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How do quarks and gluons lose energy in the QGP? and other unresolved issues in QGP physics.

Michael J. Tannenbaum[1]

[1] *Physics Department, Brookhaven National Laboratory, Upton, NY 11973-5000, USA*

Contact email: *mjt@bnl.gov*

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, $R_{AA} \approx 0.2$ relative to binary-scaling, 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 pions 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 $\sim 25\%$ 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. At the Utrecht meeting in 2011, I corrected for the fractional imbalance of di-jets with the same cuts 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 compared to the same quantity derived at RHIC from two-particle correlations of di-jet fragments, corresponding to jet $\hat{p}_T \approx 10 - 20$ GeV/c, which appear 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, for instance, the absence of evidence for a $\hat{q}$ effect, due to momentum transferred to the medium by outgoing partons, which would widen the away-side di-jet and di-hadron correlations in a similar fashion as the k_T-effect. Another issue well known from experiments at the CERN ISR, SpS and SpS collider is that parton-parton hard-collisions make negligible contribution to multiplicity or transverse energy production in p-p collisions—soft particles, with $p_T \leq 2$ GeV/c, predominate. Thus an apparent hard scattering component for A+A multiplicity distributions based on a popular formula, $dN_{\rm ch}^{AA}/d\eta = [(1-x)\langle N_{\rm part}\rangle dN_{\rm ch}^{pp}/d\eta/2 + x \langle N_{\rm coll}\rangle dN_{\rm ch}^{pp}/d\eta]$, seems to be an unphysical way to understand the deviation from $N_{\rm part}$ scaling. Based on recent p-p and d+A measurements, a more physical way is presented along with several other stimulating results and ideas from recent d+Au (p+Pb) measurements.