Exact Quantum Scars in the Chiral Non-Linear Luttinger Liquid

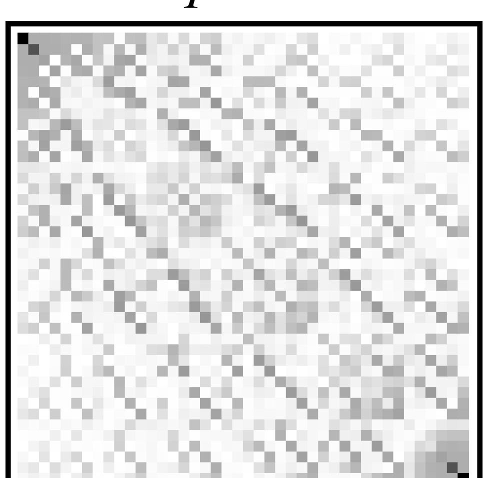
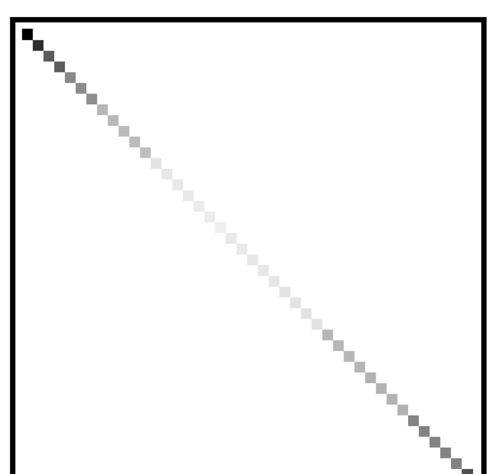
$$H = \sum_p \epsilon(p) c_p^\dagger c_p + \sum_{p>0} \left[V(p) \sum_{qk} c_{q+p}^\dagger c_q c_{k-p}^\dagger c_k \right]$$

$\epsilon(p) = vp$: integrable

$\epsilon(p) = vp + ap^2 + \ldots$: no exact solution

Bosonization is a unitary transformation:

$$\sum_{p>0} V(p) \sum_{qk} c_{q+p}^\dagger c_q c_{k-p}^\dagger c_k$$

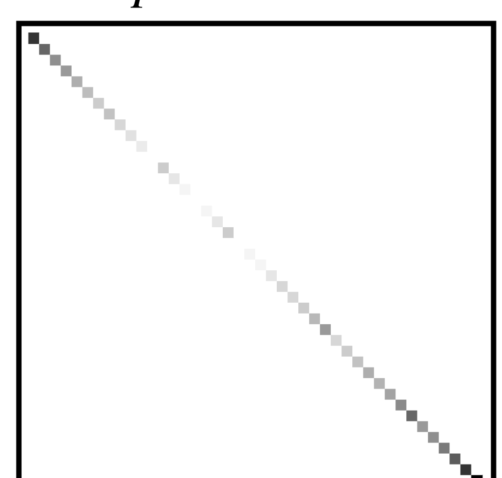
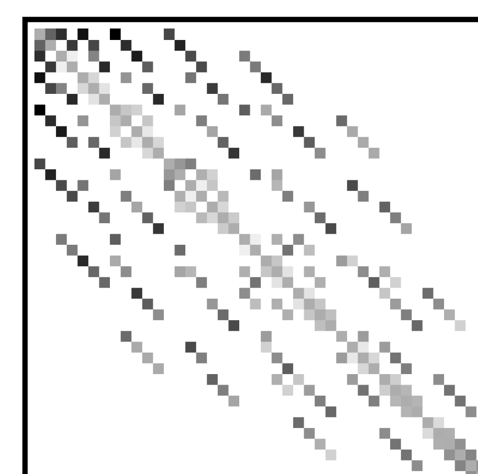
U  $U^\dagger =$ 

Fermi

Bose

$$\sum_p p^2 c_p^\dagger c_p$$

breaks integrability

U  $U^\dagger =$ 

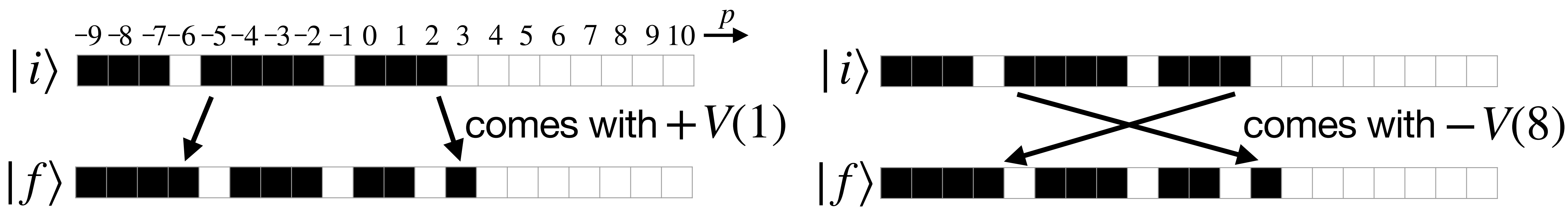
Fermi

Bose

Exact Slater-determinant eigenstates

The Hamiltonian $H_{\text{int}} = \sum_{p>0} V(p) \sum_{qk} c^{\dagger}_{q+p} c_q c^{\dagger}_{k-p} c_k$ has a special structure:

