Supersymmetric Many-Body Systems from Partial Symmetries - Scrambling and Localization -

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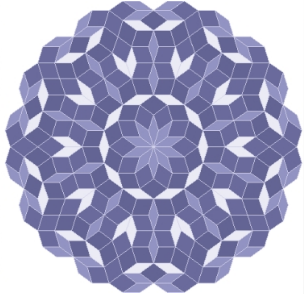
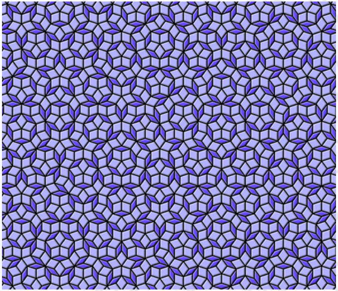
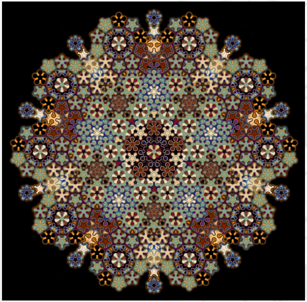
What do these pictures have in common?







Quasicrystals: described by **inverse semigroups!**

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Our motivation: use them to realize **supersymmetry.**

Definition of inverse semigroup $\mathcal{S} = (S, *)$:

$$\forall x \in S, \exists\, y \in S \text{ such that } \begin{cases} x * y * x = x \\ y * x * y = y \end{cases}$$

Types of inverse semigroups we consider...

$\boxed{\mathcal{S}_p^n}$

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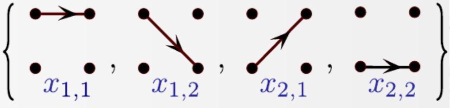
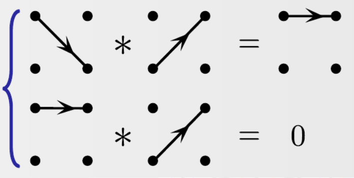
Example: $\mathcal{S}_1^2$

Partial symmetries =



Composition rule:

$(x_{i,j} * x_{k,\ell} = \delta_{j,k} x_{i,\ell})$



Supersymmetric Quantum Mechanics with Partial Symmetries

Focus on $\mathcal{S}_1^3$. The Hilbert space will be $\mathcal{H}(\mathcal{S}_1^3) = \text{span}\{x_{i,j}\}_{i,j=1}^3$.

To construct supersymmetry algebra, define the supercharges as

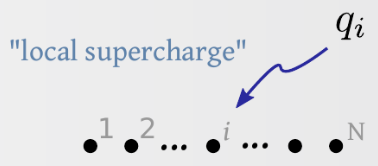
$$\begin{aligned} q &= \frac{1}{\sqrt{2}}(x_{1,2} + x_{1,3}), \\ q^\dagger &= \frac{1}{\sqrt{2}}(x_{2,1} + x_{3,1}). \end{aligned}$$

Then, $q^2 = q^{\dagger 2} = 0$ and

$$H = \{q, q^\dagger\}.$$

Supersymmetric many-body systems on a chain

Fill lattice sites with the supercharge q.



Define a "global" supercharge Q as some combination of the q_is.

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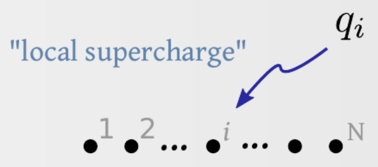


Define a "global" supercharge Q as some combination of the q_is.

Prototype: $$Q = \prod_i J_i q_i, \qquad H = \{Q, Q^\dagger\},$$

where the J_is are random variables.

What do these models have in common?

Scrambling

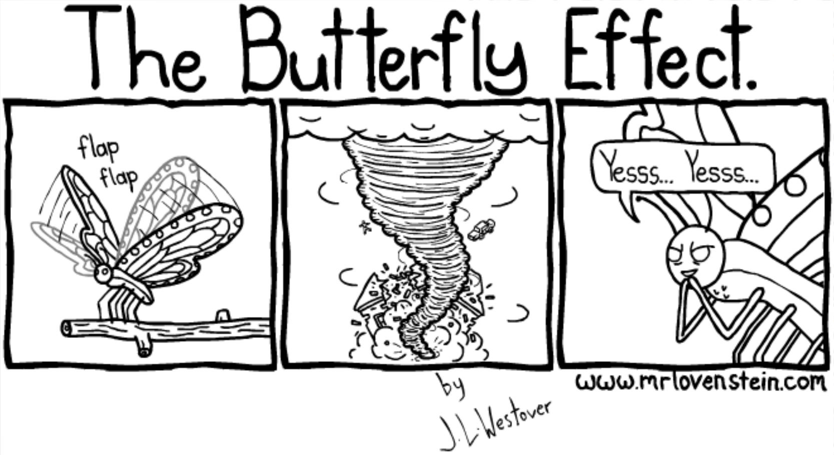
$$\Updownarrow$$

How does quantum information spread across the degrees of freedom of the system?

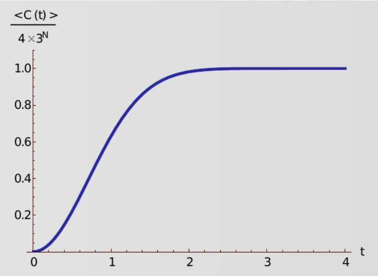
Probing scrambling...

$$C(t) = \langle [W(t), V(0)]^{\dagger} [W(t), V(0)] \rangle_{\beta}$$

...measure of


The Butterfly Effect.
flap
flap
Yesss... Yesss...
by
J.L.Westover
www.mrlovenstein.com

Phase	C(t)	Scrambling
Thermal	Exponential growth	Fast
Many-body localized (MBL)	Power law growth	Slow
Anderson localized	Constant	None



$$C(t) \propto 1 - e^{-J^2 t^2} \sim t^2 \quad \text{for early times.}$$

$$\Downarrow$$

Many-body localized phase!

Summary

Two main results:

(1) We realize supersymmetry algebra using partial symmetries and show how to generate many-body Hamiltonians within this set up.

(2) As an application, we constructed a toy model exhibiting a many-body localized phase which is supersymmetric.

More details... arXiv:1702.02091