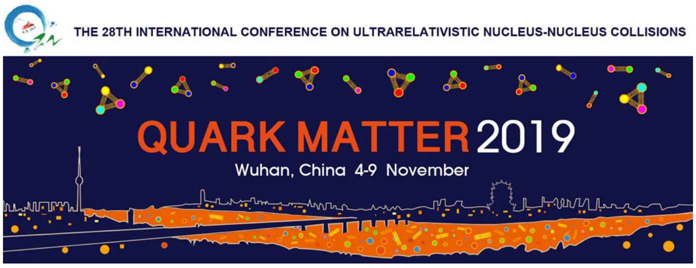

Contribution ID: **19**   Type: **Oral Presentation**

Quarkonium Production in Heavy Ion Collisions: from Open Quantum System to Transport Equation

Tuesday, 5 November 2019 17:20 (20 minutes)

The production of heavy quarkonium in heavy ion collisions has been used as an important probe of the quark-gluon plasma. The initial insight was that due to the plasma screening effect, the color attraction between the heavy quark-antiquark pair is significantly suppressed at high temperature and thus no bound states can exist, i.e., they "melt". In addition to the screening of the color attraction, quarkonium dissociates when enough energy is transferred to it in a dynamical process. The inverse process of dissociation, recombination, can also happen inside the medium when the plasma temperature allows quarkonium formation and is as crucial as dissociation. To explain experimental results on quarkonium production, we have to account for static screening, dissociation and recombination in a consistent way. One traditional approach is to use a transport equation through which the phase space distribution of quarkonium is evolved. In recent years, another approach based on the open quantum system formalism started being used. It is learnt that dissociation can be understood as a decoherence of the wavefunction of the heavy quark-antiquark pair. Recombination is automatically included in this framework.

In this talk, I will present a connection between the open quantum system formalism and the transport equation. I will discuss new insights about the quarkonium dynamics inside the quark-gluon plasma from the perspective of quantum information. I will show that under the weak coupling and Markovian approximations, the evolution equation of the open system, the Lindblad equation, turns to a Boltzmann transport equation after a Wigner transform is applied to the system density matrix. I will demonstrate how the separation of physical scales justifies the approximations, by using effective field theory of QCD. Finally, by coupling the transport equations of quarkonia and open heavy flavors, I will study how the system of open and hidden heavy flavors reaches thermal equilibrium inside a quark-gluon plasma box. Phenomenological results on the nuclear modification factor and the azimuthal angular anisotropy of quarkonium, based on the coupled transport equations will also be presented.

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Session Classification: Parallel Session - Heavy flavor III

Track Classification: Heavy flavor and quarkonium