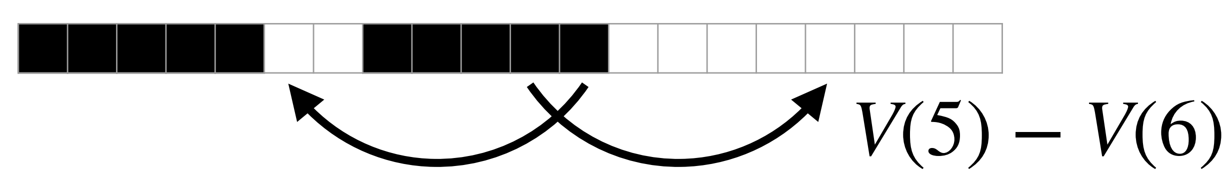
■ electron
□ hole



$$\langle f | H_{\text{int}} | i \rangle = V(1) - V(8)$$

Always have **destructive interference** between **exactly two** scattering processes

Some states do not scatter with all V(p)!



maximally: p = 6

If we set $V(1) = V(2) = \ldots = V(6)$,
then this state and similar ones will be eigenstates of H_{int}.

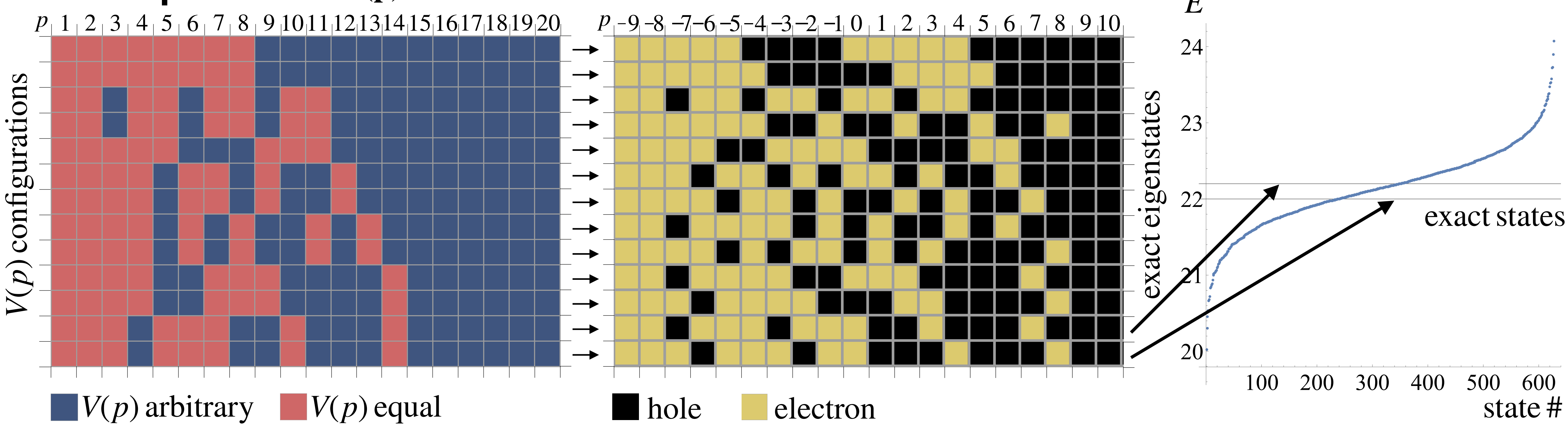
These states are eigenstates **irrespective of the kinetic term.**

More intricate tuning patterns

The choice of potentials $V(1) = V(2) = V(3) = \ldots = V(p_{\max})$ is not the only type of configuration giving exact states!

For total momentum P = 20, the frugal potentials (minimal amount of tuning) and associated exact states are:

potentials $\mathbf{V(p)}$ **exact Slater determinants**



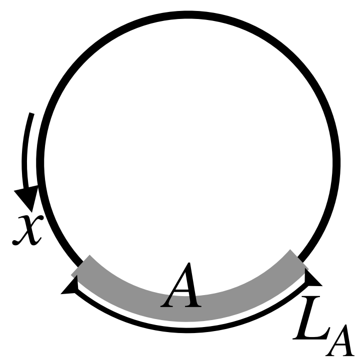
tuning less potentials gives rise to no exact states

