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Chromoelectric Distribution Function of Nuclear Matter Probed by Quarkonium

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Quarkonium suppression in heavy ion collisions has been used as a probe of the quark-gluon plasma (QGP) for decades. The intuitive picture of sequential suppression based on the Debye screening of the heavy quark potential is obscured by other in-medium processes such as dissociation and recombination. A natural question to ask is what we can learn about the QGP from measurements of quarkonium suppression.

In this talk, we will try to address this question using effective field theory techniques and the open quantum system formalism. We argue that when the quarkonium size is small, the interaction between quarkonium and the hot medium is weak. Then the density matrix of the heavy quark pair, as a subsystem, and the hot nuclear environment can be factorized. The time evolution of the subsystem is governed by the Lindblad equation. By applying the Wigner transform to the Lindblad equation and carrying out a gradient expansion, we derive the semiclassical Boltzmann equation and work out the leading quantum correction. The reaction rates are factorized into a quarkonium dipole transition function and a chromoelectric distribution function of the nuclear medium. For differential reaction rates, the chromoelectric distribution function is momentum dependent, defined by two electric fields connected via a staple-shaped Wilson line. For inclusive reaction rates, it becomes momentum independent and the Wilson line collapses into a straight line along the time axis. The relation between the Wilson line structures in the differential and inclusive reaction rates is similar to that between the gluon PDF and the gluon TMDPDF, except that the time here is the real time rather than the lightcone time. The construction can be easily generalized to the interaction between quarkonium and cold nuclear matter, which is of much relevance for quarkonium production in eA collisions, to be carried out in the future Electron Ion Collider.

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