In closed integrable systems, thermalization after a quantum quench is precluded by the existence of infinitely many conserved charges. The idea of the *generalized Gibbs ensemble* (GGE) is to include all local conserved charges into the canonical density operator with appropriate Lagrange-multipliers to ensure conservation of local charges. It is a nontrivial question whether the GGE correctly describes all local observables in the post-quench steady state. While the validity of the GGE among free theories has been established, we showed that it breaks down for certain quenches of the spin-1/2 XXZ Heisenberg spin chain.

We studied local correlations in the steady state of the XXZ chain after quenches starting from the Majumdar–Ghosh dimer product and Néel states. We computed the correlations using a quench action approach (QA) variant of the thermodynamic Bethe ansatz (TBA) and independently using an infinite time-evolving block decimation (iTEBD) algorithm which simulated the real time evolution of correlations. While the steady-state correlations obtained through the QA and the iTEBD methods agreed consistently, predictions of the GGE failed to reproduce these values. Therefore the GGE, in its present form, is not a *generally* valid statistical description of post-quench steady states of closed integrable systems.