The initial state of high energy nuclear collisions

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The initial state of nuclear collisions at very high energies is thought to be a phase of QCD called the Color Glass Condensate (CGC). A key problem in our understanding of heavy ion collisions is the question how this color glass evolves into a thermalized plasma of quarks and gluons (QGP).

One problem under continuing investigation (R.J. Fries with G. Chen and others) is the evolution of the energy momentum tensor at early times after the collision. This an important ingredient into hydrodynamic calculations of the thermalized QGP phase, which need well-constrained initial conditions from an underlying microscopic theory. The current work is based on the evolution of the classical gluon field in the framework of the CGC. The energy momentum tensor of this field is calculated to all orders in the field and the strong coupling constant in an expansion for small times. We expanded previous work to higher orders in a small time power series. A suitable matching condition for a thermalized plasma phase is under development.

In a related project [1] we computed the decoherence time for the classical gluon field in the CGC model to leading order. We confirm the anticipated qualitative result $\tau \sim 1/Q_s$, where Q_s is the saturation scale of the classical gluon fields. Our results show that the numerical factor in front is of order 1, indicating a very small decoherence time of order of magnitude 0.2 fm/c at RHIC. The decoherence time has to be smaller than the thermalization time which is experimentally found to be smaller than 1 fm/c at RHIC. Our estimate is therefore compatible with data. We also estimate the entropy created during the decoherence process to be a significant part of overall entropy production in heavy ion collisions at RHIC.

In a related work we estimated the additional entropy produced through the presence of bulk and shear viscosity in the quark gluon plasma [2]. We used boost-invariant 2^{nd} order relativistic hydrodynamics and our work was the first to include bulk viscosity effects. We find that entropy production from bulk viscosity is smaller than that from shear viscosity in an expanding quark gluon plasma, even if a conjectured cusp of the bulk viscosity around the critical temperature is taken into account, and that the total entropy production during the hydrodynamic expansion due to dissipation is about 20% of the total entropy found in heavy ion collisions at RHIC.

[1] R. J. Fries, B. Muller, and A. Schafer, Phys. Rev. C **79**, 034904 (2009).
[2] R. J. Fries, B. Muller, and A. Schafer, Phys. Rev. C **78**, 034913 (2008).