Yale Oct 29,2015 Abstract

How do quarks and gluons lose energy in the QGP?

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RHIC introduced the method of hard scattering of partons as an in-situ probe of the the medium produced in A+A collisions. A suppression, $R_{\rm AA} \approx 0.2$ relative to the binary-scaling expected for point-like processes, was discovered for π^0 production in the range $5 \leq p_T \leq 20$ GeV/c in central Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV, and surprisingly also for single-electrons from the decay of heavy quarks. Both these results have been confirmed in Pb+Pb collisions at the LHC at $\sqrt{s_{NN}} = 2.76$ TeV. Interestingly, in this p_T range the LHC results for pion suppression nearly overlap the RHIC results. Thus, due to the flatter spectrum, the energy loss in the medium at LHC in this p_T range must be $\sim 40\%$ larger than at RHIC. Unique at the LHC are the beautiful measurements of the fractional transverse momentum imbalance $1-\langle\hat{p}_{T_2}/\hat{p}_{T_1}\rangle$ of di-jets in Pb+Pb collisions. In 2011, I corrected their first publications to account for the fractional imbalance of di-jets when the same cuts are made in p-p collisions and showed that the relative fractional jet imbalance in Pb+Pb/p-p is $\approx 15\%$ for jets with $120 \leq \hat{p}_{T_1} \leq 360$ GeV/c. CMS later confirmed this much smaller imbalance. At RHIC, the same quantity derived from two-particle correlations of di-jet fragments corresponding to jet $\hat{p}_T \approx 10-20$ GeV/c, appears to show a much larger fractional jet imbalance $\approx 45\%$ in this lower $\hat{p}_T$ range. The variation of apparent energy loss in the medium as a function of both p_T and $\sqrt{s_{NN}}$ is striking and presents a challenge to both theory and experiment for improved understanding. There are many other such unresolved issues to discuss, for instance, the absence of evidence for a $\hat{q}$ effect—momentum transferred to the medium by outgoing partons, which would widen the away-side di-jet and di-hadron correlations—as predicted in the most popular model of parton energy loss.