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Solving the homogenous Bethe-Salpeter equation with a quantum annealer

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The purpose of this work is to use a Quantum Annealer (QA) to solve the homogeneous Bethe-Salpeter equation (hBSE)[1] for two massive scalars interacting via the exchange of a massive scalar, a problem previously addressed with classical computation [2]. To achieve this, we transform the hBSE,by a suitable discretization, into a non-symmetric generalized eigenvalue problem (GEVP) (see Ref. [2] for details) from which we need to determine the maximum real eigenvalues along with their corresponding eigenvectors. This involves solving a quadratic minimization problem, which, after transformation into a Quadratic Unconstrained Binary Optimization (QUBO) form, becomes manageable by the QA.

We have developed a hybrid algorithm for this task. First, we reduce the non-symmetric GEVP to a standard eigenvalue problem classically. Then, we employ the QA to solve the variational problem. Drawing inspiration from approaches for symmetric matrices [3], we generalize the algorithm to accommodate the non-symmetric case, which involves complex eigenvalues (see Ref. [4] for details). Notably, the GEVP is a problem of broad interest across various fields, thus the results obtained could have wide-reaching implications.

We benchmark and analyze the statistical distribution of results using different parameters of the algorithm, employing a simulated annealing sampler (SA)[5].After that, very nice results for the target eigenpair have obtained by using a quantum annealer provided by D-Wave Systems, thanks to the D-Wave-CINECA agreement[6], as part of an international project approved by Q@TN (INFN-UNITN-FBK-CNR)[7]. We investigate how the algorithm's performance scales with the dimension of the matrices involved by comparing results obtained with QA and SA.

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Abstract category

Numerical Methods

Primary authors: ROGGERO, Alessandro; GNECH, Alex; FORNETTI, Filippo (Università degli Studi di Perugia, INFN Sezione di Perugia); PEDERIVA, Francesco; SALME', Giovanni; RINALDI, Matteo; VIVIANI, Michele; FREDERICO, Tobias; SCOPETTA, sergio

Presenter: FORNETTI, Filippo (Università degli Studi di Perugia, INFN Sezione di Perugia)

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