Algebraic Bethe Circuits

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The Algebraic Bethe Ansatz (ABA) is a highly successful analytical method used to exactly solve several physical models in both statistical mechanics and condensed-matter physics. Here we bring the ABA to unitary form, for its direct implementation on a quantum computer. This is achieved by distilling the non-unitary matrices that make up the ABA into unitaries using the QR decomposition. Our algorithm is deterministic and works for both real and complex roots of the Bethe equations. We illustrate our method in the spin-1/2 XX and XXZ models. We show that using this approach one can efficiently prepare eigenstates of the XX model on a quantum computer with quantum resources that match previous state-of-the-art approaches. We run numerical simulations, preparing eigenstates of the XXZ model for systems of up to 24 qubits and 12 magnons. Furthermore, we run small-scale error-mitigated implementations on the IBM quantum computers, including the preparation of the ground state for the XX and XXZ models in sites. Finally, we derive a new form of the Yang-Baxter equation using unitary matrices, and also verify it on a quantum computer.

Figures

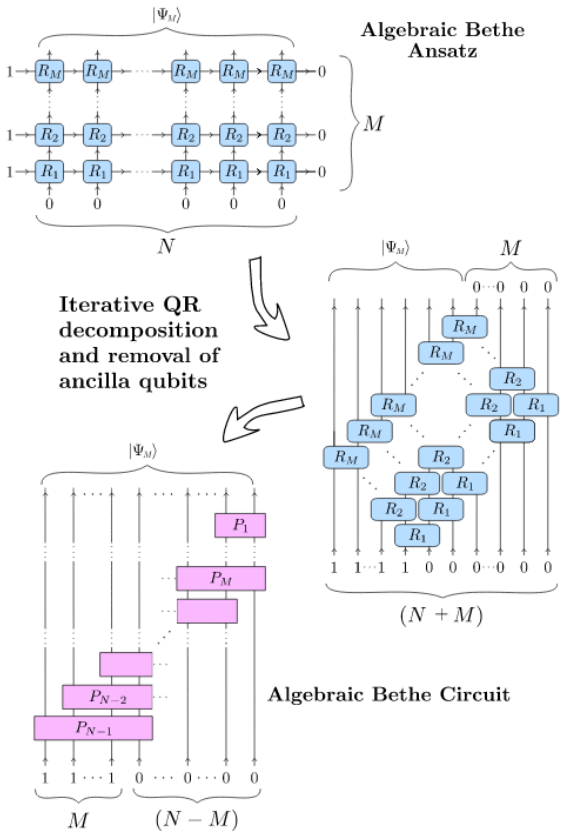

Figure 1: Conversion of the non-unitary Algebraic Bethe Ansatz into a deterministic unitary Algebraic Bethe Circuit.

References

[1] Alejandro Sopena, Max Hunter Gordon, Diego García-Martín, Germán Sierra, Esperanza López, “Algebraic Bethe Circuits” (2022), arXiv preprint arXiv: 22002.04673