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Interplay of localization and topology in disordered dimerized array of Rydberg atoms

Rydberg tweezer arrays provide a platform for realizing spin-1/2 Hamiltonians with long-range tunnelings decaying according to power-law with the distance. We numerically investigate the effects of positional disorder and dimerization on the properties of excited states in such a one-dimensional system. Our model allows for the continuous tuning of dimerization patterns and disorder strength. We identify different distinct ergodicity-breaking regimes within the parameter space constrained by our geometry. Notably, one of these regimes exhibits a unique feature in which non-trivial symmetry-protected topological (SPT) properties of the ground state extend to a noticeable fraction of states across the entire spectrum. This interplay between localization and SPT makes the system particularly interesting, as localization should help with stabilization of topological excitations, while SPT states contribute to an additional delocalization. We study excited spectra using state-of-the-art diagonalization tools and perform simulations of dynamics with tensor networks.

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