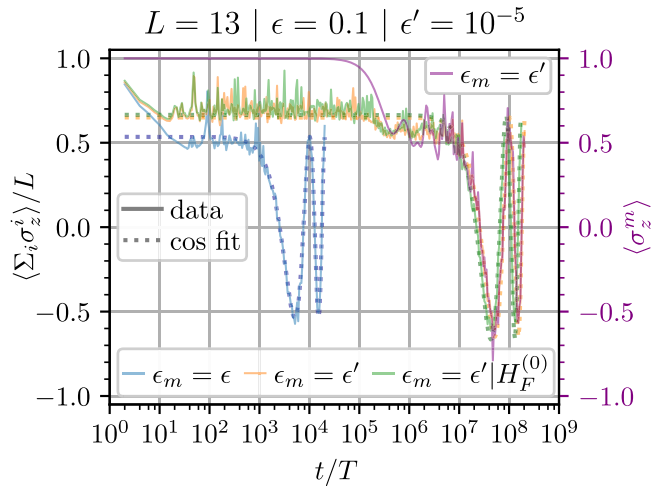


FIG. 10. The global $z$ magnetization of the spin chain of length $L = 13$ starting in a fully polarized state subjected to different driving schemes. We show the exact stroboscopic dynamics of the chain at even period numbers with and without a metronome spin at the central site as well as the average Hamiltonian given in Eq. (5). The configurations that include a metronome spin display lifetime enhancements by several orders of magnitude. All data are well described through numerical cosine fits. On the second axis (in purple font) we display the single-spin magnetization of the metronome spin itself. The dephasing of the magnetization of the metronome coincides with the dephasing of the plateau.

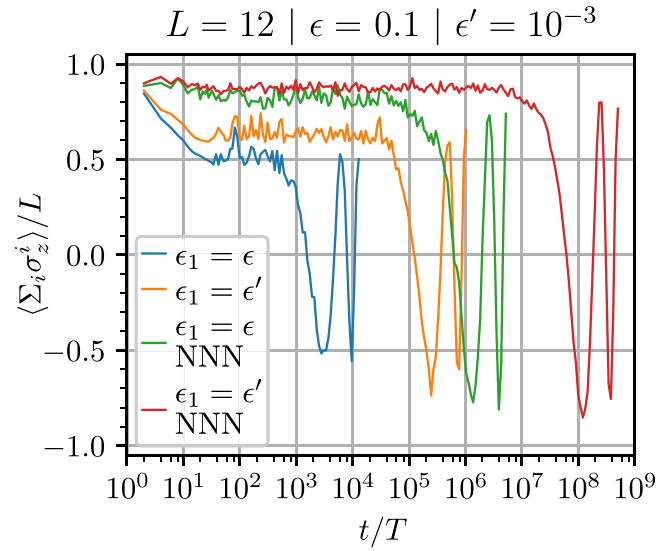


FIG. 11. The global $z$ magnetization of the spin chain of length $L = 12$ starting in a fully polarized stated subjected to different interaction Hamiltonians. We show the exact stroboscopic dynamics of the chain at even period numbers with and without a metronome spin at one boundary site, for both the standard and the integrability-breaking model (denoted NNN). Configurations that include a metronome spin display a lifetime enhancement of several orders of magnitude. For better visibility, only the first two oscillation cycles are plotted for each curve.

again, leading to the intermediate plateau before the late-time Rabi oscillations.

## APPENDIX C: NNN INTERACTIONS

Here we want to study a modified version of the original interaction Hamiltonian $H_{\text{int}}$ given in Eq. (1). We include additional next-to-nearest-neighbor (NNN) interactions to the model,

$$H_{\text{int}}^{\text{NNN}} = H_{\text{int}} + \sum_{i=1}^{L-2} J_{i,i+2}\, s_z^i s_z^{i+2}, \tag{C1}$$

which break the integrability of the new effective Floquet Hamiltonian. We study the global magnetization of a polarized initial state of $L = 12$ spins subjected to the modified Floquet sequence with $H_{\text{int}}^{\text{NNN}}$ replacing the original interaction Hamiltonian $H_{\text{int}}$. We give the results for $J_{i,i+2} = 0.6$ and $\epsilon' = 10^{-3}$ in Fig. 11.

Both the standard model evolved through $H_{\text{int}}$ (blue and orange curves) and the modified model evolved through $H_{\text{int}}^{\text{NNN}}$ (green and red curves) experience qualitatively comparable lifetime enhancements $\sim 1/\epsilon'$ through the addition of a metronome spin.


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