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Jet evolution in a quantum computer

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The quark-gluon plasma is a hot and dense soup of quarks and gluons that was present in the first microseconds of the universe. Although quark-gluon plasma can be created in the laboratory, such as in the LHC and RHIC experiments, due to its short lifetime, the use of indirect methods for studying its properties is necessary.

Jets, formed at the time of the creation of the quark-gluon plasma and having their properties modified by the interaction with the medium, are one of the most common probes to study the quark-gluon plasma. The well-understood behavior of jets in a vacuum provides a baseline for identifying medium-induced modifications. Furthermore, due to the jets'complexity, the study of their dynamics in a medium is not a trivial task, which has led to the proposal of new techniques to simulate them in the last decades.

At the same time, quantum computing, based on inherent properties of quantum mechanics systems, has been growing, bringing new ways to deal with classical hard problems. Among many other applications and algorithms, such as Shor's, Grover's, and quantum phase estimation algorithms and optimization problems, following the original ideas of Feynman quantum simulation is one of the most explored applications of quantum computing.

In this context, jets, due to their quantum mechanical nature, are one of the most promising candidates to benefit from using quantum simulation algorithms to study their properties. Due to the state of the actual quantum devices, the simulation of an entire jet is still a long-term goal. Thus, to date, one is focused on simulating the dynamics of single partons in a quantum computer. Therefore, this work describes the development of a quantum routine to simulate the propagation of both single quarks and gluons within a quark-gluon plasma medium. Additionally, the results obtained from different simulation parameters are analyzed and benchmarked against analytical expectations.

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