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A variety of partially solvable models: From closed spin chains to open spin chains

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Non-thermal energy eigenstates of thermalizing isolated quantum systems have been intensively studied these days, as counter examples for the strong eigenstate thermalization hypothesis. These states are called "quantum many-body scars (QMBS)", which exhibit specific properties such as low entanglement entropies and persistent oscillations. Surprisingly, many of QMBS are exactly solvable states of non-integrable Hamiltonians. This fact strongly motivates us to study partially solvable quantum systems. We show that partial solvability of a quantum many-body system can be maintained even when the system is coupled to boundary dissipators under certain conditions. We propose two mechanisms that support partially solvable structures in boundary dissipative systems: The first one is based on the restricted spectrum generating algebra, while the second one is based on the Hilbert space fragmentation. From these structures, we derive exact eigenmodes of the Gorini-Kossakowski-Sudarshan-Lindblad equation for a family of quantum spin chain models with boundary dissipators, where we find various intriguing phenomena arising from the partial solvability of the open quantum systems, including persistent oscillations (quantum synchronization) and the existence of the matrix product operator symmetry. We discuss how the presence of solvable eigenmodes affects long-time behaviors of observables in boundary dissipative spin chains based on numerical simulations using the quantum trajectory method.

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