Limits on the Viscosity to Entropy Density Ratio from PHENIX Data on Single Electron Production

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The strong elliptic flow discovered at RHIC, together with its detailed dependence on particle mass and on transverse momentum, are well-described by ideal hydrodynamics calculations which ignore viscous effects. However, as noted by Danielewicz and Gyulassy [1], straightforward arguments based on the uncertainty principle suggest that the viscosity for any thermal system must be non-zero. This observation was extended by Kovtun, Son and Starinets (KSS) [2], who demonstrated that conformal field theories with gravity duals have a ratio of viscosity η to entropy density s of $1/4\pi$ (in natural units). KSS conjectured that this value is a bound for any relativistic thermal field theory, that is, $\eta/s \geq 1/4\pi$.
Estimates for the value of this ratio in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV based on flow [3,4], fluctuations [5] and entropy production [6] all suggest that η/s for the QGP created in these collisions can not exceed the KSS bound by more than a factor of ~ 4. By requiring a simultaneous description of the energy loss ($R_{AA}(p_T)$) and flow ($v_2(p_T)$) of single electrons from semi-leptonic decays of heavy flavor, the PHENIX experiment obtained an estimate $\eta/s \approx (1.3-2)(1/4\pi)$ [7]. Prospects for an improved understanding of the extraction of η/s from PHENIX data on heavy flavor production will be presented, along with a discussion of current theoretical work on constraining the transport properties of the medium from the experimental data.

References

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