Constituent-quarks as the fundamental elements of the initial state at RHIC and LHC

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The massive constituent-quarks [1], which form mesons and nucleons (e.g. a proton=uud), are relevant for static properties and soft physics with $p_T < 2$ GeV/c. They are complex objects or quasiparticles [2] made of the massless partons (valence quarks, gluons and sea quarks) of DIS [3] such that the valence quarks acquire masses $\approx 1/3$ the nucleon mass with radii ≈ 0.3 fm when bound in the nucleon. With smaller resolution one can see inside the bag to resolve the massless partons which can scatter at large angles according to QCD. At RHIC, hard-scattering is distinguishable from soft (exponential) particle production only for $p_T \geq 2$ GeV/c at mid-rapidity, where $Q^2 = 2p_T^2 = 8$ (GeV/c)^2 which corresponds to a distance scale (resolution) < 0.07 fm.

Based on the deconvolution of the p+p mid-rapidity E_T distribution in PHENIX [4] at $\sqrt{s} = 200$ GeV to the sum of 2–6 constituent-quark participants (NQP model), the E_T distribution of a constituent-quark is determined and applied to d+Au and Au+Au reactions in the same detector where the calculations closely follow the measured d+Au and Au+Au E_T distributions in shape and magnitude over a range of more than 1000 in cross section. For symmetric systems the NQP model is identical to the Additive Quark Model (AQM) from the 1980s, a color-string model in which the maximum number of color-strings is limited to the number of constituent-quarks in the lighter nucleus, or six for d+Au, which fails to describe the d+Au data.

For centrality-cut data, the two-component ansatz $d\mathrm{E}_T/d\eta \propto (1-x)N_{\mathrm{part}}/2 + xN_{\mathrm{coll}}$ which has been used to explain E_T distributions is shown to be simply a proxy for N_{qp}, so that the N_{coll} term does not represent a hard-scattering component in E_T distributions. The energy loss of hard-scattered partons has been shown to be proportional to the charged-particle multiplicity $dN_{\mathrm{ch}}/d\eta$ at both RHIC and LHC which follows the same N_{qp} scaling as E_T distributions. Thus it is hard to avoid the conclusion that the relevant initial state for production of the QGP in A+A collisions at both RHIC and LHC is based on massive constituent-quarks rather than the massless current quarks and gluons which are observable at finer resolution as the partons of hard-scattering which produce the jet and single particle probes at large p_T.

References

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