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Upsilon ground state formation and dissociation inside quark-gluon plasma

Heavy quarkonia can be used as probes in heavy-ion collisions since the yield will contain imprint of the initial states and in-medium evolution, which can be used to extract properties of the cold and hot nuclear matters. This use of quarkonium as a probe is complicated by several factors: the competition between dissociation and recombination of quarkonium inside the quark-gluon plasma (QGP) and the feed-down contributions from excited states to the ground state. Among different quarkonium states, bottomonium ground state $\Upsilon(1S)$ is a special probe because of its smaller size and longer thermalization time. A clear understanding of the fate of $\Upsilon(1S)$ inside QGP can tell us more information about the suppression mechanism: whether it arises solely from the suppression of excited states, or originates from the suppression of both the ground and excited states. To this end, a consistent treatment of formation and dissociation is needed.

We use potential non-relativistic quantum chromodynamics (pNRQCD) to study $\Upsilon(1S)$ inside QGP. The dissociation has been studied in pNRQCD but not the formation. The potential terms for the color singlet and octet can be calculated under the weak coupling assumption or fitted from lattice QCD results of the quarkonium free energy. The singlet and octet wave functions are calculated by solving the corresponding Schrödinger equations. Then the wave functions are used to calculate the in-medium rates of $\Upsilon(1S)$ formation and dissociation, which are at leading order through a color dipole interaction. The rates depend on the quarkonium velocity relative to the medium. The two rates are compared as a function of the plasma temperature. Its connection to the phenomenological studies of Upsilon production from heavy-ion collisions will be discussed, together with a future plan to incorporate quarkonium formation and dissociation into transport models for heavy quarks.

Preferred Track

Quarkonia

Collaboration

Not applicable

Primary author: YAO, Xiaojun (Duke University)

Presenter: YAO, Xiaojun (Duke University)

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