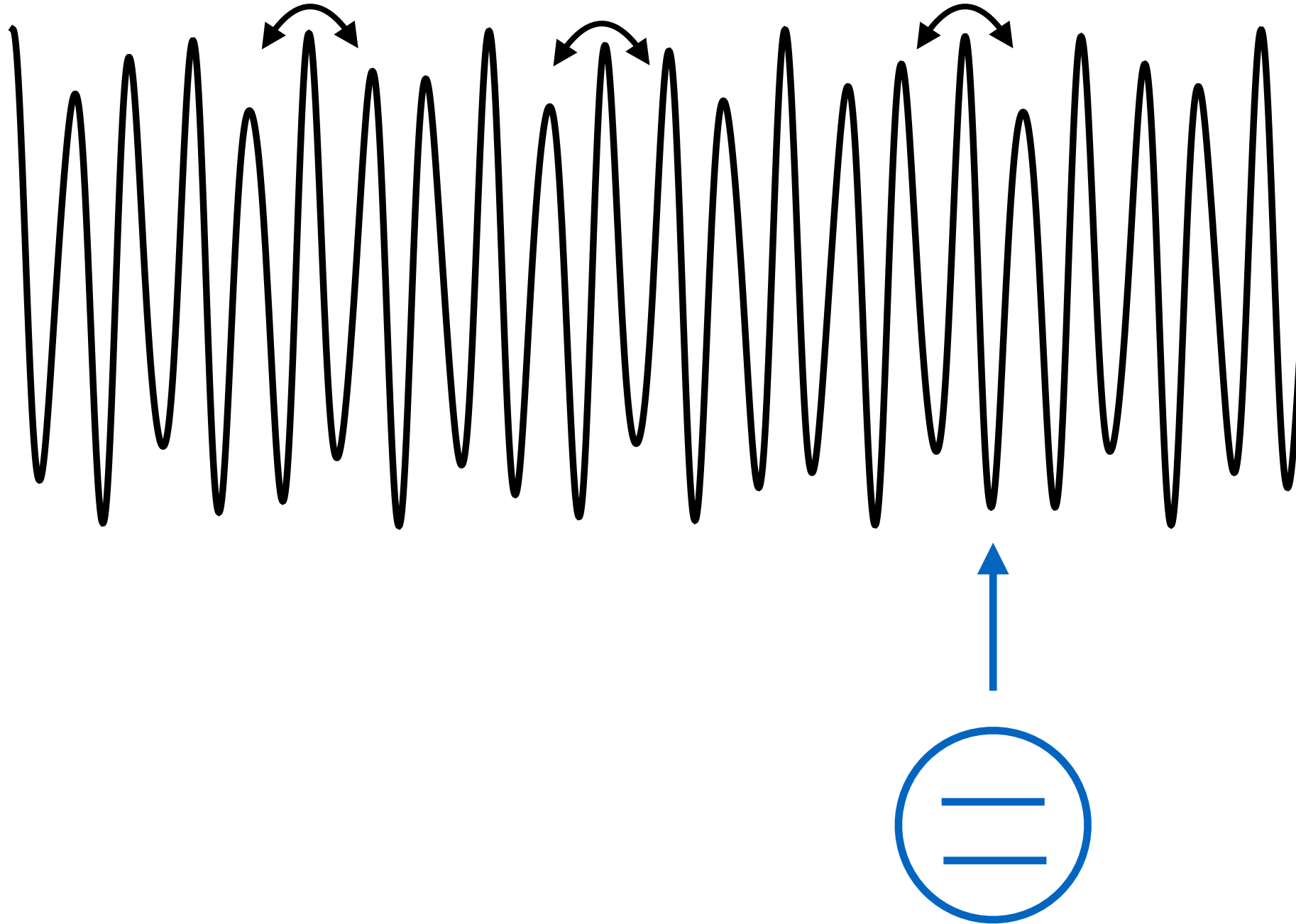
- ♣ Incommensurate lattice partially filled with fermions.

# Setup



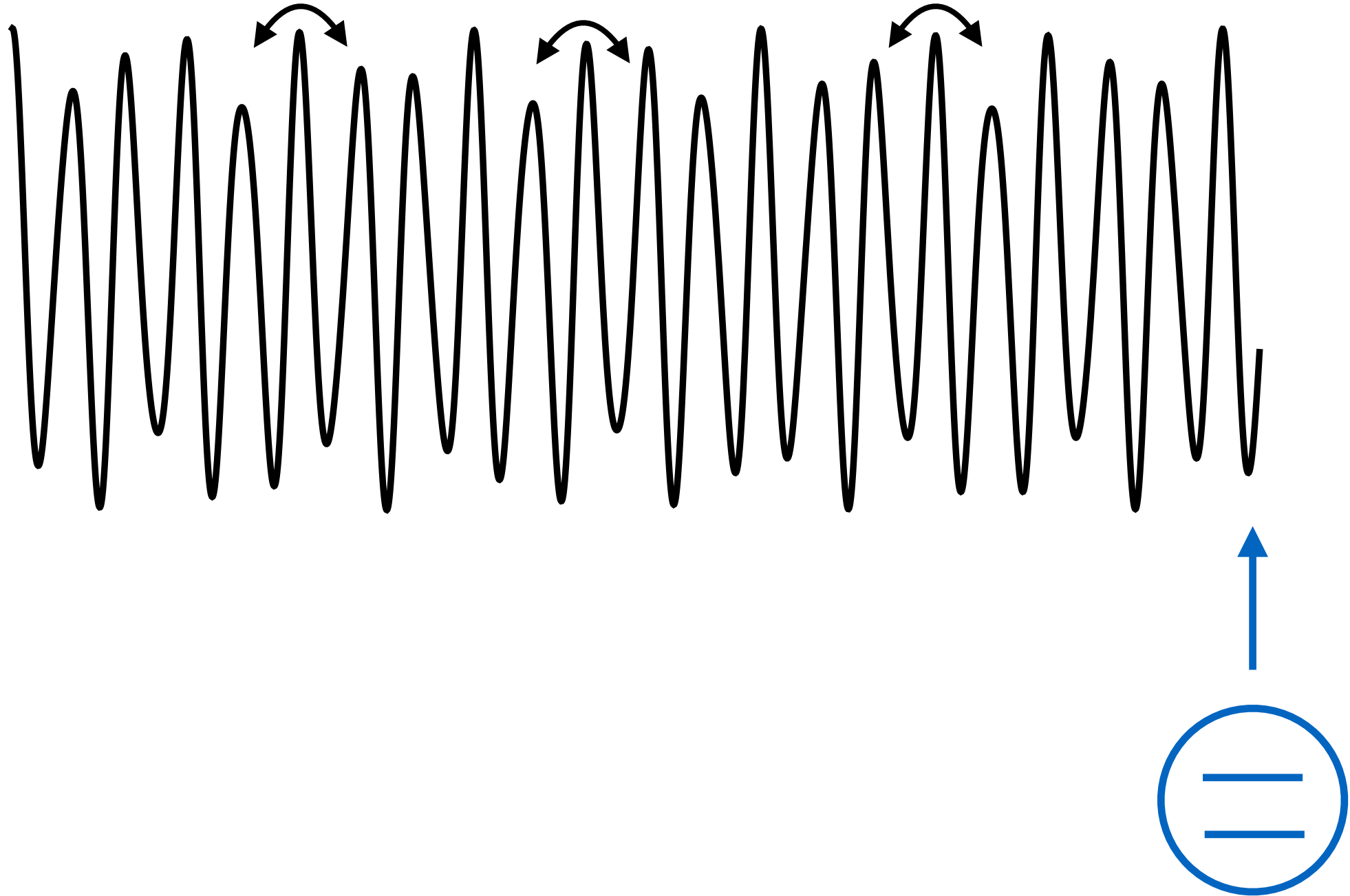
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# Setup



