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Heavy quarkonium dissociation, regeneration and equilibration in the quark-gluon plasma

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We present a comprehensive investigation of the heavy quarkonium dynamics in the quark-gluon plasma (QGP), including the dissociation caused by dynamical scatterings off the medium partons and the regeneration from the unbound single heavy quarks. The dissociation cross sections and transition rates for both 2->2 leading-order (gluo-dissociation) and 2->3 next-to-leading order (partonic inelastic scattering) processes are calculated within the framework of second-order quantum mechanical perturbation theory [1], utilizing an effective color-electric dipole coupling of the quarkonium with thermal gluons. We then employ the microscopic transition amplitudes for these processes and simulate the kinetic and chemical equilibration for heavy quarkonium via transport in a static QGP box within the semi-classical Boltzmann equation approach [2], where the Boltzmann transport of heavy quarkonium is coupled to the single heavy quark diffusion simulated by Langevin equations in a real-time fashion. The pertinent equilibration time turns out to be comparable to the lifetime of the QGP created in the most central heavy-ion collisions at the LHC energies. This work paves the way for realistic phenomenological applications to heavy quarkonium transport.

References
[1] S. Zhao and M. He, Phys. Rev. D 110, no.7, 074040 (2024).
[2] S. Zhao and M. He, arXiv: 2508.11897 [hep-ph].

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