Impact of the eigenstate thermalization hypothesis on the relaxation of significantly off-equilibrium initial states

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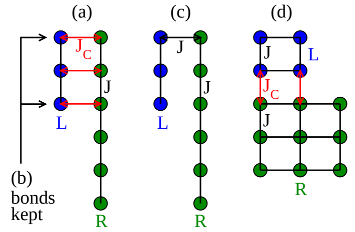
Berlin, March. 17th, 2015

- Temperature differences between macroscopic objects in energy exchanging contact are expected to vanish, irrespective of their initial values.
- Applicability of the the eigenstate thermalization (ETH), is sufficient (but not necessary) for initial state independent (ISI) relaxation of observable $\hat{D}$

$$\text{ETH} : \Sigma(\hat{D}, \hat{H}) \;\text{ small !} \quad \Sigma^2 \equiv \sum_{n=1}^{d} p_n \langle n|\hat{D}|n\rangle^2 - \bar{D}^2 \quad \bar{D} \equiv \sum_{n=1}^{d} p_n \langle n|\hat{D}|n\rangle$$

p_n probability distribution, sharply peaked at some $E_n = \bar{E}$



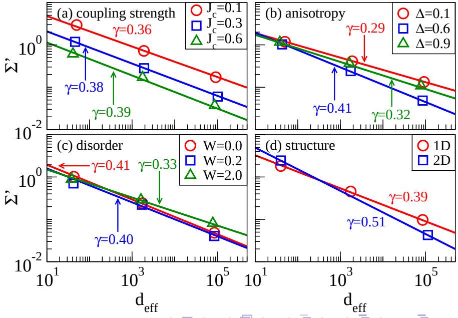
pieces of the Hamiltonian:

$$\hat{S}_x^\alpha \hat{S}_x^\beta + \hat{S}_y^\alpha \hat{S}_y^\beta + \Delta\, \hat{S}_z^\alpha \hat{S}_z^\beta + B_\alpha \hat{S}_z^\alpha$$

observable: energy difference:

$$\hat{D} = \hat{H}_L - \hat{H}_R$$

scaling of $\Sigma \propto d_{eff}^{-\gamma}$ for $N = 12, 28, 24, (25)$



Do energy differences in the clean Heisenberg chain not relax ISI?

What **initial state**? $\Rightarrow$ microcanonical observable displaced state (MOD) (no "quench")

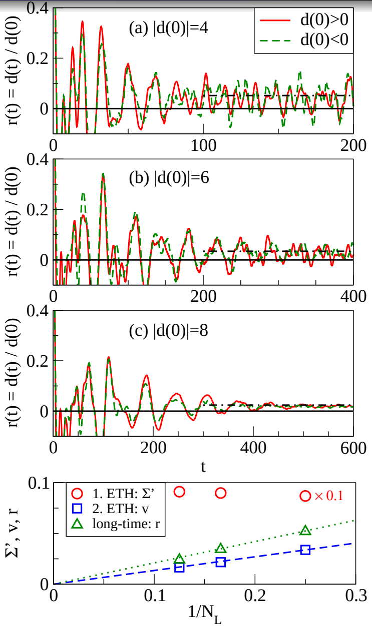
$$\hat{\rho}(0) = \rho_{\text{MOD}} :\propto e^{-\frac{(\hat{H}-E')^2}{2\sigma^2} - \frac{(\hat{D}-d')^2}{2\chi^2}} .$$

This way we are able to "prepare" states that have the biggest part of the energy in the left/right part while, still being energetically restricted to ca. 1/100 of the full spectrum ("energy shell")

dynamics: $d(t) := \langle \hat{D}(t) \rangle$ "stick effect": it looks like $d(t) \to r(N_L) d(0)$ where $r(N_L)$ is a constant which is independent of $d(0)$
Does the stick effect vanish with increasing size?

Besides, Σ is not a dimensionless quantity, so what is "small"?
Define, just for fun: $v^2 = \Sigma^2/\delta^2$ with

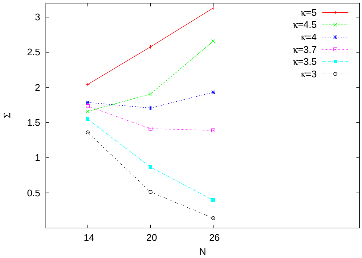
$$\delta^2 = \langle \hat{D}^2 \rangle_{\text{shell}} - \langle \hat{D} \rangle^2_{\text{shell}}$$



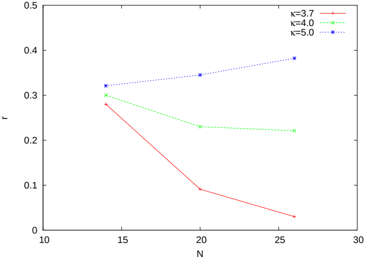
"More integrable" than clean Heisenberg chain ?

Same model (a), strong interchain couplings $J_c = (3...5)J$

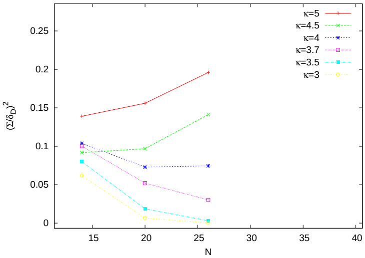
Σ may increase



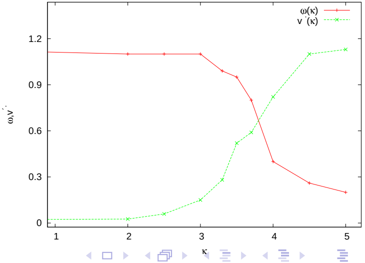
serious stick effect, "detected" by v



even v may increase



level statistics and stick effect



Thank you for your attention!

The talk itself as well as related papers from our group may be found on our webpage.