

Heavy-quark dynamics in a hot and dense medium*

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Introduction

We study the dynamics of on- and off-shell heavy quarks Q in the quark-gluon plasma (QGP) as produced in relativistic nucleus-nucleus collisions. The interactions of heavy quarks with the partonic environment at finite temperature T and finite quark chemical potential μ_q are investigated in terms of transport coefficients within the dynamical quasiparticle model (DQPM) designed to reproduce the lattice-QCD (lQCD) results (including the partonic equation of state) in thermodynamic equilibrium. The collisional scattering cross sections σ_{elas}^Q are evaluated for perturbative partons (massless on-shell particles) and for dynamical quasi-particles (massive on or off-shell particles) using the leading order Born diagrams [2, 3].

Charm spatial diffusion coefficient

Based on σ_{elas}^Q in a finite T and μ_q medium [1, 2, 3, 4], the on- and off-shell heavy quark dynamical collisional energy loss and transport coefficients are computed [1, 3, 4]. As an example, the charm spatial diffusion coefficient D_s is shown in Fig. 1 at finite T (top) and finite T and μ_q (bottom) where our non-perturbative DpQCD model (Dressed pQCD using DQPM pole masses for the partons) is confronted with nuclear many-body calculations below and close to the critical temperature T_c from Ref.[5].

The hadronic and partonic D_s join smoothly and show a pronounced minimum close to T_c at $\mu_q = 0$ as well as at finite μ_q . Close to and above T_c its absolute value matches the lQCD calculations for $\mu_q = 0$. The smooth transition of the heavy-quark transport coefficients from the hadronic to the partonic medium corresponds to a crossover transition in line with lattice calculations, and differs substantially from perturbative-QCD calculations (Moore & Teaney) which show a large discontinuity at T_c . This indicates that in the vicinity of T_c dynamically dressed massive partons should be the effective degrees of freedom in the quark-gluon plasma.

The heavy quark scattering cross sections and transport properties [1, 2, 3, 4] form the basis of a consistent study of the heavy quark dynamics in heavy-ion collisions at FAIR, SPS, RHIC and LHC energies where the partonic processes are implemented into the Parton-Hadron-String-Dynamics (PHSD) transport approach.

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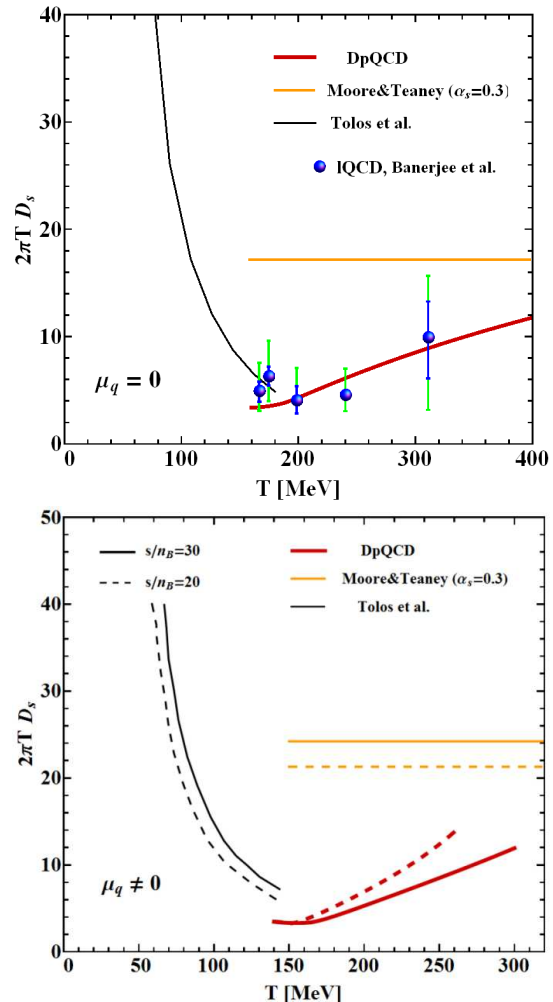


Figure 1: Spatial diffusion coefficient for heavy quarks, D_s , as a function of T for $\mu_q = 0$ (top) and $\mu_q \neq 0$ (bottom). The hadronic diffusion coefficient is taken from [5]. For partonic environment the result from the DpQCD model is compared to pQCD [6], and lattice calculations from Ref. [7].

References

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