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Search of causal Feynman integrals with quantum algorithm

Abstract

We present a novel benchmark application of a quantum algorithm to Feynman loop integrals. The two on-shell states of a Feynman propagator are identified with the two states of a qubit and a quantum algorithm is used to unfold the causal singular configurations of multiloop Feynman diagrams. To
identify such configurations, we exploit Grover's algorithm for querying multiple solutions over unstructured datasets, which presents a quadratic speed-up over classical algorithms when the number of solutions is much smaller than the number of possible configurations. A suitable modification is introduced to deal with topologies in which the number of causal states to be identified is nearly half of the total number of states. The output of the quantum algorithm in IBM Quantum and QUTE Testbed simulators is used to bootstrap the causal representation in the loop-tree duality of representative multiloop topologies. The algorithm may also find application and interest in graph theory to solve problems involving
directed acyclic graphs.

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