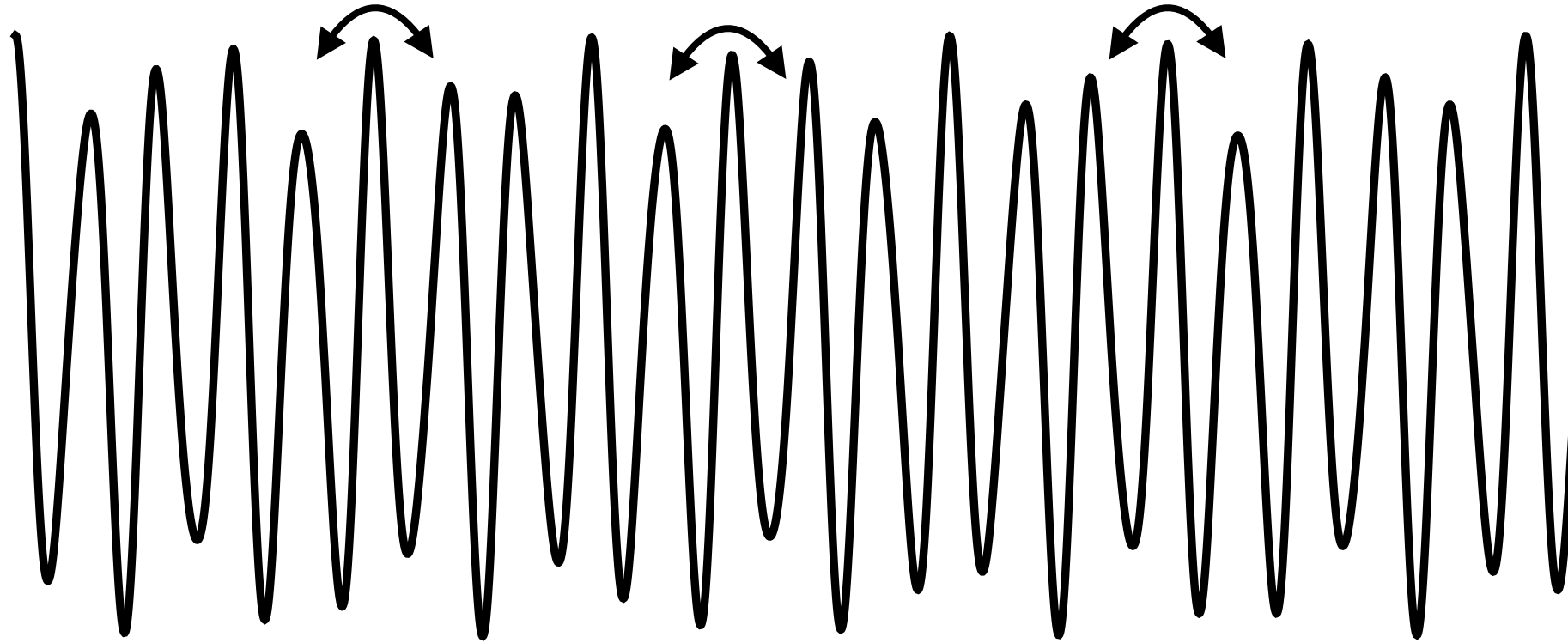
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# Setup



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# Setup



- ♣ Incommensurate lattice partially filled with fermions.



# Aubry-André model

$$\hat{H}_{AA} = -J \sum_{i=1} (\hat{a}_{i+1}^\dagger \hat{a}_i + \hat{a}_i^\dagger \hat{a}_{i+1}) + \Delta \sum_{i=1} \hat{n}_i \cos(2\pi\beta i + \phi)$$

$$\hat{H}_{int} = g|e\rangle\langle e| \otimes \hat{a}_{\bar{x}}^\dagger \hat{a}_{\bar{x}}$$

