Non-perturbative linked-cluster expansions for quantum statistical models

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Non-perturbative linked-cluster expansions have become a diverse and powerful tool for the investigation of quantum lattice models used to calculate ground-state energies and thermodynamic quantities, to derive effective low-energy models and to investigate non-equilibrium physics directly in the thermodynamic limit. A fundamental challenge of such expansions is the breaking of translational symmetry on single clusters affecting the applicability in certain regimes severely.

Here we tackle this important open issue by studying the derivation of effective quasi-particle pictures for a variety of microscopic models using a variant of non-perturbative linked-cluster expansions called graph-based continuous unitary transformations (gCUTs). Our work demonstrates a crucial mechanism to successfully solve the above challenge. Most interestingly, this mechanism demands to go beyond the paradigm of performing exact diagonalizations on clusters as typically done in non-perturbative linked-cluster expansions.