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A Novel Quantum Realization of Jet Clustering in High-Energy Physics Experiments

Exploring the application of quantum technologies to fundamental sciences holds the key to fostering innovation for both sides. In high-energy particle collisions, quarks and gluons are produced and immediately form collimated particle sprays known as jets. Accurate jet clustering is crucial as it retains the information of the originating quark or gluon and forms the basis for studying properties of the Higgs boson, which underlies the mechanism of mass generation for subatomic particles. For the first time, by mapping collision events into graphs—with particles as nodes and their angular separations as edges—we realize jet clustering using the Quantum Approximate Optimization Algorithm (QAOA), a hybrid quantum-classical algorithm for addressing classical combinatorial optimization problems with available quantum resources. Our results, derived from 30 qubits on quantum computer simulator and 6 qubits on quantum computer hardware, demonstrate that jet clustering performance with QAOA is comparable with or even better than classical algorithms for a small-sized problem. This study highlights the feasibility of quantum computing to revolutionize jet clustering, bringing the practical application of quantum computing in high-energy physics experiments one step closer.

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