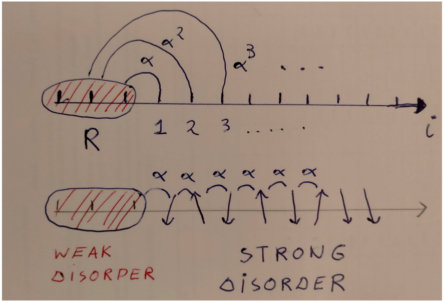
Many-body localization in the avalanche model (aka Quantum Sun Model)

Wojciech De Roeck, Amirali Hannani
Leuven University, Belgium

IRS, Paris, January 2025

Avalanche model (aka "Quantum Sun Model")

$$H = H_R + \sum_{i=1}^{n} \left(h_i Z_i + \alpha^i (X_R \otimes X_i) \right)$$



1. Finite GOE matrix H_R models bath R.
2. $X_R \otimes X_i$ couples bath R to spin i.
3. Parameter: $0 \leq \alpha < 1$.
4. $\alpha = 0$: spins not coupled to R: eigenvectors of $H \approx$ eigenvectors of $Z_{i=1,2,\ldots}$.
   $\Rightarrow$ many-body localization.

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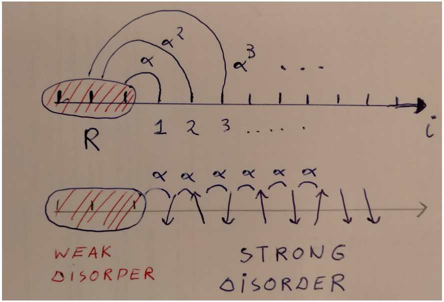

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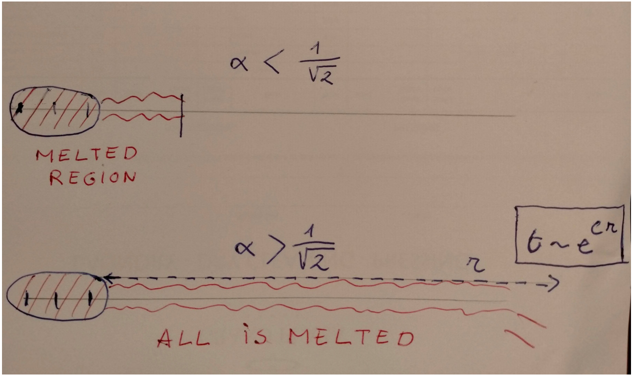
1. R is the only source of non-integrability/interaction/deloc.
2. In equilibrium statmech at positive temperature, there can be no effect of R at large distance, but loc/deloc is a dynamical phase transition.

Avalanche model: Phenomenology

Consistent theory + good numerical evidence (DR, Huveneers, Luitz 2017, ...)

1. For $\alpha < \frac{1}{\sqrt{2}}$: localization: eigenvectors $\approx$ eigenvectors of $(Z_i)_{i>O(1)}$.
2. For $\alpha > \frac{1}{\sqrt{2}}$: full ergodicity (thermalization, but slow dynamics).



Avalanche model: Mathematics

Localization for $\alpha \ll \frac{1}{\sqrt{2}}$ (DR, Hannani (in preparation))

1. Eigenvectors close to eigenvectors of $(Z_i)_{i>O(1)}$: straightforward argument!
2. Poisson spectral statistics: we need also randomness g_i in interactions.

$$H = H_R + \sum_{i=1}^{n} \left(h_i Z_i + \alpha^i g_i (X_R \otimes X_i) \right), \qquad g_i \text{ i.i.d. RV's}$$

Localization is very intuitive in this model, but technically it is still many-body:

$$\text{Hilbert space dimension} \sim (\sqrt{2})^{\text{number of independent RV's}}$$