Multistrange Baryon Production in Relativistic Heavy Ion Collisions

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One possible signal for the quark-gluon plasma, that is expected to be formed in relativistic heavy ion collisions, is enhanced production of strange particles [1], particularly those consisting of multistrange quarks such as cascade and omega as well as their antiparticles. Although transport models [2] can explain the enhanced production of light strange hadrons such as kaons and antikaons by hadronic scattering alone, they failed in accounting for the enhanced production of multistrange baryons by about a factor of three, and the discrepancy is even larger for their antiparticles [3]. One possible mechanism for enhancing the production of these particles is to increase the string tension or to decrease the constituent quark mass during the fragmentation of the initial strings in the dense matter [3]. It has also been suggested that the observed enhancement of multistrange baryons and antibaryons may be due to topological defects arising from the formation of disoriented chiral condensate in the initial high density stage of collisions [4]. Of course, the enhancement could simply be a result of the formation of the quark-gluon plasma during the collisions. However, to establish strangeness enhancement as a signal for the quark-gluon plasma, we need to exclude any conventional mechanisms. As recently suggested by Vance [5], strangeness-exchange reactions between antikaons and hyperons as well as between their antiparticles can contribute significantly to the production of multistrange baryons and antibaryons in relativistic heavy ion collisions. To determine this contribution, we have extended a recently developed multiphase transport (AMPT) model [6] to include multi-strange baryon production.

We include the following reactions: $\overline{K}$ 7 ↔ =B, $\overline{K}$ φ ↔ =B, and $\overline{K}$ = ↔ ΣB. Since there is no empirical information on the cross sections for the above reactions, we thus assume that they are similar to the reaction $\sigma_{\overline{K}N\to Y\pi}$ which is obtained from the experimental cross sections for $K^- p \to$ 7B^0, $K^- p \to$ φ^{0}B^0, and $K^- n \to$ φ^{0}B$^-$ [7].

The results for heavy ion collisions at

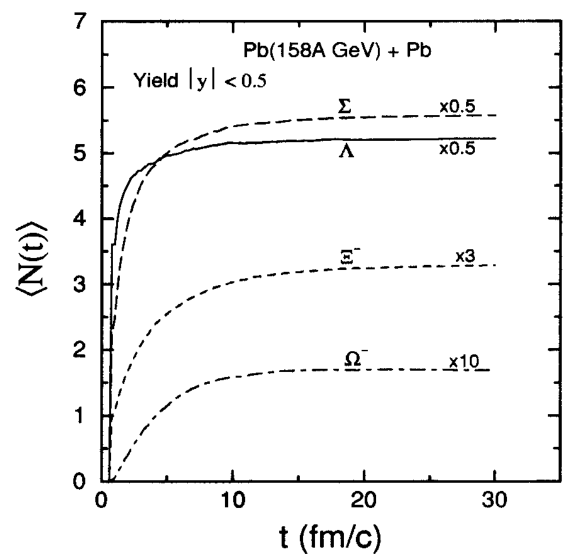

Figure 1: Time evolution of multistrange baryons in central (b < 3 fm) heavy ion collisions at SPS.

SPS are shown in Fig. I for the time evolution of the abundance of 7, φ, =, and Σ. These numbers are comparable to the experimental data from the WA97 collaboration [8].

The predictions of the AMPT model for multistrange baryon production at RHIC are given in Fig. 2. Compared to that from heavy ion collisions at SPS, the abundance of these multistrange particles at midrapidities in these

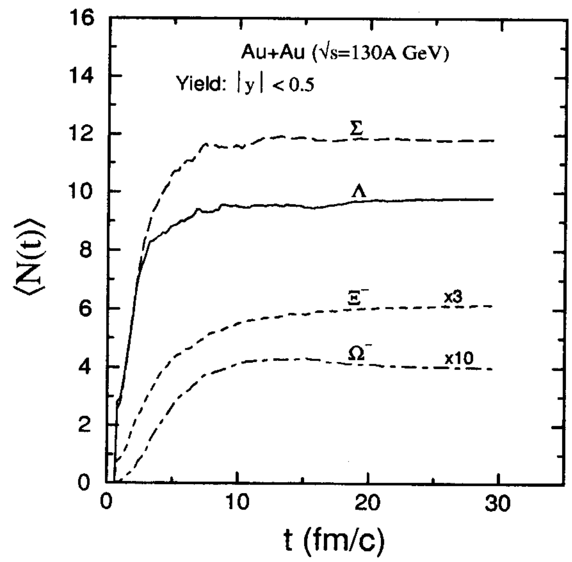

Figure 2: Time evolution of multistrange baryons in central (b < 3 fm) heavy ion collisions at RHIC.

collisions is only increased by about of factor of two.

Although there is a partonic stage in the AMPT model, strange quark production has not been included. To simulate the effects of strange particle production from non-hadronic scattering, we increase the strangeness suppression factor in the string fragmentation to one, so strange quarks are produced with the same probability as light quarks. This then leads to a further enhancement of multistrange baryon production as shown in Fig. 3. In particular, the abundances of = and Σ are about a factor of 2.5 and 5, respectively, larger than those in the case with initial strangeness suppression. This thus suggests that strangeness enhancement remains a possible signal for the quark-gluon plasma formed in heavy ion collisions at RHIC.

References

[1] J. Rafelski and B. Müller, Phys. Lett. **B101**, 111 (1982).

[2] C. M. Ko and G. Q. Li, J. Phys. G **22**, 1673 (1996); S. Bass *et al.*, Prog. Part. Nucl. Phys. **41**, 225 (1998); W. Cassing and E. Bratkovskaya, Phys. Rep. **308**, 65 (1999).

[3] S. Soff *et al.*, Phys. Lett. B **471**, 89 (1999).

[4] J. I. Kapusta and S. M. H. Wong, nucl-th/0012006.

[5] S. Vance, J. Phys. G **27**, 603 (2001).

[6] B. Zhang C. M. Ko, B. A. Li and Z. W. Lin, Phys. Rev. C **61**, 067901 (2000); Z. W. Lin, S. Pal, C. M. Ko, B. A. Li, and B. Zhang, Phys. Rev. C (In Press) nucl-th/0011059.

[7] J. Cugnon, P. Deneye and J. Vandermeullen, Phys. Rev. C **41**, 1701 (1990).

[8] E. Anderson *et al.*, WA97 Collaboration, Phys. Lett. **B433**, 209 (1998); ibid. **449**, 401 (1999).

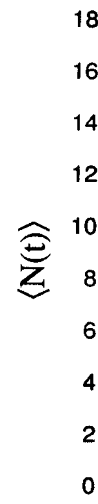

Figure 3
central (b
strangenes