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Heavy vs. light flavor jet quenching, flow, thermalization and D-hadron correlations from RHIC to the LHC energies

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Hard hadrons, including heavy flavor and high $p_{\rm T}$ light flavor hadrons, serve as valuable probes of the quark-gluon plasma (QGP) matter produced in relativistic heavy-ion collisions. We establish a Linear Boltzmann Transport (LBT) coupled to (3+1)-D viscous hydrodynamic model that simultaneously describes the temporal evolution of both heavy and light partons inside QGP on the same footing [1]. Both quasi-elastic [2] and inelastic [3,4,5] processes are included in our LBT model for parton energy loss in the de-confined QCD medium. On the freeze-out hypersurface, the hadronization of hard partons into their corresponding color neutral bound states is calculated utilizing our hybrid fragmentation plus jet-thermal coalescence model [1,6].

Within this newly developed framework, we demonstrate that while quasi-elastic scattering leads to linear increase of parton energy loss with respect to time and is important at early time, inelastic scattering results in quadratic increase of energy loss at early time but then saturates to linear increase and dominates parton evolution at later time. With proper incorporation of the temperature and energy dependences of parton-medium interaction, we simultaneously describe heavy (D and B mesons) and light flavor (charged hadron) suppression, 2nd and 3rd order harmonic flows for all centrality bins and all collision energies as observed from RHIC to the LHC experiments. The temperature and momentum dependences of the jet transport coefficient ($\hat{q}$) extracted from our model to data comparison are consistent with the range previously constrained by the JET Collaboration. While $\Delta E_g > \Delta E_q > \Delta E_c > \Delta E_b$ holds in our framework, we show that such flavor hierarchy in $R_{\rm AA}$ at hadron level can be modified due to the combinatory effect of initial momentum spectra, parton energy loss and fragmentation functions.

We also perform a systematic comparison for the 2nd and 3rd order harmonic flows of heavy vs. light flavor hadrons, from which the degree of heavy quark thermalization inside QGP is investigated as functions of centrality and colliding energy. D-hadron and e-hadron correlation functions are studied for the first time as well and shown to be a good observable to quantify not only the thermalization degree of heavy quarks [7] but also the medium response to the energy deposited by hard probe particles. Comparisons between our predictions and future measurements are expected to provide better insights of the interaction dynamics between hard partons and the QGP.

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Preferred Track

Open Heavy Flavors

Collaboration

Not applicable

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