Quarkonium formation time in quark-gluon plasma

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We have studied [1] the quarkonium formation time in QGP by using the approach based on the space-time correlator of heavy quark vector currents [2] . The imaginary part of the resulting heavy quark pair polarization function, which is the spectral function of heavy quark pair in $e^{+}+e^{-}$ annihilation, is constructed by solving the Schroedinger equation with the heavy quark potential extracted from lattice calculations. The real part of the polarization function, which is related to its imaginary part by the dispersion relation, then provides the information on how different states of the heavy quark pair evolve with time. Using bottomonia as examples, we have found that the average formation time of a quarkonium from a heavy quark-antiquark pair increases with temperature and diverges near the dissociation temperature of the quarkonium as shown in the left window of Fig.1. Furthermore, the quarkonium formation time is longer if the heavy quark potential is taken to be their free energy instead of their internal energy from the lattice calculations. We have also found that the average relative velocity between the heavy quark pair before they form the quarkonium, calculated via the ratio of the mean distance between the heavy quark and antiquark in a quarkonium to its formation time, decreases with increasing temperature as shown in the right window of Fig.2. Surprisingly, the one obtained from the free energy potential is found to agree with the temperature dependence of the QCD coupling constant (scaled by 1.1) at the screening distance between heavy quark and antiquark pair extracted from the lattice free energy [3].

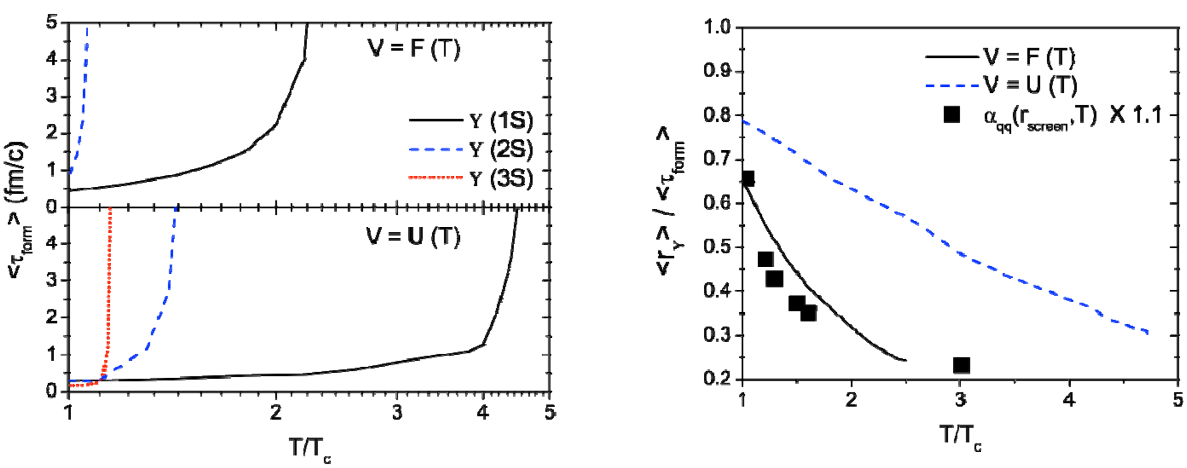

FIG. 1. Left window: Average formation times of Υ(1S), Υ(2S), and Υ(3S) as functions of temperature for the cases of free energy (upper) and internal energy (lower) potentials. Right window: Ratio of the mean distance between bottom quark and antibottom quark in Υ(1S) to its formation time as a function of temperature for the cases of free energy (solid line) and internal energy (dashed line) potentials. Solid squares are the temperature dependence of the QCD coupling constant (scaled by 1.1) at the screening distance between heavy quark and antiquark pair extracted from the lattice free energy [3].

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