# Localization Study of a Helical Aubry-André Model

**B. Tanatar**
Taylan Yildiz

*Department of Physics, Bilkent University, Ankara, Türkiye*

*Balázs Hetényi*

*Budapest University of Technology and Economics, Budapest, Hungary*

tanatar@fen.bilkent.edu.tr

## Abstract

We study localization in a one-dimensional quasiperiodic lattice obtained by extending the Aubry-André model with an additional $N$th-neighbor hopping term of strength $J_N$. This long-range tunneling couples successive windings of an effective helical chain and introduces a second control parameter beyond the quasiperiodic potential strength. Working with noninteracting fermions, we diagnose the delocalization--localization transition using the modern theory of polarization. Specifically, we compute the polarization amplitudes of the many-body Slater-determinant ground state and construct a geometric Binder cumulant from polarization amplitudes. The critical potential where the localization transition happens is extracted from the sign change of the geometric Binder cumulant. We map critical potential as a function of $J_N$ and the helical range $N$, finding that stronger helical hopping generally stabilizes the extended phase (shifting critical potential upward), while the $N$-dependence can display commensurability induced spikes. We further compare geometric Binder cumulant with the Fermi gap, which remains near zero at small potential and opens in the same parameter regime where geometric Binder cumulant departs from extended phase. Finally, to take a controlled thermodynamic limit along Fibonacci system sizes, we employ a Zeckendorf-shift construction that fixes the many-body sector consistently as system size goes to infinity.

## References

[1] S. Aubry and G. André, Ann. Isr. Phys. Soc. 3 (1980) 18
[2] B. Hetényi, Phys. Rev. B 110 (2024) 125124
[3] K. Binder, Z. Phys. B, 43 (1981) 119
[4] R. Resta, Rev. Mod. Phys. 66 (1994) 899
[5] E. Zeckendorf, Bull. Soc. R. Sci. Liège 41 (1972) 179

## Figures

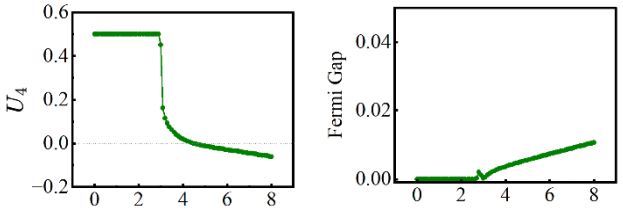


**Figure 1:** Geometric Binder cumulant (left) and Fermi gap (right) versus quasiperiodic potential strength where $N = 40$ and $J_N = 0.5$. The sign change of geometric Binder cumulant corresponds to localization transition.

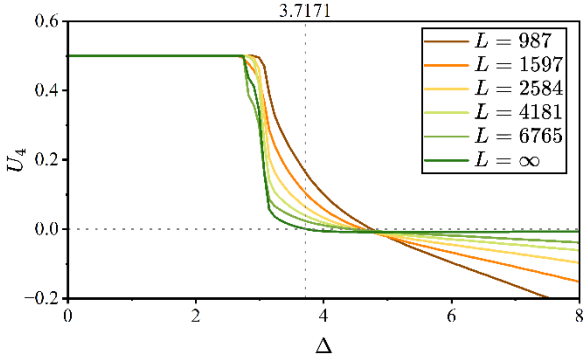


**Figure 2:** Geometric Binder cumulant versus quasiperiodic potential strength where $N = 40$ and $J_N = 0.5$, we approach thermodynamic limit with Zeckendorf decomposition.