Heavy Ion Collisions with Non-Equilibrium Mean Fields

C. Fuchs [a], T. Gaitanos, and H. H. Wolter
[a] Institut für Theoretische Physik, Universität Tübingen

The study of heavy ion collisions (HIC) at intermediate energies is important to investigate the dynamical properties of nuclear matter far away from saturation density. Theoretically HIC are investigated by transport models often in a relativistic approach (RBUU-models) [1], which have been developed to describe the evolution of the phase space density under the influence of the nuclear mean field and of two-body scattering.

Usually RBUU-calculations are performed in the Hartree mean field approximation in the framework of the non-linear Walecka model (e.g. NL2). Such mean fields describe equilibrated nuclear matter (NM) in the local density approximation (LDA). However a realistic description of HIC requires to take into account many body effects and the non-equilibrium phase space distribution which is typical for HIC. A very successful approach to treat correlations in the relativistic many body problem in the ground state microscopically is the Dirac-Brueckner-Hartree-Fock (DBHF) theory [2]. The relativistic mean field is then obtained from the $\mathcal{T}$-Matrix, which also serves as the effective in-medium NN-interaction. With respect to non-equilibrium momentum configuration the DBHF theory has not yet been solved for such anisotropic configurations. However, Sehn et. al. [3] developed a procedure to construct mean fields for non-equilibrium situations, in particular for two-Fermi-sphere configurations or colliding NM from an appropriate parametrisation of DBHF groundstate results. The utilization of these non-equilibrium DBHF mean fields in HIC is done in a *Local Phase Space Configuration Approximation* (LCA) [4], in which the non-equilibrium momentum configuration is described locally by colliding NM with the densities and the relative velocity as parameters. Note that the LDA which refers to a single Fermi sphere in momentum space is obtained as the limiting case of vanishing relative velocity.

In this work we study the influence of realistic forces and non-equilibrium features on the reaction dynamics by comparing dynamical observables between different mean fields and to experiment. We use, in particular, the FOPI flow data of the system Au on Au at 400 $A \cdot MeV$ [5]. In order to obtain a reliable comparison with the experiment the observables are treated with filter programs for the geometrical detector acceptance and fragments are generated by a coalescence model. Fig. 1 shows the transverse flow as a function of rapidity for four different $ERAT$ [5] bins corresponding to impact parameter bins from peripheral ($b \approx 6\ fm$ corresponding to small $ERAT$ values) to central (large $ERAT$ values) collisions. The DBHF mean field in LCA is able to reproduce the data especially for central collisions while in LDA it overestimates the flow data for central collisions. The phenomenological Walecka model underestimates the data for all $ERAT$ bins. Fig. 2 shows corresponding rapidity distributions. Here also realistic forces give a reasonable description, except for the large impact parameters. However, here detector efficiencies may play an important role in the comparison with experiment. The present results show that DBHF theory also describes NM at high densities, if the influence of the non-equilibrium phase space is taken into account. They also show that such effects are important to reliably extract the equation of state from HIC.

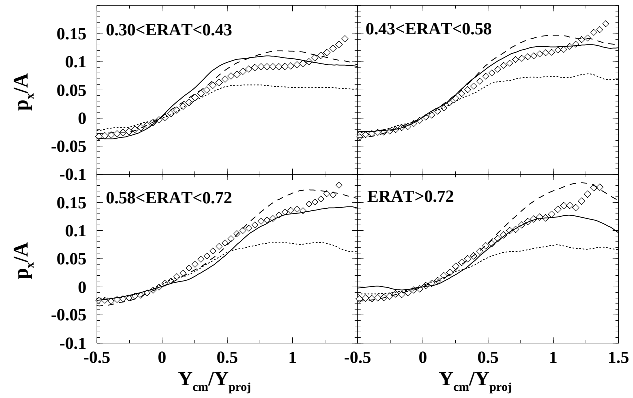

Fig. 1: Transverse flow per nucleon in units of nucleon mass for different $ERAT$ bins for Au on Au at 400 A.MeV [5] with DBHF mean fields in the local density (LDA) (dashed) and local configuration (LCA) approximation (solid) and in the NL2 model (dotted). The data (diamonds) is taken from Ref. [5].

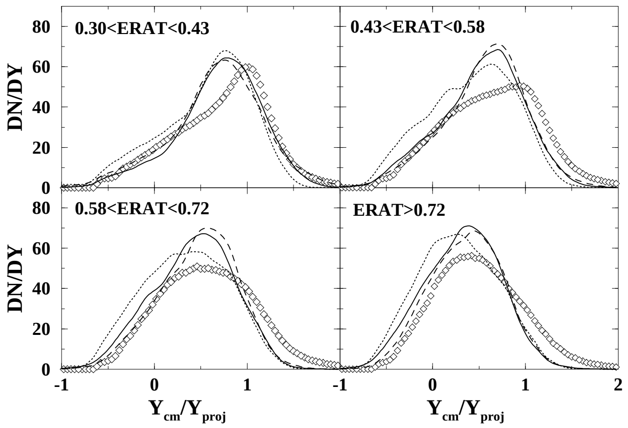

Fig. 2: Rapidity distributions for the same reaction as in Fig. 1. The curves have the same meaning.

References

[1] C. Fuchs, H. H. Wolter, Nucl. Phys. **A589** (1995) 732
[2] C. J. Horowitz, B. D. Serot, Nucl. Phys. **A464** (1987) 613
[3] L. Sehn, H. H. Wolter, Nucl. Phys. **A** (in press)
[4] C. Fuchs, L. Sehn and H. H. Wolter, Nucl. Phys. **A545** (1992) 151
[5] The FOPI collaboration, Nucl. Phys. **A587** (1995) 802