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Efficient Iterative Symmetrization algorithm for quantum computing and hadron applications

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Abstract

Efficient algorithms for the (anti)symmetrization of quantum registers are necessary for upcoming few- and many-body physics applications, from atomic to particle-physics scales. We propose a recursive algorithm (anti) symmetrizing the last particle added to memory, each time one is created or destroyed, respect to the rest of already (anti)symmetrized ones.

Given a generalized Dicke state (GDS) of (j-1) quantum registers, each assigned to a particle, the algorithm produces another GDS of j registers (of n_{qb} qubits each) using a mere O(jlog^2 j + j n_{qb}) CNOT and single-qubit gates, and 2j + O(max(n_{qb},log_2 j)) clean auxiliary qubits.

The (anti)symmetrizing operator constructed for this purpose depends on the quantum numbers of the additional particle being introduced or ``created\'\'.

The algorithm improves upon the construction presented in Appendix A of (Galvez-Viruet and Llanes-Estrada PRD 2024) by two powers of j and is, to our knowledge, the most efficient to date.

We exemplify its applicability with a selection of problems from hadron physics which are expected to be addressable with upcoming quantum computers.

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