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Multi-scale probe of the jet-medium interaction via internal jet structure modification

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We present the scale dependence of the jet-medium interactions seen in the modification of jet substructure observables in high-energy heavy-ion collisions by systematic studies with JETSCAPE 3, a publicly available software package of a framework for Monte Carlo event generators [1]. In high-energy heavy-ion collisions, jet partons interact with the quark-gluon plasma medium while changing their energy and virtuality via their shower evolution. Measured jets are reconstructed from the final state particles in the shower and thus carry information about the interactions with the medium at the various scales of the jet partons. The multi-stage framework for the jet evolution of JETSCPE is designed to cover a broader range of the scale in the in-medium parton shower evolution by stitching multiple models together; Each model becomes active depending on the virtuality or energy of a parton.

Recently, we found that the explicit virtuality dependence in the jet quenching strength qhat [2] at the early high-virtuality phase is essential for the simultaneous description of the experimental data for the reconstructed jet suppression and single-particle suppression. In this study, we perform numerical simulations with a model incorporating the virtuality-dependent formulation with MATTER+LBT setup within the JETSCAPE framework. We systematically study the observables characterizing internal structures of jets to explore the details of the strength of the interaction with the medium at each scale. In particular, we examine the splitting function, which displays the effect of the medium interaction with a parton with large virtuality at the very early stage, and the jet fragmentation function, which clearly shows the medium effect on partons throughout a wide range of scales.

[1] JETSCAPE Collaboration (A. Kumar et al.), Jet quenching in a multi-stage Monte Carlo approach, Nucl. Phys. A 1005, 122009 (2021); JETSCAPE Collaboration (A. Kumar et al.), JETSCAPE framework: p+p results, Phys. Rev. C 102, no.5, 054906 (2020).

[2] Amit Kumar, Abhijit Majumder, and Chun Shen, Energy and scale dependence of qhat and the JET puzzle, Phys. Rev. C, 101(3):034908, 2020.

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