Weak ergodicity breaking in Hubbard, t-J-U and related models

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Many-body scars are states that do not obey the eigenstate thermalization hypothesis and thus lead to weak ergodicity breaking. Time evolution starting from a mix of such states exhibits "revivals" - the system returns to the exact initial state after equal periods of time. It has been shown [arXiv:2007.00845] that three families of highly symmetric states are many-body scars for any spin-1/2 fermionic Hamiltonian of the form H0+OT, where T is a generator of an appropriate Lie group. One of these families consists of the well-known eta-pairing states. In addition to having the usual properties of scars, these families of states are insensitive to electromagnetic noise and have advantages for storing and processing quantum information. We show that a number of well-known coupling terms, such as the Hubbard and the Heisenberg interactions, and the Hamiltonians containing them, are of the required form and support these states as scars without fine-tuning. The explicit H0+OT decomposition for a number of most commonly used models, including topological ones, is provided. To facilitate possible experimental implementations, we discuss the conditions for the low-energy subspace of these models to be comprised solely of scars. Further, we write down all the generators T that can be used as building blocks for designing new models with scars, most interestingly including the spin-orbit coupled hopping and superconducting pairing terms. We expand this framework to the non-Hermitian open systems and demonstrate that for them the scar subspace continues to undergo coherent time evolution and exhibit "revivals". A full numerical study of an extended 2D tJU model explicitly illustrates the novel properties of the invariant scars and supports our findings.

[1] arXiv:2106.10300.
[2] arXiv:2007.00845.