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What lattice QCD spectral functions can tell us about heavy quarkonium in the QGP (15' + 5')

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The bound states of a heavy quark and antiquark ($b\bar{b}$, $c\bar{c}$) are ideal probes of the quark-gluon plasma created in relativistic heavy-ion collisions at the RHIC and LHC, since their comparatively large mass allows them to sample the properties of the bulk over its full lifetime. A rich phenomenology is connected with these states. On the one hand, their sequential melting, as e.g. observed in di-muon spectra by CMS, has been considered for a long time as prime signal of QGP formation. On the other hand with measurements of Charmonium replenishment by the ALICE collaboration, the aspect of recombination at the phase boundary has received renewed interest.

Here we present recent progress in understanding the in-medium behavior of heavy-quarkonium with the help of first principles lattice QCD simulations, in particular spectral functions extracted therein using a novel Bayesian method [1].

The suppression pattern in di-lepton spectra, observed for the heavier species $b\bar{b}$ urge for a real-time understanding of Bottomonium evolution in the QGP. Due to the heavy bottom mass it can be cast in the language of a Schrödinger equation with an in-medium potential. Lattice QCD spectral functions allow us to determine the values of this in general complex potential from first principles [2] at temperatures even close to the deconfinement crossover transition [3], eliminating the need for model potentials.

With experimental indications mounting that Charmonium participates to some extent collectively in the bulk (e.g. $v_2 \neq 0$) we might approximate heavy quarkonium as kinetically thermalized and extract its thermal spectral functions also directly from lattice QCD at $T > 0$ [4]. These in-medium spectra in turn provide insight on phenomenologically relevant observables such as the ψ' to J/ψ ratio [5] under measurement in run2 at the LHC.

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