

Centrality dependence of viscous quark gluon plasma at LHC

Extensive analysis of RHIC data at $\sqrt{s_{NN}}=200$ GeV Au+Au collisions has provided convincing evidence that Quark Gluon Plasma (QGP) produced in such a collision behaves almost like a perfect fluid with viscosity per specific entropy η/s is around the lower bound as per AdS/CFT $\eta/s = 1/4\pi$. Recently, ALICE collaboration has come out with the data for elliptic flow as a function of p_T as well as the centrality dependence of charged particle multiplicity in $\sqrt{s_{NN}}=2.76$ TeV Pb+Pb collision [1]. Curiously enough ALICE data for charged particles can be explained by using almost the same value of $\eta/s \approx 0.08$ as in RHIC, except for very central collision where the data favors ideal fluid $\eta/s \approx 0$ rather than a viscous fluid, although energy of collision at LHC is substantially higher than RHIC energy and expected to go up still further to $\sqrt{s_{NN}}=5.5$ TeV.

It is also expected, in general, that η/s should go up for QGP as a function of temperature [2]. For RHIC, it is also expected that the hadron system is more relevant than QGP, whereas, for LHC QGP viscosity should be more important than the hadronic system [3]. So, it is quite natural to ask the question why η/s for RHIC remain rather similar to LHC, around $\eta/s \approx 0.08$.

We investigate this issue and came to the inevitable conclusion that this similarity is forced upon us by the dynamics related to the geometry of the collision. For central collision or near about a value of initial time of $\tau_i \approx 0.2$ fm and a temperature of 700 MeV is quite reasonable. However, taking into account peripheral collision (70-80%) one can not escape from $\tau_i \approx 0.6$ fm with initial temperature of 500 MeV. Please note that even for $\tau_i=0.6$ fm the fitted energy density remains at ~ 126 GeV/fm³, a factor of 3.5 larger than required for RHIC energy collision.

The role of peripheral collision has been overlooked by for and large; it is interesting to note that it is the peripheral collision which precipitates recent LHC data to behave rather closely to RHIC data. We need to know η/s as a function of temperature to pin point the location of phase transition or rapid cross over from hadronic to quark gluon plasma. Data even at a higher energy $\sqrt{s_{NN}}=5$ TeV especially for photon and dilepton results will facilitate this idea.

[1] K. Aamodt et al, Phys. Rev. Lett. 106, 032301 (2011), arXiv:1011.3914 [nucl-ex].

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[3] H. Niemi, G. S. Denicol, P. Huovinen, E. Molnar, D. Rischke, arXiv:1101.2442 [nucl-th].

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