$N < L$     spineless fermions

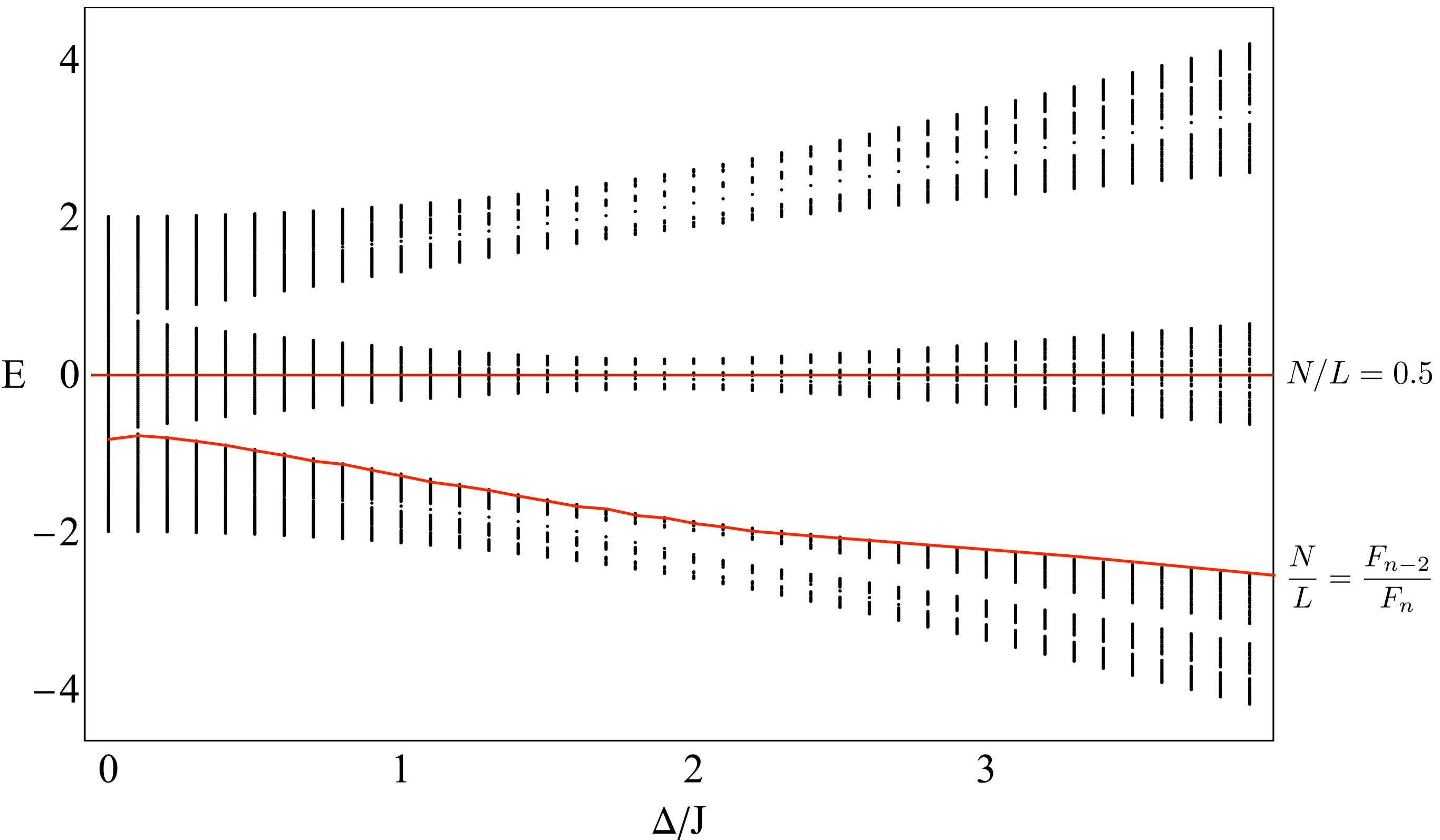
$$\Delta/J < 2$$

**EXTENDED**

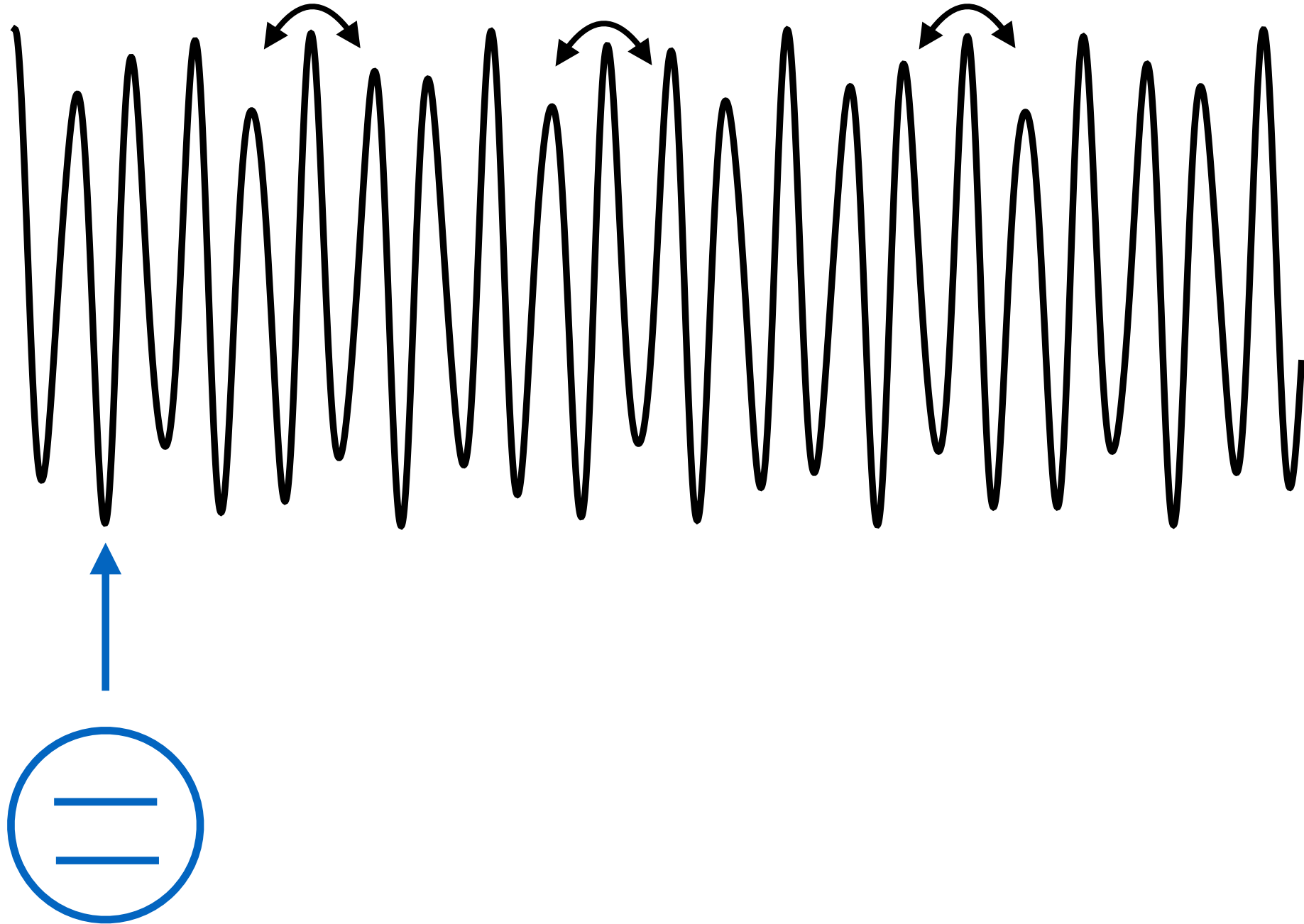
$$\Delta/J > 2$$

**LOCALIZED**

# Spectrum

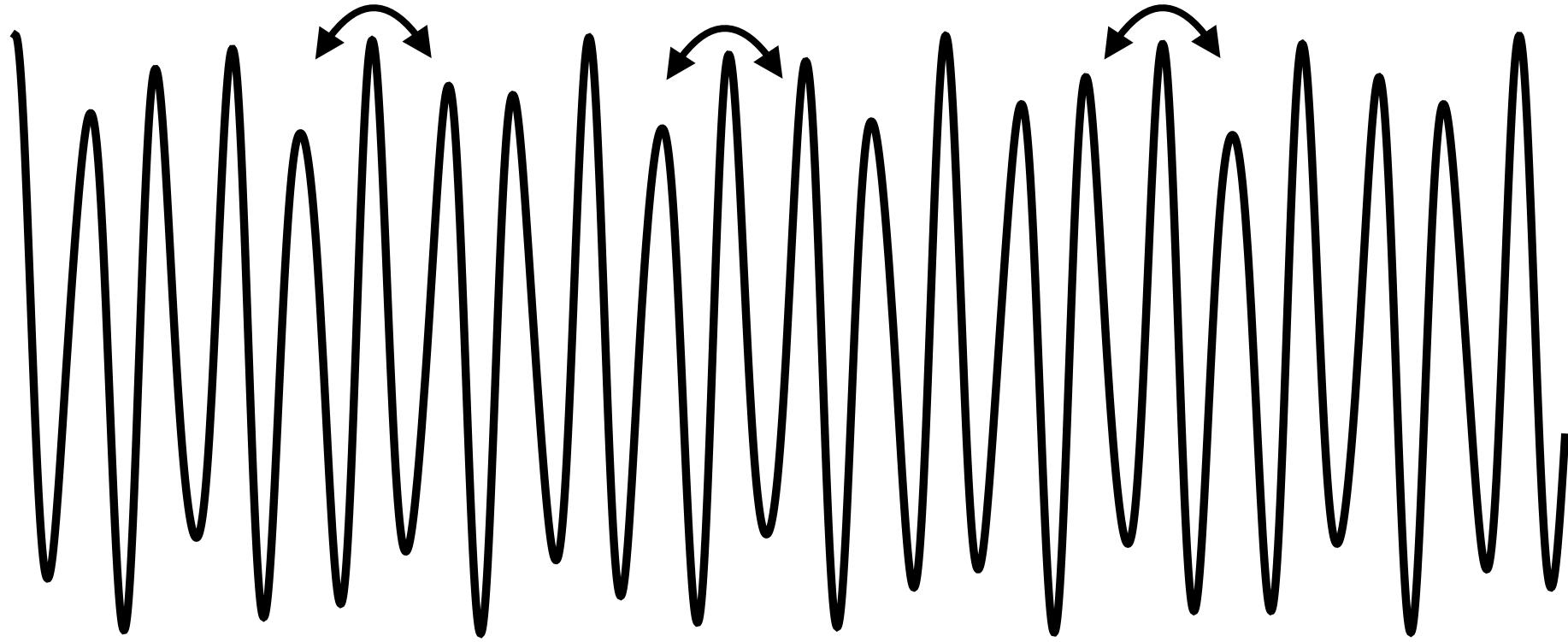


# Loschmidt echo

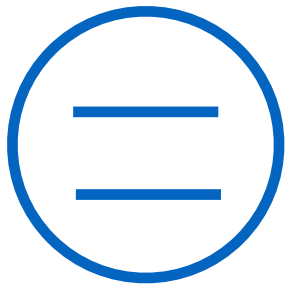


$$|\psi\rangle = \frac{1}{\sqrt{2}}(|g\rangle + |e\rangle)$$

# Loschmidt echo



$$\sqrt{|L(t)|} = |\rho_{eg}(t)| = |\langle \Phi_{GS} | e^{-i\hat{H}_e t} e^{i\hat{H}_g t} | \Phi_{GS} \rangle|$$

