Studies of jet quenching within a partonic transport model*

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Jet quenching is one of the most promising phenomena for investigating hot and dense matter created in ultra-relativistic heavy-ion collisions at RHIC and LHC. Among the observables for characterizing the energy loss of a high-p_t parton are the suppression of particle spectra defined in terms of the nuclear modification factor R_{AA} [1] and the momentum imbalance A_J [2] of reconstructed di-jets. Both observables show a significant modification within heavy-ion collisions in comparison with p+p collisions [1, 2].

Within this report we show our progress in understanding jet quenching within the partonic transport model BAMPS [3], which numerically solves the 3+1D relativistic Boltzmann equation for quarks and gluons. While employing a running coupling $\alpha_s(t)$ evaluated at the momentum transfer of the respective, microscopic collision, BAMPS uses screened leading-order pQCD cross sections for the elastic $2 \rightarrow 2$ collisions and matrix elements calculated in a recently developed, improved Gunion-Bertsch approximation [4] for the inelastic $2 \leftrightarrow 3$ processes

$$\left|\overline{\mathcal{M}}_{X\rightarrow Y+g}\right|^2 = \left|\overline{\mathcal{M}}_{X\rightarrow Y}\right|^2 48\pi\alpha_s(k_\perp^2)\,(1-\bar{x})^2 \left[\frac{\mathbf{k}_\perp}{k_\perp^2} + \frac{\mathbf{q}_\perp - \mathbf{k}_\perp}{(\mathbf{q}_\perp - \mathbf{k}_\perp)^2 + m_D^2\,(\alpha_s(k_\perp^2))}\right]^2, \quad (1)$$

in which problems of the original GB matrix element [5] at non-zero rapidity of the emitted gluon are cured [4]. Since BAMPS is a classical transport model, the quantum Landau-Pomeranchuk-Migdal (LPM) effect is effectively implemented by a theta function $\theta\,(\lambda - X_{LPM}\,\tau_f)$ in the radiative matrix elements, where λ is the mean free path of the radiating parton and τ_f the gluon formation time.

After fixing the LPM parameter $X_{LPM} = 0.3$ by comparing to RHIC data, Fig. 1 shows the nuclear modification factor within BAMPS for gluons and quarks at LHC [6]. Additionally, the R_{AA} of charged hadrons obtained via a folding with AKK fragmentation functions is shown. The same X_{LPM} value for LHC simulations does not only describe the suppression of inclusive particle spectra, both at RHIC and LHC, nicely but also explains the momentum imbalance of reconstructed di-jets as shown in Fig. 2 [7].

Since BAMPS provides the full 3+1D microscopic information of all particles also studies of bulk observables like e.g. the elliptic flow v_2 are possible. Recently, these studies have shown that the *same* microscopic pQCD interactions as used in the jet quenching investigations lead to a sizable elliptic flow within the bulk medium [6].

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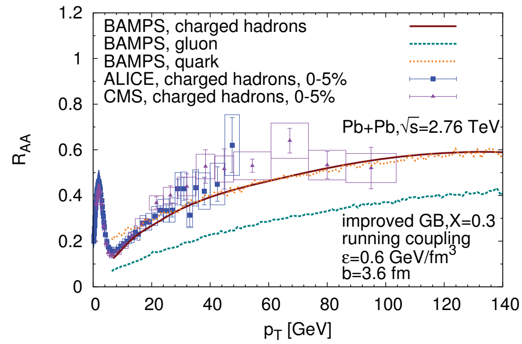

Figure 1: Nuclear modification factor R_{AA} of gluons, light quarks, and charged hadrons at LHC for PYTHIA initial conditions, a running coupling and LPM parameter $X_{LPM} = 0.3$ together with data of charged hadrons [1].

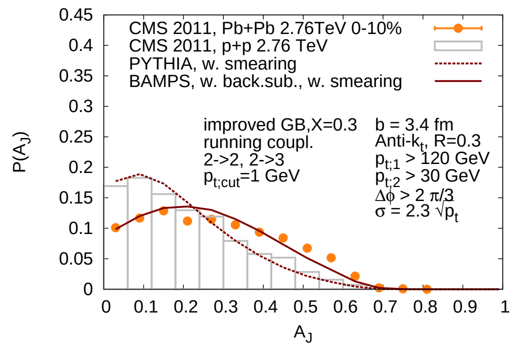

Figure 2: Momentum imbalance A_J of reconstructed jets in central Pb + Pb collisions at LHC for PYTHIA initial conditions, a running coupling and LPM parameter $X_{LPM} = 0.3$ together with data [2].

References

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