Heavy-Quark Kinetics in the QGP at LHC

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Abstract. We present predictions for the nuclear modification factor and elliptic flow of D and B mesons, as well as of their decay electrons, in semicentral Pb-Pb collisions at the LHC. Heavy quarks are propagated in a Quark-Gluon Plasma using a relativistic Langevin simulation with drag and diffusion coefficients from elastic interactions with light anti-/quarks and gluons, including non-perturbative resonance scattering. Hadronization at T_c is performed within a combined coalescence-fragmentation scheme.

In Au-Au collisions at the Relativistic Heavy Ion Collider (RHIC) a surprisingly large suppression and elliptic flow of "non-photonic" single electrons ($e^{\pm}$, originating from semileptonic decays of D and B mesons) has been found, indicating a strong coupling of charm (c) and bottom (b) quarks in the Quark-Gluon Plasma (QGP).

We employ a Fokker-Planck approach to evaluate drag and diffusion coefficients for c and b quarks in the QGP based on elastic scattering with light quarks and antiquarks via D- and B-meson resonances (supplemented by perturbative interactions in color non-singlet channels) [1]. This picture is motivated by lattice QCD computations which suggest a survival of mesonic states above the critical temperature, T_c. Heavy-quark (HQ) kinetics in the QGP is simulated with a relativistic Langevin process [2]. Since the initial temperatures at the LHC are expected to exceed the resonance dissociation temperatures, we implement a "melting" of D- and B-mesons above $T_{\rm diss}$=$2T_c$=360 MeV by a factor $(1+\exp[(T-T_{\rm diss})/\Delta])^{-1}$ (Δ=50 MeV) in the transport coefficients.

The medium in a heavy-ion reaction is modeled by a spatially homogeneous elliptic thermal fireball which expands isentropically. The temperature is inferred from an ideal gas QGP equation of state with N_f=2.5 massless quark flavors, with the total entropy fixed by the number of charged hadrons which we extrapolate to $\mathrm{d}N_{\rm ch}/\mathrm{d}y\simeq$1400 for central $\sqrt{s_{NN}}$=5.5 TeV Pb-Pb collisions. The expansion parameters are adjusted to hydrodynamic simulations, resulting in a total lifetime of $\tau_{\rm fb}\simeq$6 fm/c at the end of a hadron-gas QGP mixed phase and an inclusive light-quark elliptic flow of $\langle v_2\rangle$=7.5%. The QGP formation time, τ_0, is estimated using of $\tau_0 T_0$=const (T_0: initial temperature), which for semicentral collisions (impact parameter $b\simeq$7 fm) yields $T_0\simeq$520 MeV.

Initial HQ p_T spectra are computed using PYTHIA with parameters as used by the ALICE Collaboration. c and b quarks are hadronized into D and B mesons at T_c by coalescence with light quarks [3]; "left over" heavy quarks are hadronized with δ-function fragmentation. For semileptonic electron decays we assume 3-body kinematics [2].

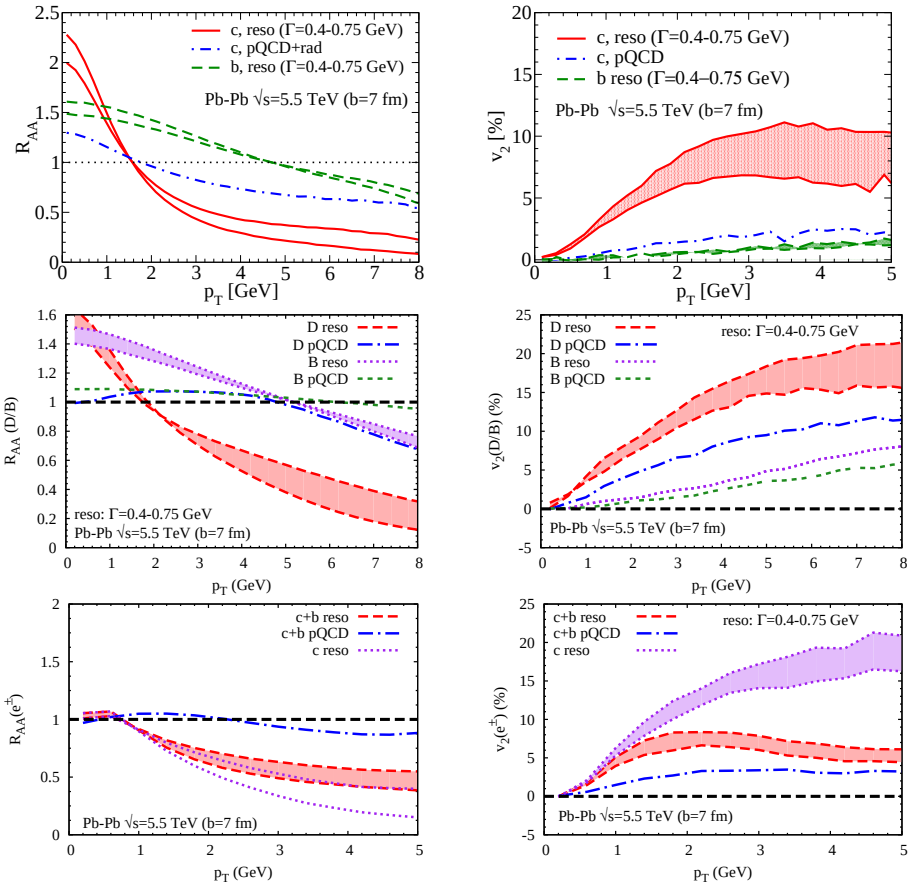

Figure 1. (Color online) Predictions of relativistic Langevin simulations for heavy quarks in a sQGP for b=7 fm $\sqrt{s_{NN}}$=5.5 TeV Pb-Pb collisions: R_{AA} (left column) and v_2 (right column) for heavy quarks (1$^{\rm st}$ row), D and B mesons (2$^{\rm nd}$ row) and decay-$e^{\pm}$ (3$^{\rm rd}$ row).

Fig. 1 summarizes our results for HQ diffusion in a QGP in terms of $R_{AA}(p_T)$ and $v_2(p_T)$ at the quark, meson and $e^{\pm}$ level for b=7 fm Pb-Pb collisions at the LHC (approximately representing minimum-bias conditions). Our most important findings are: (a) resonance interactions substantially increase (decrease) v_2 (R_{AA}) compared to perturbative interactions; (b) b quarks are much less affected than c quarks, reducing the effects in the $e^{\pm}$ spectra; (c) there is a strong correlation between a large v_2 and a small R_{AA} at the quark level, which, however, is partially reversed by coalescence contributions which increase *both* v_2 and R_{AA} at the meson (and $e^{\pm}$) level. This feature turned out to be important in the prediction of $e^{\pm}$ spectra at RHIC; (d) the predictions for LHC are quantitatively rather similar to our RHIC results [2, 4], due to a combination of harder initial HQ-p_T spectra with a moderate increase in interaction strength in the early phases where non-perturbative resonance scattering is inoperative.

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