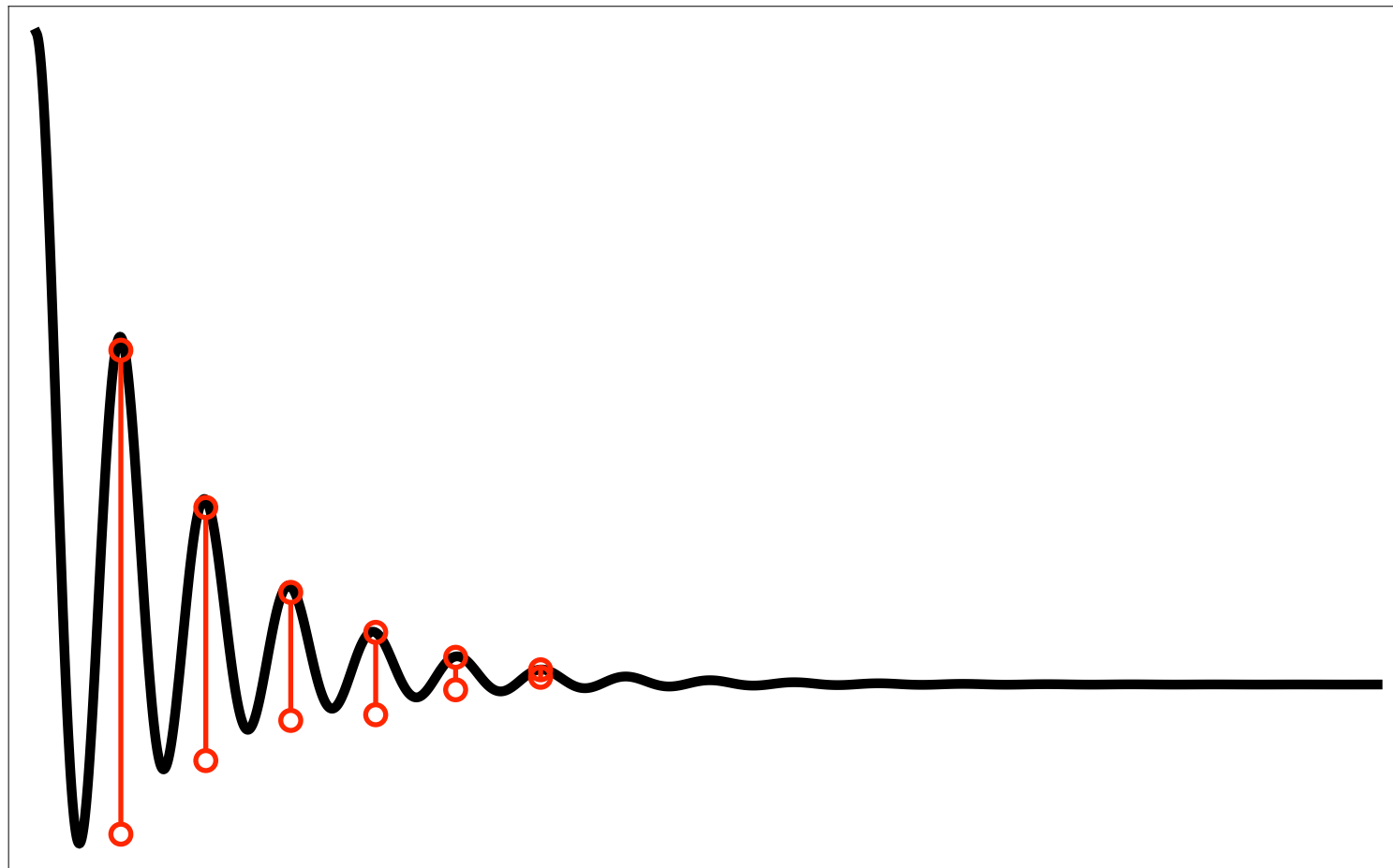


$$\hat{H}_g = \langle g | \hat{H}_{tot} | g \rangle \text{ and } \hat{H}_e = \langle e | \hat{H}_{tot} | e \rangle.$$

