Unconventional superconducting correlations in fermionic many-body scars

Kiryl Pakrouski[1] and Kirill V. Samokhin[2]

[1] *ETH Zurich*
[2] *Brock University, St. Catharines, Ontario, Canada L2S 3A1*

Weak ergodicity breaking in interacting quantum systems may occur due to the existence of a subspace dynamically decoupled from the rest of the Hilbert space. In two-orbital spinful lattice systems, we construct such subspaces that are in addition distinguished by strongest inter-orbital and spin-singlet or spin-triplet, long-range superconducting pairing correlations. All unconventional pairing types we consider are local in space and unitary. Alternatively to orbitals, the additional degree of freedom could originate from the presence of two layers or through any other mechanism. Required Hamiltonians are rather non-exotic and include chemical potential, Hubbard, and spin-orbit interactions typically used for two-orbital superconducting materials. Each subspace is spanned by a family of group-invariant quantum many-body scars combining both 2e and 4e pairing/clustering contributions. One of the basis states has the form of a BCS wavefunction and can always be made the ground state by adding a mean-field pairing potential. Analytical results in this work are lattice-, dimension- and (mostly) system size-independent. We confirm them by exact numerical diagonalization in small systems.

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