Path-length dependence of jet-energy loss

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Jet-quenching observables are considered to be significant probes of the medium evolution during a heavy-ion collision. We performed a systematic study on the jet-energy loss [1] based on a generic energy loss model [1, 2] that can interpolate between a pQCD-based and an AdS/CFT-inspired jet-energy loss prescription. The results were compared to the measured nuclear modification factor $R_{AA}$ and the high-$p_T$ elliptic flow [3] to study the jet-medium coupling $\kappa$ and the impact of the jet path-length dependence.

The generic energy-loss model

The generic energy-loss model [1, 2] parametrizes the energy loss via

$$\frac{dE}{dx} = \frac{dE}{d\tau}(x_0, \phi, \tau) = -\kappa(T) E^a(\tau) \tau^z e^{-\kappa T c}.$$

Here, the jet-energy dependence, the path-length dependence, the temperature dependence, and the jet-energy loss fluctuations are characterized by the exponents $(a, z, c, q)$. The jet-energy loss fluctuations are distributed via $f_q(\zeta_q) = \frac{(q+1)}{(q+2)}(q+2-\zeta_q)^q$, allowing for an easy interpolation between non-fluctuating ($q = -1, \zeta = 1$) and fluctuating ($\zeta < 1$ for $q > -1$) distributions.

The jets are distributed according to a transverse initial profile specified by the QGP expansion of VISH2+1 [4].

Results

Below we consider an exponentially falling ansatz for the jet-medium coupling, $\kappa(T) = \kappa_1 e^{-b(T-T_1)}$, assuming that the coupling is zero below a certain temperature $T_1$, representing the freeze-out, where the coupling peaks at a value of $\kappa_1$ and falls off for larger temperatures to a value of $1/e$ at a temperature $T_c$.

Fig. 1 shows the result for the nuclear modification factor and the high-$p_T$ elliptic flow both at RHIC and at LHC energies with and without additional jet-energy loss fluctuations. Given the space-time uncertainties of the hydrodynamic evolution (for details see Ref. [1]), such a temperature-dependent jet-medium coupling represents a decent fit to the measured data.

Conclusions

Performing a systematic study on the jet-energy loss [1] we found (see Table 2 of Ref. [1]) that a pQCD-like energy loss with a temperature running coupling appears to be favored (see Fig. 1). Besides that, a realistic QGP expansion is essential to account for the dependence of the data on transverse momentum $p_T$, azimuth $\phi$, impact parameter $b$, and collision energy $\sqrt{s}$.

References


Figure 1: Azimuthal jet tomography at RHIC and LHC for a pQCD-like ansatz (see text for details) [1].

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