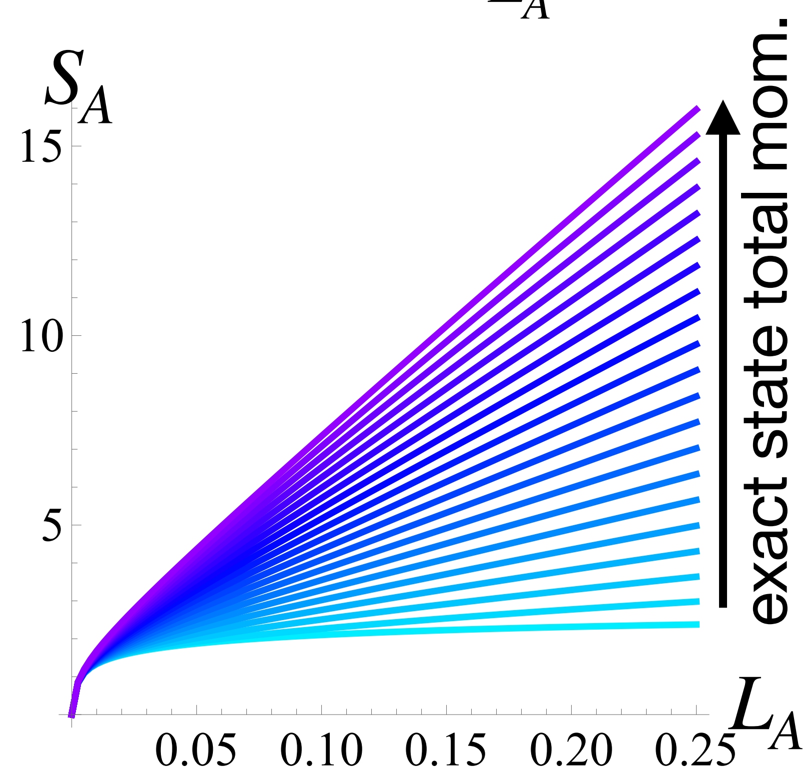
exact states show up at intermediate energies

In our paper, we describe the general method for finding all exact state solutions in all Hilbert space sectors

Exact state entanglement

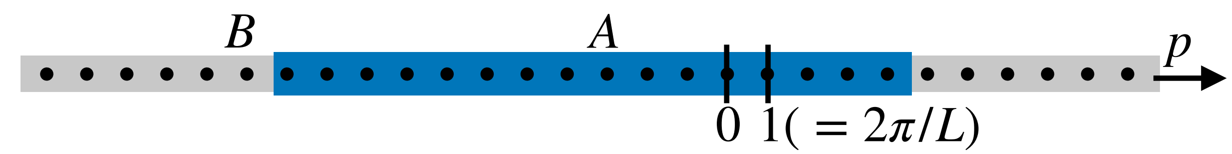
Real-space cut

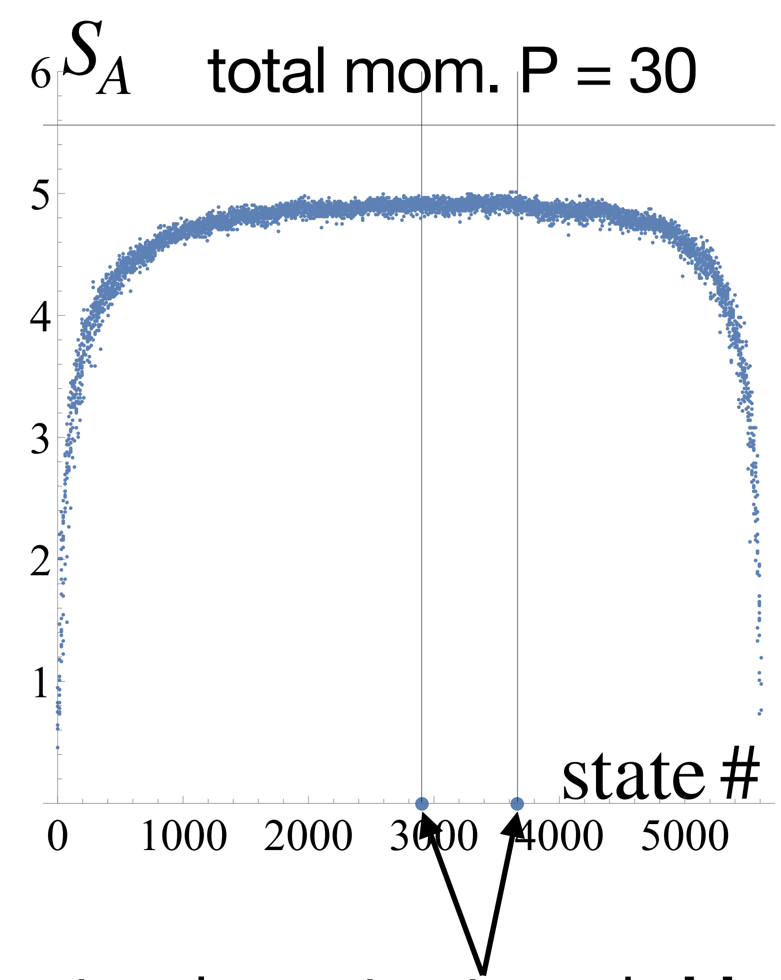




exact state entanglement can range from **sub-volume** to **volume-law**

Momentum-space cut





exact state entanglement entropy is **identically zero**

exact states are non-thermal, but with respect to momentum space entanglement!