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AdS/CFT predictions for partonic and fragmented momentum, azimuthal, and rapidity correlations of heavy flavors in heavy ion collisions

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We compute the suppression, angular, and rapidity distribution of single open heavy flavour and the momentum, angular, and rapidity correlations for pairs of open heavy flavour at RHIC and LHC from an AdS/CFT-based energy loss model. We quantitatively compare these strongly-coupled QGP predictions to the weakly-coupled QGP predictions of Nahrgang et al., PRC90 (2014) [arXiv:1305.3823]. In the strong-coupling energy loss model, we include both the mean energy loss and thermal fluctuations; in the weak-coupling energy loss model, one set of predictions corresponds to the inclusion of purely collisional processes while the other additionally incorporates radiative corrections.

When restricted to leading order production processes, we find that the strongly coupled correlations of high transverse momentum pairs (>4 GeV) are broadened less efficiently than the corresponding weak coupling based correlations, while low transverse momentum pairs (1–4 GeV) are broadened with similar efficiency, but with an order of magnitude more particles ending up in this momentum class. The strong coupling momentum correlations we compute account for initial correlations and reveal that the particle pairs suppressed from initially high momenta to the low momentum domain do not suffice to explain the stark difference to the weak coupling results in momentum correlations for 1–4 GeV. From this, we conclude that heavy quark pairs are more likely to stay correlated in momentum when propagating through a strongly coupled plasma than a weakly coupled one.

When initialised at next-to-leading order (POWHEG+Pythia8), we observe significant additional broadening of azimuthal correlations, with the angular correlations of low momentum pairs (1–4 GeV) essentially washed. However, the momentum correlations remain even when NLO production mechanisms are included. Thus, our conclusion for differences in momentum correlations with leading order production processes should carry over to next-to-leading order production processes once comparable predictions for a weakly-coupled QGP emerge.

Summary

A key step in understanding the quark gluon plasma is identifying its relevant coupling strength. Finding observables that can distinguish between weakly and strongly coupled plasmas is thus very desirable. In this light, we compare the azimuthal and momentum correlations of $b\bar{b}$ pairs in Pb+Pb collisions ($\sqrt{s} = 2.76$TeV) of pQCD calculations and an AdS/CFT based energy loss model sensitive to thermal fluctuations. By accounting for initial momentum correlations as well, we gain further insight into the inherent differences in dynamics between the models.
Finally, we demonstrate that low momentum correlations (1-4GeV) serve as a potential distinguishing observable between weakly and strongly coupled plasmas.

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