$$|\psi\rangle = \frac{1}{\sqrt{2}}(|g\rangle + |e\rangle)$$

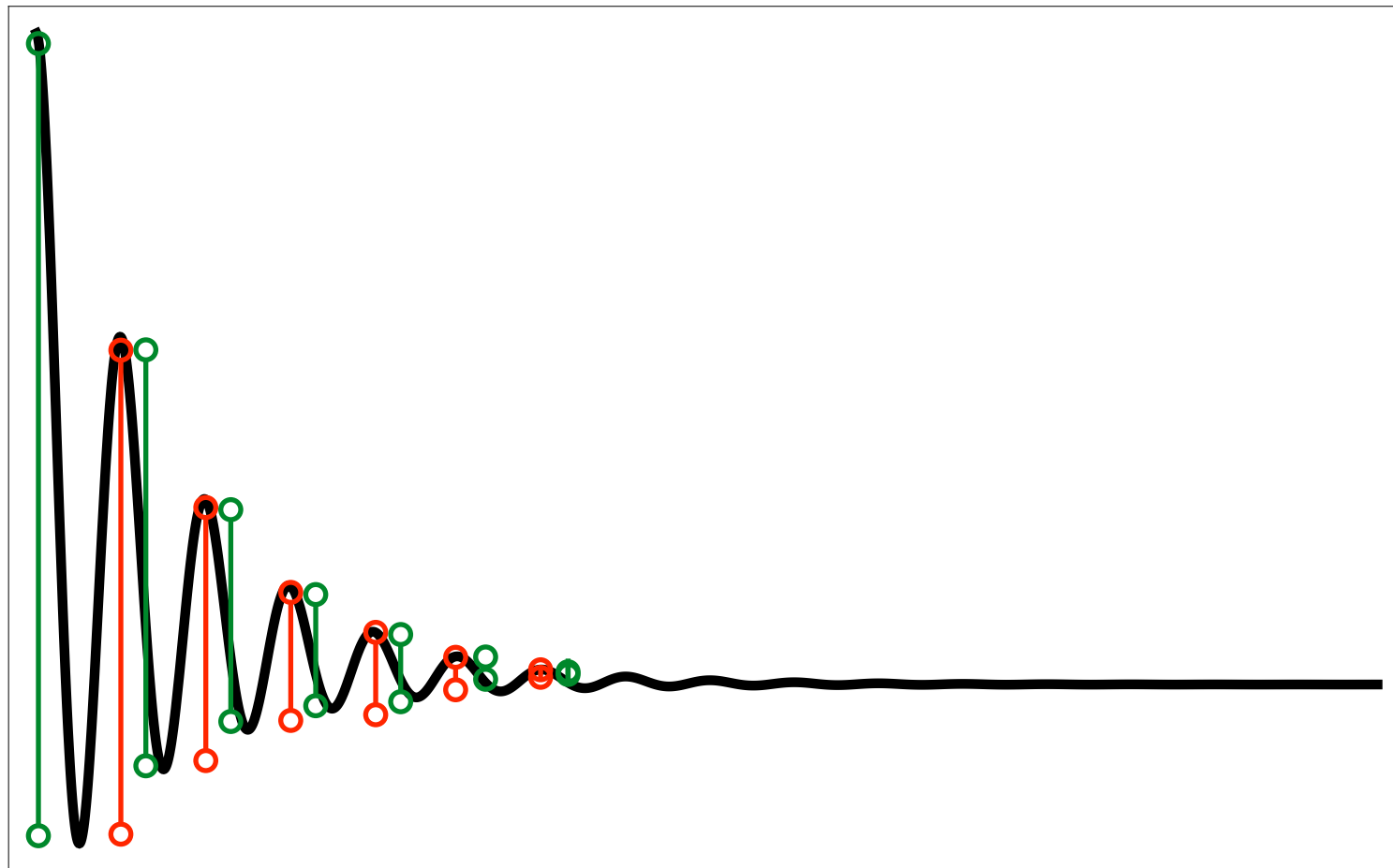
# Non-Markovianity

$$\mathcal{N}_{\mathcal{BLP}} = \sum_n \sqrt{L(t_{n+1})} - \sqrt{L(t_n)},$$

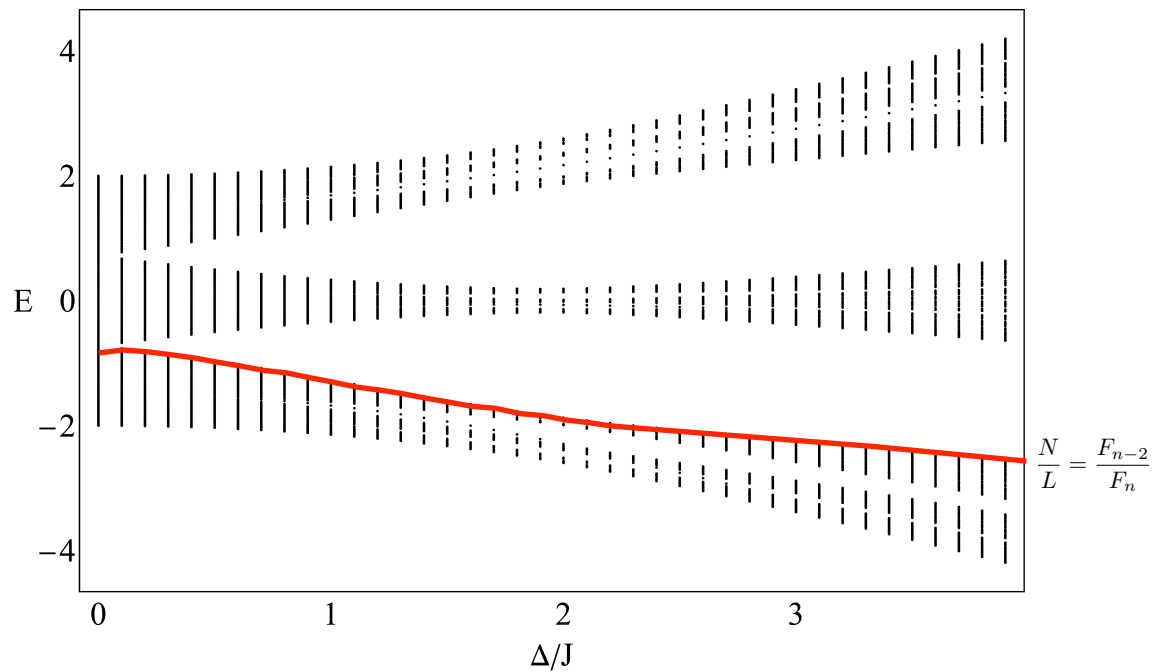


# Non-Markovianity

$$\mathcal{N}_{\mathcal{BLP}} = \sum_n \sqrt{L(t_{n+1})} - \sqrt{L(t_n)},$$



