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Solving the homogeneus Bethe-Salpeter equation with a quantum annealer

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This work aims to solve the Bethe-Salpeter equation (BSE) [1] of two massive scalars bound by the exchange of a massive scalar (solved in Ref. [2] with classical computation) with a Quantum Annealer (QA). One can transform the BSE into a non-symmetric generalized eigenvalue problem (GEVP) (see Ref. [2] for details). For our scope, we are interested to determine only in the maximum and minimum real eigenvalues, with the corresponding eigenvectors, so we have to solve a suitable quadratic minimization problem. After transforming the non symmetric GEPV into a Quadratic Unconstrained Binary Optimization (QUBO) form, the only type of problem manageable by the QA, we have applied a hybrid algorithm: first, we classically reduced the GEVP to a standard eigenvalue problem, then, we used the QA to solve the variational problem. We started with the approach of Ref. [5] for symmetric matrices and we generalized the algorithm for the non-symmetric case, which notably involves complex eigenvalues (see Ref. [6] for details). We are studying how the algorithm scales with the dimension of the matrices involved in the problem to explore the possible advantages of quantum computation compared to the classical one. We want to remark that the GEVP is a problem of general interest, so the results we will obtain could be relevant for a large area of fields. Our code is running on the D-Wave QA, thanks to the agreement D-Wave-CINECA[3], in the context of an international project approved by Q@TN (INFN-UNITN-FBK-CNR)[4]. We are performing the benchmarking and the analysis of the statistical distribution of the results through different parameters of the algorithm by running the algorithm with a simulated annealing sampler[7].

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Autore principale: FORNETTI, Filippo (Istituto Nazionale di Fisica Nucleare)

Coautore: GNECH, Alex (ECT*); PEDERIVA, Francesco (Istituto Nazionale di Fisica Nucleare); SALME', Giovanni (Istituto Nazionale di Fisica Nucleare - Roma); RINALDI, Matteo (Istituto Nazionale di Fisica Nucleare); VIVIANI, Michele (Istituto Nazionale di Fisica Nucleare); SCOPETTA, Sergio (Istituto Nazionale di Fisica Nucleare); FREDERICO, Tobias (Instituto Tecnologico de Aeronautica)

Relatore: FORNETTI, Filippo (Istituto Nazionale di Fisica Nucleare)

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