Richardson-Gaudin integrable systems (and beyond) for strongly correlated quantum many-body systems

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ABSTRACT: Integrable systems take a special niche in quantum many-body systems. Due to the underlying algebraic structure, it is possible to capture all the quantum correlations *exactly* within a Bethe Ansatz wavefunction at a favourably scaling computational cost. Richardson [1] and Gaudin [2] have shown that the reduced Bardeen-Cooper-Schrieffer (BCS) Hamiltonian of superconductivity [3] is integrable and that the Bethe Ansatz state corresponds to a product wave function of generalized Cooper pairs [4]. In this formulation, the Bethe ansatz state is equivalent to a non-orthogonal geminal, which is widely used in quantum chemistry to describe electron pair correlations in atoms and molecules [5].

Inspired by Richardson-Gaudin integrable systems, it is possible to construct classes of non-orthogonal geminals, allowing for an accurate description of realistic and non-integrable strongly correlated atoms and molecules, while retaining the favorable computational scaling [6, 7]. In this contribution, I will discuss Richardson-Gaudin integrability and why it is useful for strongly correlated systems.

References

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