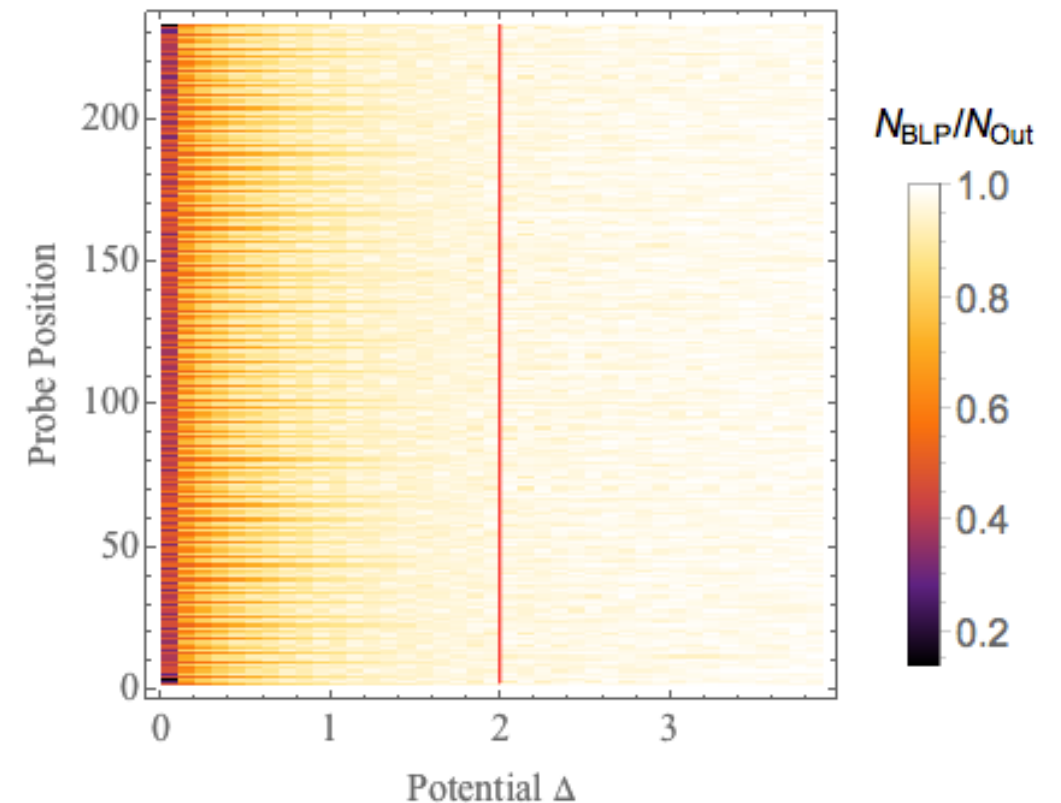
# Fibonacci filling



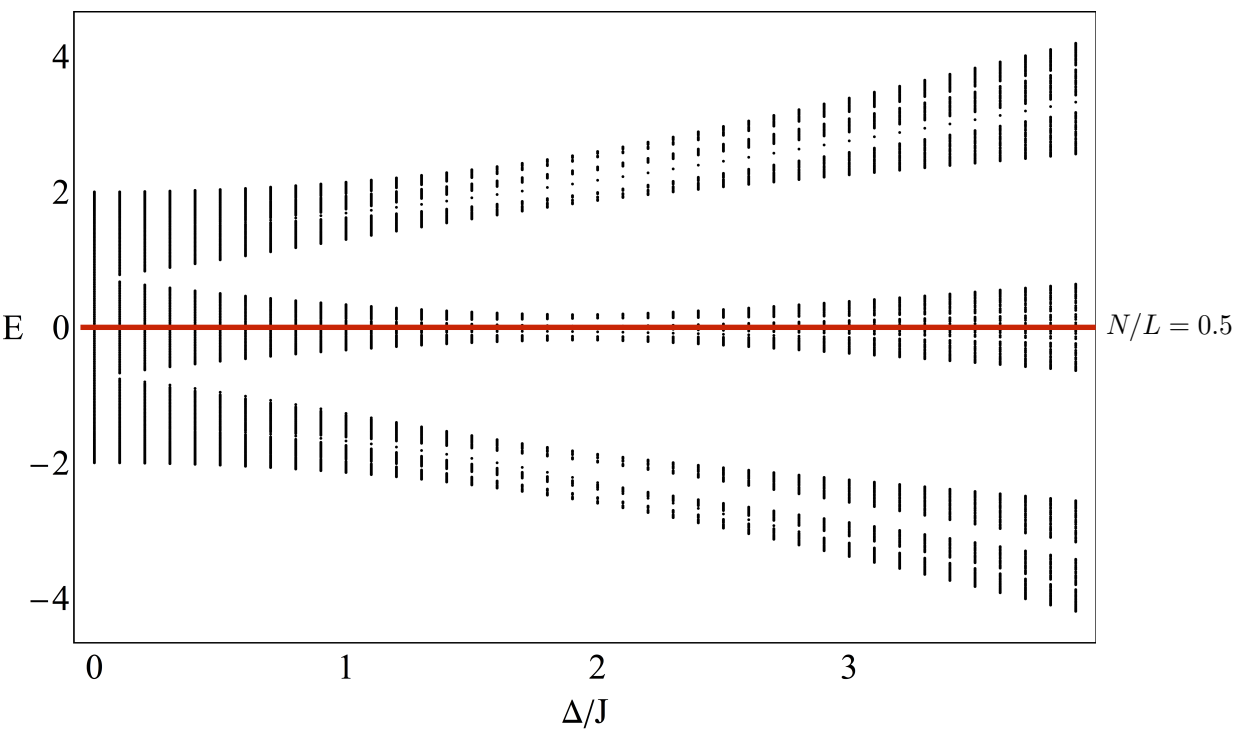
$$L = 233 \quad g = J$$

- ❖ Similar to Anderson 1D in S. Lorenzo et al. Scientific Reports 7, 42729 (2017).

- ❖ Band insulator
- ❖ Non-Markovianity increases with more localisation

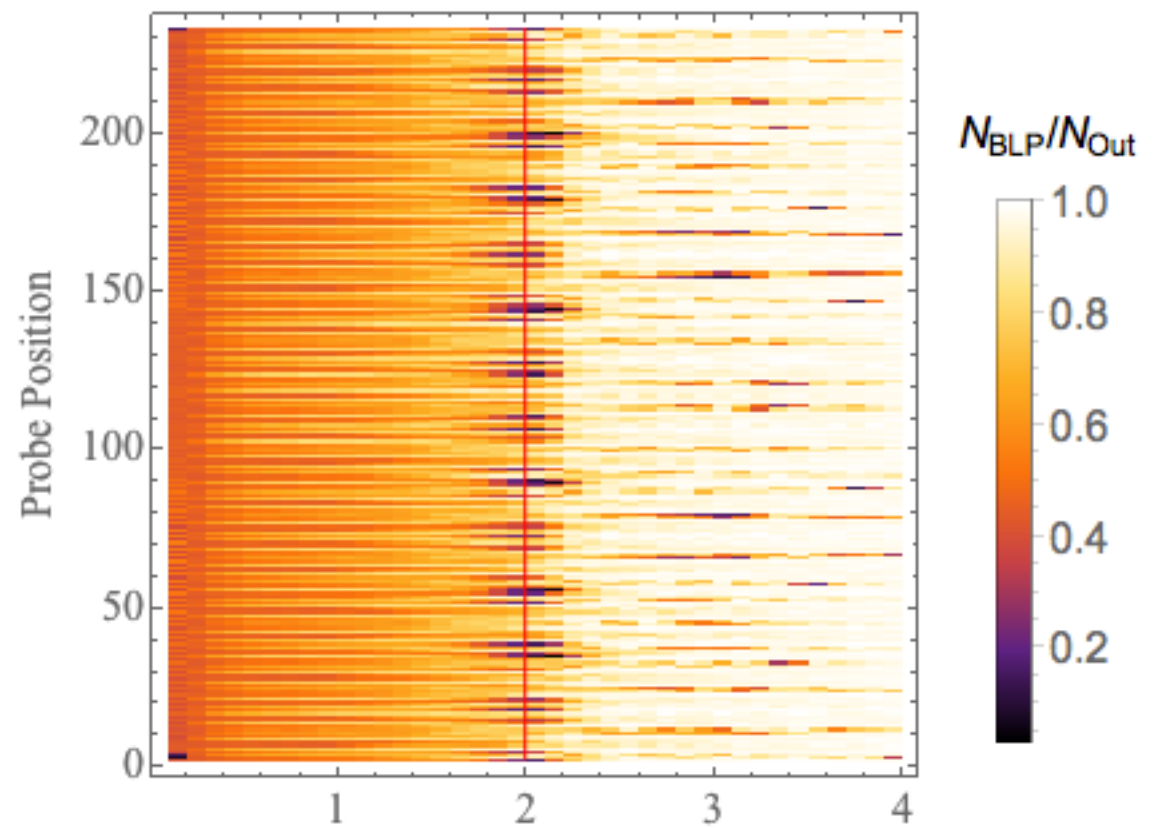


