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Lattice QCD calculation of $\hat{q}$ with dynamical fermions

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The jet transport coefficient $\hat{q}$ is the leading property of a strongly interacting medium that effects jet propagation. It introduces momentum transverse to a jet parton's direction, changing its virtuality and thus controls the modification of hard jets in a dense extended medium. In this talk, we present the first unquenched lattice QCD calculation of $\hat{q}$. The calculation is carried out using (2+1)-flavors of quarks, using the highly improved staggered quark action (HISQ) and tree-level Symanzik improved gauge action. The calculation is performed in a wide range of temperatures, ranging from 200 MeV T 800 MeV using the MILC code package.

Following earlier work in quenched SU(2) and SU(3) [1,2], we considered a single hard parton scattering off the glue field of a thermal QCD medium by exchanging a Glauber gluon (whose transverse momentum is larger than its longitudinal components). The hard scale associated with the jet parton allows the coupling of the gluon to that parton to be treated in perturbation theory. The coupling of the gluon to the medium is treated non-perturbatively. This non-perturbative part is expressed in terms of a non-local (two-point) Field-Strength-Field-Strength operator product which can be Taylor expanded after analytic continuation to the deep-Euclidean region. Such an expansion allows us to write $\hat{q}$ in terms of the expectation of a diminishing series of local operators, which are suppressed by factors of the hard parton energy. We also discuss the connection between our formalism and a method outlined in Ref. [3] that allows one to extract light-cone correlations using the matrix elements of frame-dependent, equal-time correlators in the large momentum limit. The calculated $\hat{q}$ and its temperature dependence demonstrates considerable agreement with the phenomenological extractions carried out by the JET collaboration.

[1] A. Kumar, A. Majumder, C. Nonaka, PoS LATTICE2018 169 (2018),
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[3] X. Ji, Phys. Rev. Lett. 110, 262002 (2013).

Collaboration (if applicable)

Track

New Theoretical Developments

Contribution type

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