Multiphase Transport Model for Heavy Ion Collisions at RHIC

Z. W. Lin, S. Pal, B. Zhang[a], C. M. Ko and B. A. Li[a]
[a]*Department of Chemistry and Physics, Arkansas State University, P.O. Box 419, State University, AR72467-0419*

To describe heavy ion collisions at the Relativistic Heavy Ion Collider, in which the quark-gluon plasma is expected to be formed, we have developed a multiphase transport model that includes the dynamics of both initial partonic and final hadronic matter [1, 2]. Specifically, the initial conditions are obtained from the HIJING model [3] by using a Woods-Saxon radial shape for the colliding nuclei and including the nuclear shadowing effect on partons via the gluon recombination mechanism of Mueller and Qiu [4]. After the colliding nuclei pass through each other, the Gyulassy-Wang model [5] is then used to generate the initial space-time information of partons. Subsequent time evolution of the parton phase-space distribution is modeled by the Zhang's Parton Cascade (ZPC) [6], which at present includes only the gluon elastic scattering. After partons stop interacting, they combine with their parent strings and are then converted to hadrons using the Lund string fragmentation model [7] after an average proper formation time of 0.7 fm/c. Dynamics of the resulting hadronic matter is described by a relativistic transport model (ART) [8].

The parameters in the AMPT model are fixed using the experimental data from central Pb+Pb collisions at center of mass energy of 17 AGeV [9]. Specifically, we have included in the Lund string fragmentation model the popcorn mechanism for baryon-antibaryon production in order to describe the measured net baryon rapidity distribution. Also, to account for the pion and enhanced kaon yields, we have modified the values of the parameters in the string fragmentation function. The same parameters are then used to study heavy ion collisions at RHIC energies. In Fig. 1, the results for Au+Au collisions at center of mass energies of 56 AGeV (dashed curves) and 130 AGeV (solid curves) are shown together with the data from the PHOBOS collaboration [10].

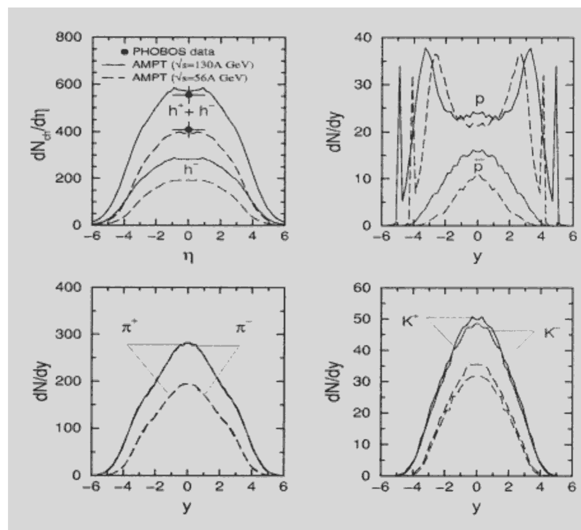

Figure 1: Rapidity distributions of total and negatively charged particles (upper left panel), protons and antiprotons (upper right panel), charged pions (lower left pane), and charged kaons (lower right panel) in heavy ion collisions at $\sqrt{s}=56$ and 130 AGeV. The circles are the experimental data for 6% most central Au+Au collisions from the PHOBOS Collaboration, and the solid curves are the AMPT model calculations for impact parameter of $b \leq 3$ fm.

In Fig. 2, we show the energy dependence of charged particle yields at mid-rapidity. The proton yield is seen to have a minimum at energies between SPS and the highest energy at RHIC, while antiproton yield increases almost linearly with ln s. As a result, the $\bar{p}/p$ ratio increases rapidly from about 0.1 at SPS to about 0.8 at the RHIC energy of $\sqrt{s}$ = 200 AGeV, indicating the formation of nearly baryon-antibaryon symmetric matter at high energies. Meson yields in general exhibit a faster increase with energy; in particular, we find that the K^+/K^- ratio is almost constant within this energy range, suggesting the approximate chemical equilibrium for strangeness production. The K^+/K^- ratio increases gradually from 0.71 at SPS to about 1.0 at $\sqrt{s}$ = 200 AGeV as a result of the nearly baryon-antibaryon symmetric matter formed at high energies.

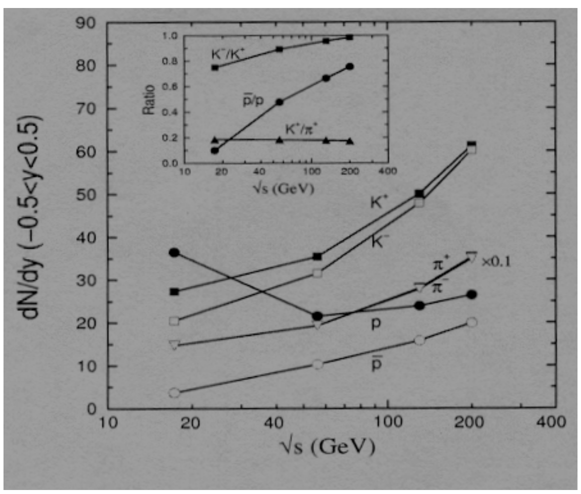

Figure 2: Energy dependence of charged particle yields at mid-rapidity. The ratios of K^-/K^+, $\bar{p}/p$ and K^+/B^+ are shown in the insert.

If the partonic cascade in the AMPT model is turned off, there is then a ~ 5% reduction in the final charged particle yields at $\sqrt{s}$ = 130 AGeV. This indicates that the multiplicity distribution of hadrons are not sensitive to parton elastic scattering. To observe the effects of the partonic matter formed in the initial stage thus requires measurements of other observables such as the elliptic flow and J/ψ suppression. The magnitude of elliptic flow has been shown to be sensitive to the parton-parton cross sections in the ZPC parton cascade model [11], and the J/ψ suppression results using the AMPT model indicate that the partonic matter plays a much stronger role than the hadronic matter [12].

References

[1] B. Zhang, C. M. Ko, B. A. Li and Z. W. Lin, Phys. Rev. C **61**, 067901 (2000).

[2] Z. W. Lin, S. Pal, C. M. Ko, B. A. Li and B. Zhang, Phys. Rev. C (In Press) nucl-th/0011059.

[3] M. Gyulassy and X. N. Wang, Comp. Phys. Comm. **83**, 307 (1994).

[4] A. H. Mueller and J. Qiu, Nucl. Phys. B **268**, 427 (1986).

[5] M. Gyulassy and X. N. Wang, Nucl. Phys. B **420**, 583 (1994).

[6] B. Zhang, Comp. Phys. Comm. **109**, 193 (1998).

[7] T. Sjöstrand, Comp. Phys. Comm. **82**, 74 (1994).

[8] B. A. Li and C. M. Ko, Phys. Rev. C **52**, 2037 (1995).

[9] H. Appelshäuser *et al.* (NA49 Collaboration), Phys. Rev. Lett. **82**, 2471 (1999).

[10] B. B. Back *et al.* (PHOBOS Collaboration), Phys. Rev. Lett. **85**, 3100 (2000).

[11] B. Zhang, C. M. Ko and M. Gyulassy, Phys. Lett. **B455,** 45 (1999).

[12] B. Zhang, C. M. Ko, B. A. Li, Z. W. Lin and B. H. Sa, Phys. Rev. C **62,** 054905 (2000).