# Half(ish) filling



❖ Different from Anderson 1D

- ❖ Localised-extended transition
- ❖ Non-Markovianity is not uniform on the localised side.



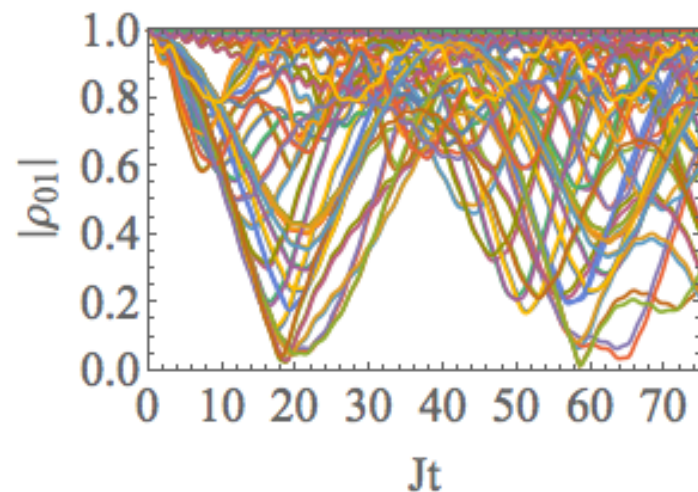


# S+OC

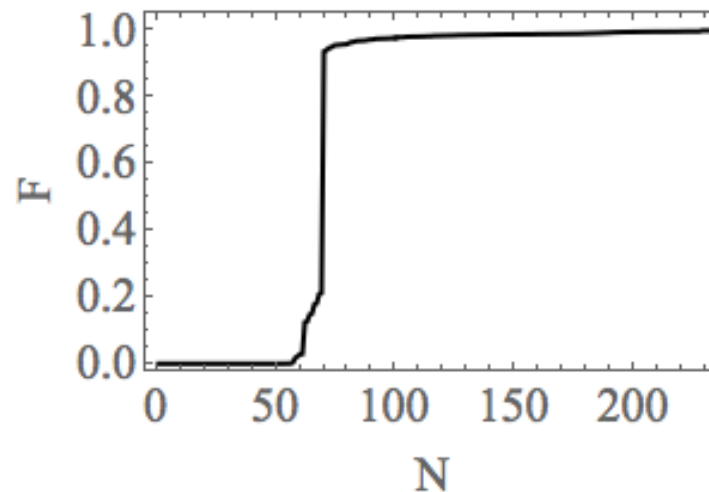
- ❖ For some positions we observe (exponential) orthogonality catastrophe

