Extraction of the heavy-quark potential from bottomonium observables in heavy-ion collisions

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The in-medium color potential between quarks is a fundamental quantity for understanding the properties of the strongly coupled quark-gluon plasma (sQGP). Heavy quarkonia, whose vacuum spectroscopy is well described by the Cornell potential, have long been recognized as an excellent tool to investigate the color screening of the potential in the QCD medium formed in ultrarelativistic heavy-ion collisions (URHICs). However, the production of charmonia receives large contributions from the recombination of charm quarks, which, while interesting in itself, complicates the originally envisaged suppression signature as a probe of deconfinement. On the other hand, within our previously developed transport approach [1], we have found that the suppression of the ground-state bottomonium state, Υ(1S), is a rather sensitive and robust indication of its in-medium binding energy. Based on this insight, we here [2] deploy our transport approach for the first time in a statistical analysis to extract the color-singlet potential from experimental results on Υ production in URHICs. Starting from a parameterized trial potential, we evaluate the Υ transport parameters and conduct systematic fits to available data for the centrality dependence of ground and excited states at RHIC and the LHC. As an important extra ingredient we account for nonperturbative effects in the Υ dissociation rate guided by open HF phenomenology by utilizing a "K-factor" of at least 5 in the coupling of bottom quarks to the sQGP. Our best fits with their statistical significance represented by a 95% confidence level band are shown in Fig. 1, and the pertinent potentials for selected temperatures in Fig. 2.

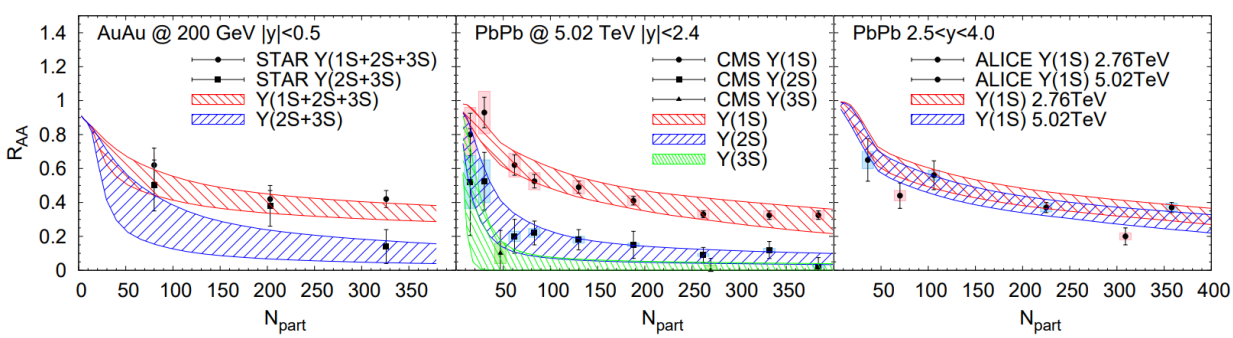

FIG. 1. Bands of 95% confidence level in our fits of Υ R_{AA}'s in the K=5 scenario, compared to Υ(1S +2S +3S, 2S+3S, 1S, 2S, 3S) data from STAR [3] , CMS [4], and ALICE [5] at RHIC and the LHC.

Our results yield a rather strongly coupled potential with substantial remnants of the long-range confining force surviving well into in the QGP. A similarly strong potential was found in previous T-matrix calculations when constrained by lattice-QCD data [6], leading to a small specific viscosity and heavy-quark diffusion coefficient. The remnants of the confining force are therefore identified as the main agent in producing the liquid-like properties of the sQGP.

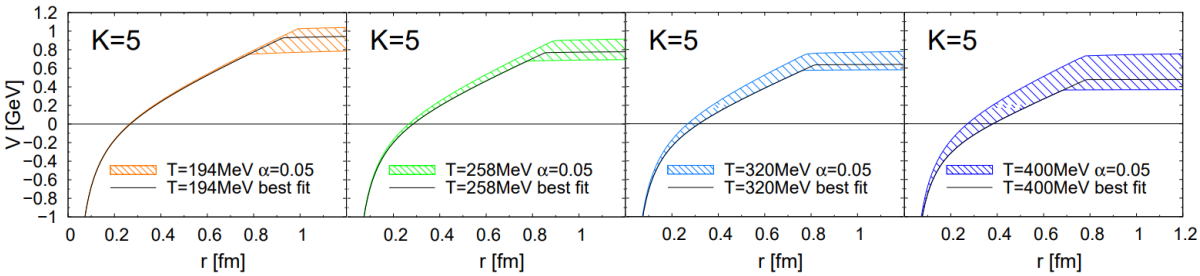

FIG. 2. Best fits (lines) and 95% confidence level bands for the extracted in-medium color-singlet heavy-quark potential at different temperatures (left to right) for K=5.

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