Initial Condition Dependence of Hydrodynamic Flow of Quark Gluon Plasma

Md Hasanujjaman, Sushant Kumar Singh, Snigdha Ghosh,
Golam Sarwar, Sandeep Chatterjee, Jan-e Alam, Sourav Sarkar*
Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, INDIA

Introduction

Nuclear collisions at relativistic energies may produce a new state of deconfined quarks and gluons. A thermalized state of these quarks and gluons is called quark gluon plasma (QGP). The relativistic hydrodynamical equations have been solved to study the evolution of QGP formed in relativistic heavy ion collisions (RHIC). Numerical codes based on different algorithms to solve the hydrodynamic equations have been developed from scratch to examine the efficiency and accuracy of the algorithms. Influence of realistic initial conditions containing cold nuclear matter effects on the flow patterns have been studied. Results for different numerical algorithms to solve these equations will also be presented.

Model

Relativistic hydrodynamics is an efficient tool to describe the evolution of matter formed in RHIC. Numerical codes have been developed for two types of algorithms (FCT and Relativistic HLLE) to solve the hydrodynamic equations:

$$\partial_\mu T^{\mu\nu} = 0, \quad \partial_\mu n_B^\mu = 0. \qquad (1)$$

where $T^{\mu\nu} = (\epsilon + P)u^\mu u^\nu - g^{\mu\nu}P$ is the energy momentum tensor and $n_B^\mu = n_B u^\mu$ is the baryon flux. ϵ, P, n_B, u^μ and $g^{\mu\nu}$ are energy density, pressure, baryon density, four velocity and metric tensor respectively. In the present work we take $n_B = 0$. The results of the codes have been contrasted with existing results in the literature.

Results

In this contribution we will present reults for the evolution of energy density in the the transverse plane (xy plane) of the collision zone with time for two types of initial energy density profiles: (i) Monte Carlo Glauber Model (MCGM) and (ii) Wood-Saxon (WS) profiles. The equation of state (EoS) used for the evolving QGP is $P = \epsilon/3$. The results presented below are obtained for ideal EoS, however, results for more realistic, lattice QCD EoS will be discussed during the presentation.

In Figs. 1-3 we display the results on the evolution of energy density in space and time for WS type initial energy density profile. The initial tranverse components of the flow velocity are taken as zero. The maximum value of the energy density is taken as 45 GeV/fm^3 for Au+Au system. It is observed that the dimension of the high energy density domains reduce with progress of time and there is no spatial fluctutaion in energy density. Such smooth profiles are unable to describe the fluctuations in global observables in RHIC.

The spatial distributions of the energy density with time for MCGM initial conditions are displayed in Figs. 4-6. It is interesting to note that the energy deposited in nuclear collision has a fluctuating space time structure approprtiate to study the effects of fluctuations on the global observables like flow coefficients.

The effects of nuclear shadowing on the flow will be presented [1].

*Electronic address: jaman.mdh@gmail.com

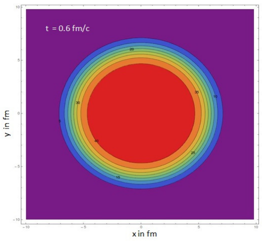

FIG. 1: Energy density contours in xy plane at initial time, $\tau_i = 0.6$ fm/c for Au+Au collision at RHIC energy for WS model.

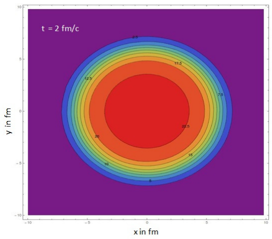

FIG. 2: Energy density contours in xy plane at $\tau = 2$ fm/c for Au+Au collision at RHIC energy for WS model.

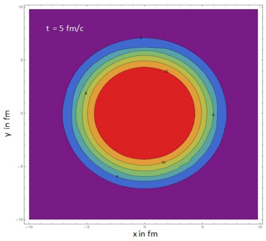

FIG. 3: Energy density contours in xy plane at $\tau = 5$ fm/c for Au+Au collision at RHIC energy for WS model.

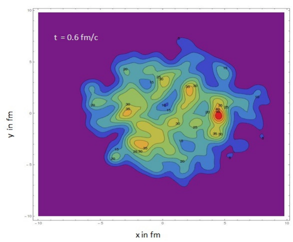

FIG. 4: Energy density contours in xy plane at initial time, $\tau_i = 0.6$ fm/c for Au+Au collision at RHIC energy for MCGM.

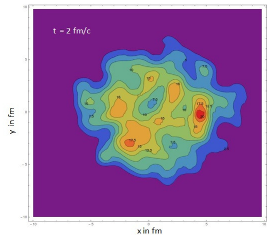

FIG. 5: Energy density contours in xy plane at $\tau = 2$ fm/c for Au+Au collision at RHIC energy for MCGM.

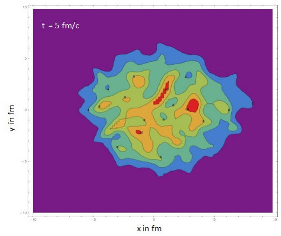

FIG. 6: Energy density contours in xy plane at $\tau = 5$ fm/c for Au+Au collision at RHIC energy for MCGM.

Summary

The relativistic hydrodynamical equations have been solved to study the evolution of QGP. Codes have been developed from scratch to examine the efficiency and accuracy of the different algorithms. Influence of realistic initial conditions containing nuclear shadowing effects on the flow patterns will be discussed. Results for different numerical algorithms to solve these equations will also be contrasted.

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References

[1] Md Hasan *et al.* to be published.