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EPOSHQ - a new approach to describe charmed mesons in pp, pA and AA collisions

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Abstract

We present first results of a new approach, EPOSHQ, which combines the EPOS3 event generator with the heavy quarks physics. In this approach light and heavy quarks are simultaneously created in the elementary collisions. The heavy quarks interact by elastic and radiative collisions with the plasma constituents, given by the EPOS3 approach, employing the full Boltzmann collision integral. This approach will allow for the description of correlations between light and heavy mesons.

Keywords: Heavy Quarks, Heavy Ion Collisions

There is overwhelming evidence that in heavy-ion collisions at top-RHIC and LHC energies a color-deconfined QCD medium of high temperatures and a low chemical potential, the quark-gluon plasma (QGP), is created which expands and subsequently hadronizes. Its properties during the expansion are difficult to assess because the multiplicity of almost all hadrons can be well described assuming that the system is in statistical equilibrium at a temperature close to that of the inflection point calculated in lattice gauge calculations. So these hadrons do not carry information on the plasma properties prior to hadronization.

The properties of this new state of matter can be probed by heavy-flavor particles which are predominantly produced in the initial hard nucleon-nucleon interactions. Due to the propagation through the colored partonic medium high-p_T heavy quarks suffer from a substantial energy loss, while low-p_T heavy quarks are expected to thermalize partially within in the medium. Suppression of high-p_T and a nonvanishing elliptic flow of D mesons, heavy-flavor electrons and muons have been measured by the STAR [1, 2] and Phenix [3] collaborations at RHIC and the ALICE [4, 5, 6] collaboration at LHC. The simultaneous description of these observables is a challenge for theoretical heavy-ion physics. This challenge is twofold: on the one side we have to describe the elementary interaction of the heavy quarks with the plasma particles, light quarks and gluons, on the other side also different scenarios of the plasma expansion itself can modify the numerical values the heavy quark observables, even for a the same elementary interaction [7].

Many approaches describe the time evolution of the heavy quark distribution function by a Fokker Planck equation with temperature dependent drift and diffusion coefficients which were obtained by solving the

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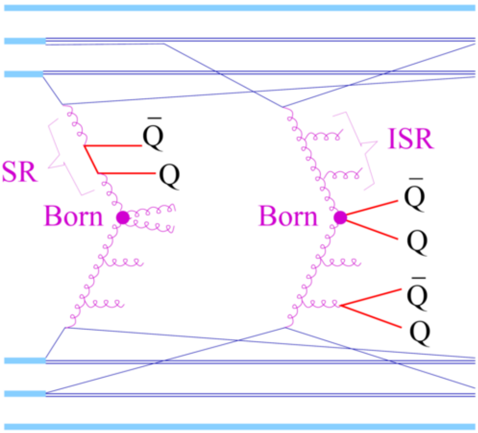

Fig. 1. (Color online)The different processes which may create a $Q\bar{Q}$ pair in elementary pp collision.

collision integral of the elementary interaction [8]. Drift and diffusion coefficients obtained in such a way do not follow the Einstein relation which assures that the distribution function arrives - for a given temperature - for large times at a thermal equilibrium distribution. Therefore usually either the drift or the diffusion coefficient is calculated from the collision integral and the other coefficient is obtained by the Einstein relation. The time evolution of the temperature is usually taken from a hydrodynamical model able to reproduce bulk observables in the light hadron sector. All this introduces uncertainties into the approach and recently it has even been doubted that Fokker Planck equations are appropriate to describe the physics of charm quarks because the scattering is not limited to small scattering angles [9].

We report here on a new approach which links the heavy and light quark physics. For the light quark physics we use EPOS3 [10, 11, 12] , an event generator based on a 3D + 1 viscous hydrodynamical evolution starting from flux-tube initial conditions,which are generated in the Gribov-Regge multiple scattering framework. An individual scattering is referred to as Pomeron, identified with a parton ladder, eventually showing up as flux tubes (or strings). Each parton ladder is composed of a perturbative QCD hard process, plus initial- and final-state linear parton emission. Nonlinear effects are considered by using saturation scales Q_s , depending on the energy and the number of participants connected to the Pomeron in question. This approach has become one of the most used event generators to predict the light quark observables measured in RHIC and LHC experiments and very good agreement with a multitude of observables has been obtained. In this approach we embed the creation of the charm quarks. They are created in exactly the same way as the light quarks, as is shown in fig. 1: A heavy quark ($Q\bar{Q}$) pair can be created by gluons during the initial or final state radiation, it can also be obtained by splitting of initial gluon in a $Q\bar{Q}$ pair. Finally also the hard Born type process can create a $Q\bar{Q}$ pair. The momentum distribution of D^+ mesons created by fragmentation from the c-quarks in EPOS3 is shown in fig.2. On the left hand side we display the transverse momentum distribution of the D^+ mesons observed at midrapidity ($|y|\langle .5$) and compare our result with the standard FONLL calculation [13] as well with the experimental data of the ALICE collaboration [16]. We find a very good agreement of both theoretical approaches with the experimental data. The modification of the transverse momentum distribution due to the introduction of a saturation scale which depends on the participant number [12] is shown on the right hand side of fig.2. There we display for PbPb collisions at $\sqrt{s} = 2.76\ ATeV$ the momentum distribution of the charm quarks as a function of the centrality of the collisions. For most central collision the maximum is suppressed by almost a factor of 3. In the former EPOS2 approach [14, 15] heavy quarks have been created independently of the light quarks in a Glauber approach and without meduim properties like saturation.

The first question to ask is whether there is a correlation between the heavy quarks and the light quarks