Covariant (D)GLV energy loss in proton-lead collisions at the LHC
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Abstract

In $A + A$ reactions we have shown [1] that, compared to the original (D)Jerdjiev-Gyulassy-Levai-Vitev [2, 3] energy loss formulation, a frame-independent (D)GLV approach results in about 50% higher $v_2$ for pions, and also D and B mesons. This is due to an interplay between jet propagation direction and collective flow of the medium. Recently we have extended that calculation to include running strong coupling but have found surprisingly small effect on the nuclear suppression factor $R_{AA}$ and elliptic flow $v_2$. With the assumption that QGP is produced in nearly central $p + Pb$ reactions at the LHC, we here use our covariant (D)GLV energy loss approach to calculate $R_{AA}$ and harmonic flow coefficients $v_n$. This is especially interesting because hydrodynamics requires high opacities, which should then be manifested in energy loss. We find non-negligible $v_2$, as well as an $R_{AA}$ slightly below unity, suggesting that the combination of hydrodynamics and (D)GLV energy loss is perhaps reasonable, compared to experimental measurements.

Covariant DGLV energy loss

The increase in elliptic flow due to jet-medium flow coupling from covariant treatment of energy loss is robust, as seen in the right plot. However, the influence of running coupling seems rather small. Figures 2 and 3 show neutral pion and D meson results for $p + Pb$ at the LHC with $\sqrt{s_{NN}} = 5.02$ TeV. Bulk medium evolution from viscous hydrodynamics with $\eta/s = 0.2$ was provided by Chan Shen. D mesons were obtained via independent parameterization using the Peterson parameterization (with identical parameters to those in Ref [8]). The conclusion about covariance and running coupling are the same as at RHIC energy (Figure 1).

Covariant GLV energy loss in $p + Pb$

Now we turn to $p + Pb$ interactions at the LHC with $\sqrt{s_{NN}} = 5.02$ TeV, top 3.4% centrality. We used GLISSANDO to generate initial conditions, and then applied 2+1D (boost invariant) ideal hydrodynamics using the HENPIC/hydro code [7] to model the bulk medium evolution. Figure 4 shows neutral pion $R_{AA}$ and $v_2$ for a single event (Event 1'). Statistical errors are shown based on ten million simulated jets. We find an $R_{AA}$ that is about 5 – 10% below unity for $10 < p_T < 40$ GeV, and a non-negligible $v_2$ on the order of 1%. The magnitudes of $v_2$ and $v_3$ are reduced by about half compared to $v_2$.

Effect of covariance in $A + A$

Figure 1 shows the influence of covariance on neutral pion observables in $A + A$ at $\sqrt{s_{NN}} = 200$ GeV with impact parameter $b = 7.5$ fm. We employ D+QCD jets with binary collision prejudice, together with bulk medium from 2+1D boost-invariant viscous hydrodynamics [6] with SKLN initial profile and lattice QCD equation of state (available from the THEQRM Collaboration [7]). Three cases are contrasted: (i) "vanilla" GLV energy loss with running coupling ("running coupling, GLV"); (ii) frame independent GLV energy loss with running coupling ("running coupling, flow"); and (iii) frame independent energy loss with fixed coupling ("fixed coupling, flow"). All three are scaled to give the same $R_{AA}$ for $p_T \sim$GeV by adjusting $\alpha_s$ (fixed coupling case) or the maximum value of $\alpha_s$ (running coupling case, as in Ref [8]).

References:

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