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Quarkonium production in heavy ion collisions: coupled Boltzmann transport equations

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Heavy quarkonia can be used as probes of the quark-gluon plasma (QGP), a hot nuclear environment produced in heavy ion collisions. Quarkonia become unbound or "melt" at sufficiently high temperature due to the screening of the color attraction between quark and antiquark. In this sense, quarkonia can be thought of as thermometers for the QGP. But extracting the melting temperature from experimental measurements is complicated. One needs to take into account cold nuclear matter (initial state) effects, static and dynamic screening, in-medium dissociation and recombination and feed-down processes in a consistent way. To this end, we develop a set of coupled Boltzmann transport equations of heavy quarks and quarkonia. It includes elastic and inelastic scattering of heavy quarks with the medium, color screening, as well as dissociation and recombination inside the medium. The dissociation and recombination processes are calculated in potential non-relativistic QCD (pNRQCD). The effective field theory pNRQCD is valid when the heavy quark mass is large and the distance between the heavy quark antiquark pair inside the quarkonium bound state is small compared with the thermal scales. We solve the Boltzmann equations by Monte Carlo simulations with given initial conditions and time dependent medium background.

We will discuss how the coupled system of heavy quarks and quarkonium approaches equilibrium in a static QGP box, which indicates that the dissociation and recombination are implemented in a consistent way. We then will present calculations with realistic initial conditions and hydrodynamical background. The initial momenta of heavy quarks and quarkonia are generated from event generators such as PYTHIA with nuclear parton distribution functions while the initial positions are sampled from binary collisions. We will also compare the calculations with experimental measurements of R_{AA} and v_2 of quarkonia at both RHIC and LHC. Finally, we will present similar studies of the production of doubly heavy baryons and discuss future plans towards a more complete understanding of quarkonium production mechanisms in heavy ion collisions.

Summary

Authors: YAO, Xiaojun (Duke University); MUELLER, Berndt (Brookhaven National Laboratory); BASS, Steffen A. (Duke University); KE, Weiyao (Duke University); XU, Yingru (Duke University)

Presenter: YAO, Xiaojun (Duke University)

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