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Excitations and ergodicity of critical quantum spin chains from non-equilibrium classical dynamics

We study a critical quantum spin-1/2 chain that is dual to the non-equilibrium Kawasaki dynamics of a classical Ising chain coupled to a bath. The quantum spin chain is stoquastic, and depends on a single parameter: the Ising coupling divided by the bath's temperature. We give its exact ground states, and single-magnon excitations. Solutions for the two-magnon spectra are derived via a Bethe ansatz scheme. In the antiferromagnetic regime, the two-magnon branch states show intricate behavior, especially regarding hybridization with the continuum. Our analysis, when combined with previous studies, suggests that the system hosts multiple dynamics at low energy. Finally, we analyze the full energy level spacing distribution as a function of the Ising coupling. We conclude that the system is non-integrable for generic parameters, or equivalently, that the corresponding non-equilibrium classical dynamics are ergodic.