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Constraints on jet quenching from a multi-stage energy-loss approach

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The evolution of leading partons and jets through deconfined QCD matter is a multi-scale phenomenon and remains as one of the challenging problems in heavy-ion physics. To address this, we use the JETSCAPE framework [1] in which the production of the hard parton is factorized from the evolution of the produced QGP. To incorporate various scales involved in the jet-medium interaction during the different epochs of the parton shower, a multi-stage energy loss model is constructed [2]. We propose a new functional form of the transport coefficient $\hat{q}$ that weakens as the parton's virtuality becomes larger and reduces to the traditional hard-thermal-loop (HTL) $\hat{q}$ at smaller virtuality [3]. In this talk, we demonstrate that a multi-stage jet quenching model with modified HTL $\hat{q}$ and recoil-hole based medium response are crucial for a simultaneous description of the nuclear modification factor for inclusive jets and leading hadrons at RHIC and LHC collision energies.

The study carried out also highlights one of the major successes of the JETSCAPE framework [1,2] in providing a tool to set up an effective parton evolution using a multi-stage energy-loss scheme. In this approach, the space-time information of the QGP is embedded in the parton shower during the high virtuality phase modeled using the MATTER event generator, followed by the low virtuality phase modeled by the LBT event generator. The switching between the jet energy loss stages is carried out on parton-by-parton basis based on the off-shellness or energy of the parton. The jet-medium response is incorporated through a weakly-coupled transport description with recoil particles excited from the QCD medium. The recoil-hole formalism shows sensitivity to the distribution of energy-momentum of particles inside the jet and hence puts further constraints on the jet quenching mechanism. The study presented demonstrates that the jet transport coefficient $\hat{q}$ indeed has a resolution scale dependence in addition to the conventional temperature and energy dependence encoded in hard-thermal-loop formula.

[1] JETSCAPE Collaboration (J. H. Putschke (Wayne State U.) et al.), The JETSCAPE framework, arXiv:1903.07706 [nucl-th] (2019).
[2] 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).
[3] Amit Kumar, Abhijit Majumder, and Chun Shen, Energy and scale dependence of q-hat and the JET puzzle. Phys. Rev. C, 101(3):034908, 2020.

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