$$F = |\langle \Phi_{GS}^0 | \Phi_{GS}^g \rangle|^2$$

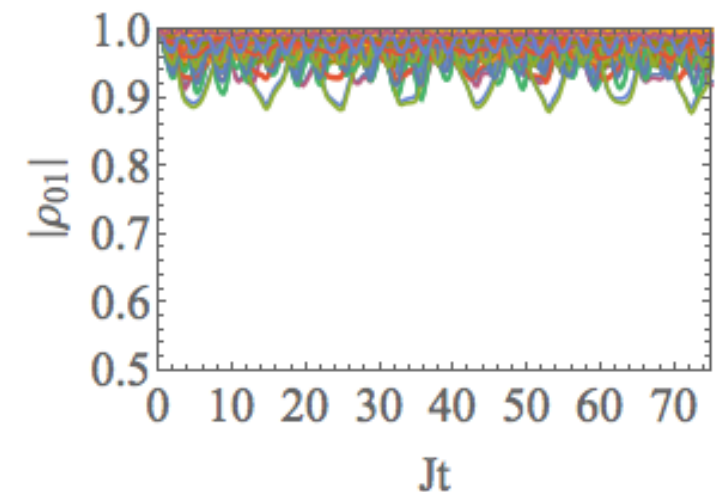
$$F \simeq 0$$



$$\Delta = 2.5 J$$



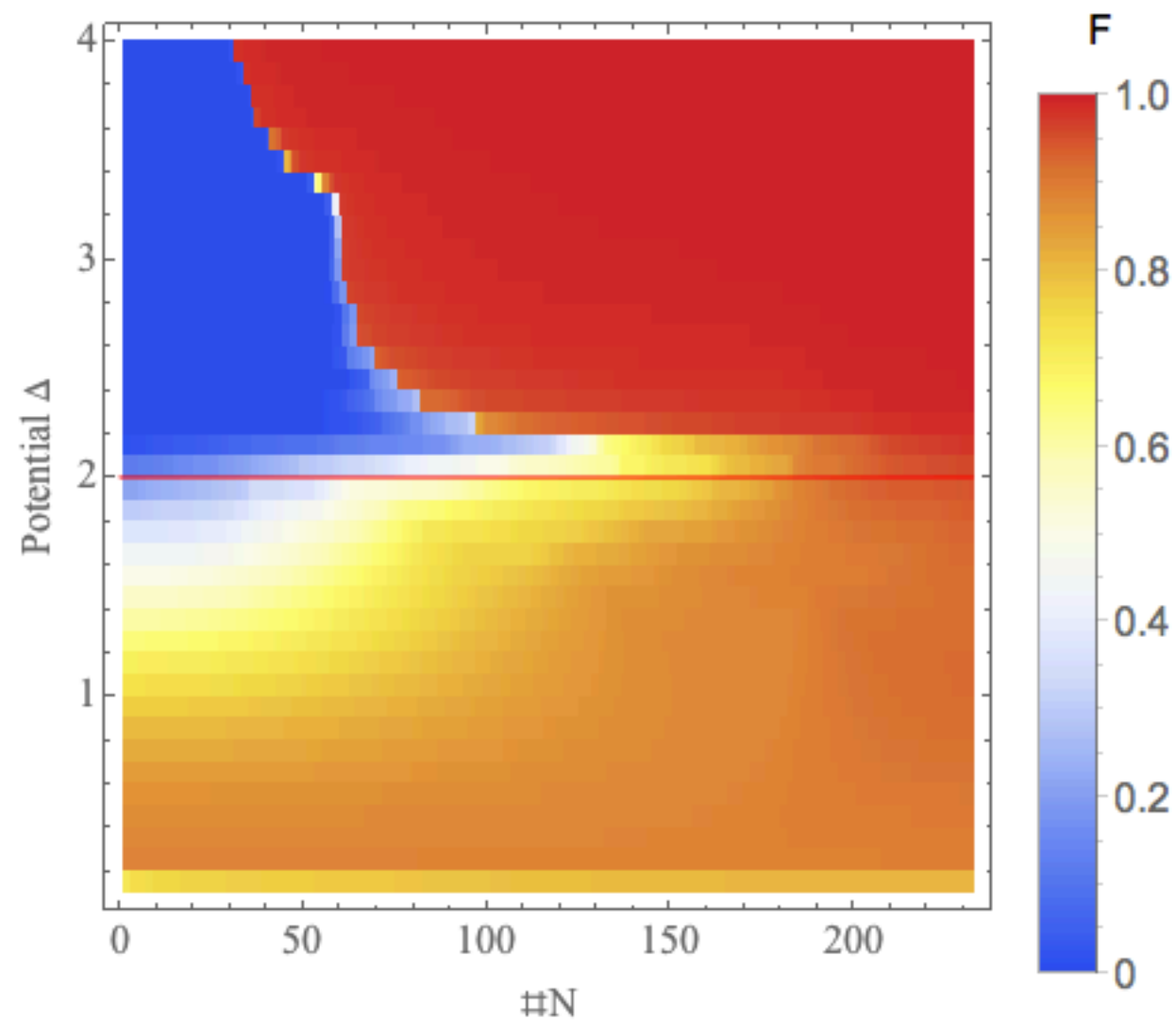
$$F \simeq 1$$



D.-L. Deng et al. Phys. Rev. B 92, 220201 (2015).  
V. Khemani et al. Nat. Phys. 11, 560 (2015).

# Half(ish) filling

- ❖ StOC on the localised side.



**Thank you!**