Creation and annihilation of antimatter at FAIR energies*

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The 'Big Bang' scenario implies that in the first micro-seconds of the universe the entire state has emerged from a partonic system of quarks, antiquarks and gluons – a quark-gluon plasma (QGP) – to color neutral hadronic matter consisting of interacting hadronic states (and resonances) in which the partonic degrees of freedom are confined. Nowadays this early phase can be reproduced in relativistic heavy ion collisions. They show indeed that such a QGP can exists and that it interacts more strongly than hadronic matter. Consequently the concept of a weakly interacting system described by perturbative QCD (pQCD) has to be questioned.

The dynamics of partons, hadrons and strings in relativistic nucleus-nucleus collisions can be analyzed within the Parton-Hadron-String Dynamics approach [1, 2]. In this transport approach the partonic dynamics is based on Kadanoff-Baym equations for Green functions with self-energies from the Dynamical QuasiParticle Model (DQPM) which describes QCD properties in terms of 're-summed' single-particle Green functions [3]. The lattice QCD results, of which the parameters of DQPM are fitted on, lead to a critical temperature $T_c \approx 160$ MeV which corresponds to a critical energy density of $\epsilon_c \approx 0.5\ \mathrm{GeV.fm}^{-3}$.

The aim of this project is with the help of the PHSD to study the creation and annihilation of anti-matter at the FAIR facility in the future CBM and PANDA experiments. Since anti-matter (or antiparticles) doesn't exist in our world it has to be created first by strong interactions before its dynamics can be studied in different hadronic or partonic environments. These experiments aim at the exploration of the QCD phase diagram, especially to find out the order of the phase transition between hadrons and partons at high baryonic densities. In addition we will study the optical potential of different hadrons and the in-medium properties of hadrons in the strange and the charm sector. To verify that our approach is adequate for this study we start out with the calculation of the measured spectra of particles and anti-particles at RHIC energies. We have found a good agreement with the PHENIX data for single particle spectra in Au+Au (figure 1) and p+p (figure 2) collisions at mid-rapidity. One can see that the production of particles and anti-particles in pp collisions is very similar while in Au+Au collisions we observe the effects of anti-baryon absorption at low p_T as well as rescattering on the partonic and hadronic levels.

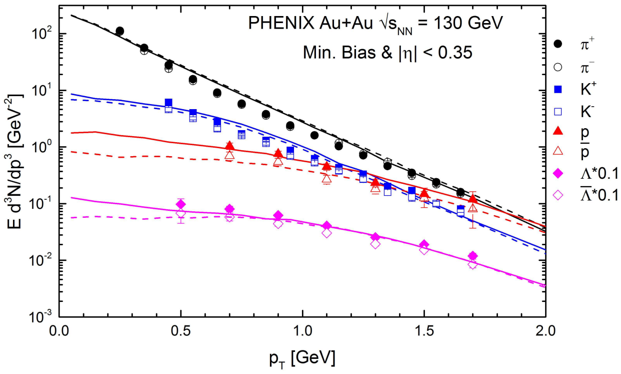

Figure 1: Invariant p_T spectra in Au+Au collisions at $\sqrt{s_{NN}} = 130$ GeV for π^+, π^-, K^+, K^-, p, $\bar{p}$, Λ and $\bar{\Lambda}$ obtained with PHSD, in comparison with the experimental data from the PHENIX collaboration [4, 5].

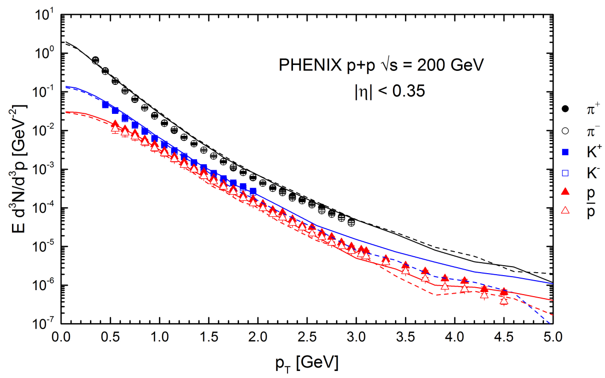

Figure 2: Invariant p_T spectra in p+p collisions at $\sqrt{s} = 200$ GeV for π^+, π^-, K^+, K^-, p and $\bar{p}$ obtained with PHSD in comparison with the experimental data from the PHENIX collaboration [6].

References

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