

Prethermalization in Random Multipolar Driven Systems

The goal of this project is to investigate the prethermalization dynamics of quasi-periodically driven systems (as opposed to periodically driven systems). In particular we want to observe the formation of prethermal plateaus away from the strictly periodic regimes, and analyze their lifetimes.

A periodic two-step drive can be constructed by e.g. periodically switching between two different unitary evolution operators U_{\pm} . Random multipolar drives interpolate between completely random drives, i.e., drives where the sequence of U_{+} and U_{-} is completely random, and periodic drives with a sequence $U_{+}U_{-}U_{+}U_{-}U_{+}U_{-}\dots$. The simplest example in this hierarchy is the random dipolar drive which is a random sequence of the two dipoles $U_{+}U_{-}$ and $U_{-}U_{+}$, and higher-order multipolar drives can be defined analogously, see Figure:

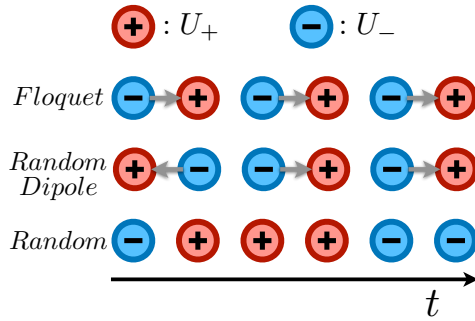


Figure 1: An example of a random multipolar drive (For more details, see reference.)

For this project we will consider two unitaries $U_{\pm} = \exp(-iTH_{\pm})$ where

$$H_{\pm} = \sum_j J_x \sigma_{j+1}^x \sigma_j^x + J_z \sigma_{j+1}^z \sigma_j^z + B_z \sigma_j^z + (B_0 \pm B_x) \sigma_j^x, \quad (1)$$

where σ_j^{α} denote the Pauli matrices, and the parameters are chosen as $\{J_z, J_x, B_x, B_z, B_0\} = \{1, 0.243, 0.809, 0.357, 0.21\}$. The project is based on the paper *Random multipolar driving: tunably slow heating through spectral engineering* by Zhao *et al.*, [Phys. Rev. Lett. 126, 040601 \(2021\)](#). This project is numerical and makes use of QuSpin.

- Write down a QuSpin code which implements the RMD evolution using the above unitaries. You may want to check this [example](#).
- Reproduce the figure below (Fig. 2 from the paper) for the so-called Thue-Morse sequence.
- Investigate the lifetime of the prethermal plateau for different order n of the random multipolar drive; reproduce Fig 3a,b from the paper.
- Optional goal: Can you reverse-engineer properties of the prethermal plateau (such as its lifetime) by playing with the properties of the noise spectrum (i.e. the Fourier transform of the noise signal)?

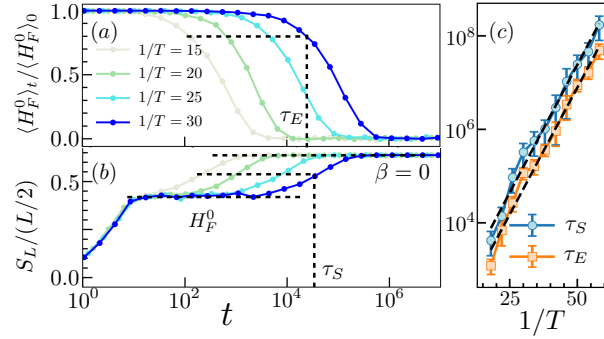


Figure 2: Heating dynamics of the Thue-Morse quasiperiodic sequence. (For more details, see reference.)

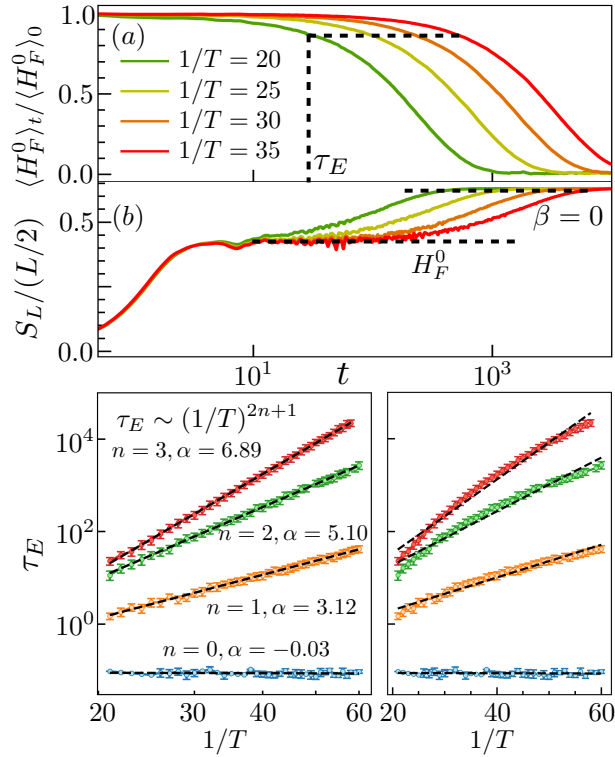


Figure 3: Scaling of the lifetime of the prethermal plateau as a function of the order n of the RMD. (For more details, see reference.)