Open heavy flavor and $J/\psi$ at RHIC and LHC within a transport model

Jan Uphoff, Oliver Fochler, Zhe Xu, and Carsten Greiner
Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt am Main, Germany

Abstract

We employ the running coupling and an improved screening procedure, which reproduces the energy loss from hard thermal loop calculations, which effectively enhances the heavy quark cross section with the medium. The prefactor $\kappa$ is mostly set to 1 in the literature without a sophisticated reason. However, one can fix this factor analytically to $\kappa \approx 0.2$ by comparing the energy loss per unit length $dE/dx$ of the LO cross section including $\kappa$ to the energy loss obtained within the hard thermal loop approach [4].

Quantitative comparisons [2] [3] show that elastic processes are responsible for a large fraction of the energy loss of heavy quarks. However, they are not able to reproduce the data of the nuclear modification factor or elliptic flow of any heavy flavor particle species. This is not too surprising since we expect that realistic $2 \rightarrow 3$ processes play an important role and that both processes together should account for the measured suppression and flow. Currently, we mimic the radiative influence by effectively increasing the elastic cross section by a factor $K = 0.1$, which fits the heavy flavor elliptic flow and $R_{AA}$ data from RHIC [4].

Conclusions

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Figure 1: $R_{AA}$ of $J/\psi$ at mid-rapidity $|y| < 0.3$ and forward rapidity $1.2 < y < 2.2$ for Au+Au collisions at RHIC as a function of the number of participants, together with experimental data [2].

Preliminary results of the nuclear modification factor $R_{AA}$ of $J/\psi$ obtained with BAMPS agree well with the data at forward rapidity, but are slightly too large at forward rapidity. The elliptic flow of all $J/\psi$ is very small and consistent with the experimental data.

Figure 2: Elliptic flow of $J/\psi$ at RHIC with data [3]. For comparison the charm quark $v_2$ is also shown.

Elliptic flow and nuclear modification factor of open heavy flavor

Commonly used observables for investigating the coupling of heavy quarks with the medium are the elliptic flow and the nuclear modification factor of heavy quarks:

$\varepsilon_2 = \frac{p_T^2 - p_T^2}{p_T^2}$, $R_{AA} = \frac{dN_{AA}/dy}{N_{pp}dN_{pp}/dy}$

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Figure 3: Elliptic flow $v_2$ of heavy flavor electrons for Au+Au collisions at RHIC. The heavy quark cross section with light partons is multiplied with the factor $K = 3.5$. For comparison, data of heavy flavor electrons [1] is shown.

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Figure 4: Nuclear modification factor $R_{AA}$ of heavy flavor electrons at RHIC for the same configurations as in Fig.

With the same parameter we find a good agreement with the $D$ meson elliptic flow data at LHC. However, the $R_{AA}$ of $D$ mesons, non-prompt $J/\psi$, and muons are underestimated.

First BAMPS results with radiative contributions look very promising. The RHIC electron $R_{AA}$ can be described without a $K$ factor.

Figure 5: Elliptic flow $v_2$ of $D$ mesons, non-prompt $J/\psi$, muons, and electrons as a function of transverse momentum for Pb+Pb collisions at LHC together with data [2].