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Heavy Flavor, Quarkonia, and Electroweak Probes at Quark Matter 2012

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Abstract

We summarize and discuss some of the experimental and theoretical results on heavy flavor, quarkonia, and electro-weak probes presented at *Quark Matter 2012*.

1. Introduction

This edition of the *Quark Matter* series of conferences has witnessed an impressive number of new theoretical and experimental results, which is a testament to the activity in this vibrant field. We discuss in turn some of the new results that were presented at the meeting.

2. Theory results

Starting with calculations of the electromagnetic emissivity of the quark-gluon plasma, photon emission rates have been known at leading order (LO) in α_s, the strong fine structure constant, for little over a decade [1]. Given that RHIC phenomenology seems to favor values $0.2 \leq \alpha_s \leq 0.3$, one may wonder about the size of next-to-leading-order (NLO) contributions. These have recently been calculated and a report on the results has been given at this meeting [2]. The NLO contribution is parametrically of order $g^3 \ln(1/g) + g^3$, where g is the strong interaction coupling constant. Interestingly, the effect of small angle radiation gets enhanced at NLO, while the contributions at larger angles - of the same order in g - get suppressed at NLO, owing in part to an interplay between enhanced scattering rates and a modification of the phase space. The net effect, shown in the left panel of Figure 1, is a modest “K-factor”, which deviates from unity by at most 20-30% at $k/T \sim 2$. Bearing in mind the caveats inherent to a perturbative analysis, this NLO study implies that the phenomenology that relies on those photon rates need not be redone. The techniques developed there, however, will be of use for other finite temperature applications. Other communications on electromagnetic observables included a proposal to observe photons originating from QCD jet conversion by first triggering on a reconstructed jet, and then searching for the back-scattered photon correlated with this hard parton [3]. This technique should avoid contamination from the direct photon sources without an underlying hard process, and suppress fragmentation photons which populate low values of $z = E^\gamma/E^{\rm jet}$. Recent dilepton calculations were also shown which highlighted the effects of a finite shear viscosity coefficient on lepton-pair observables [4]. The dilepton yields were shown to be somewhat insensitive to the viscosity corrections, but the dilepton elliptic flow - as quantified by $v_2(p_T)$ - shows greater sensitivity. The absolute value of the predicted dilepton v_2 does remain small, which is consistent with the

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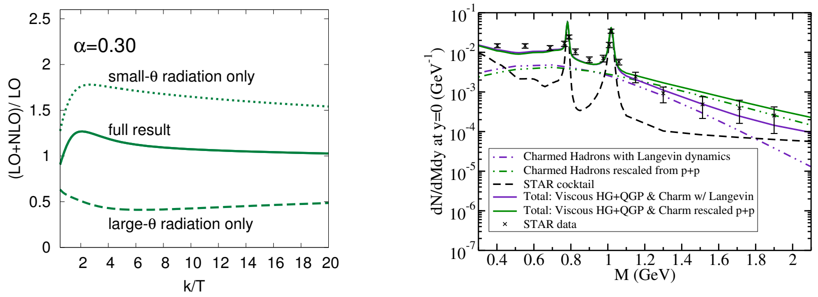

Figure 1: (Color Online) (Left panel) The ratio (LO+NLO)/LO for the photon production rate, with parameters appropriate for RHIC phenomenology ($\alpha_s = 0.3$, $N_f = 3$). This plot is from Ref. [2]. (Right panel) The dilepton invariant mass spectrum, obtained using a 3+1D viscous hydrodynamic model. The full lines show the effect of charm quark energy loss (top/bottom: without/with energy loss). This plot is from Ref. [4].

different hydrodynamic calculations of photon elliptic flow [5]. These, however, are at odds with current measurements by the PHENIX collaboration. The theoretical results for dilepton yields were in accord with recent measurements by the STAR collaboration (to be shown and discussed further below), and relied on vector spectral densities that were also found to be consistent with NA60 data [6]. The data there appear to be consistent with a scenario where the charm quarks lose energy during the viscous evolution, see Figure 1, right panel. All channels of energy loss will need to be considered before a final assessment is made.

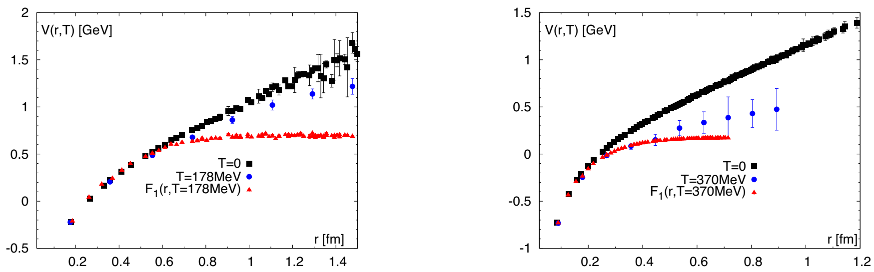

Figure 2: (Color Online) The non-perturbative finite-temperature quark-antiquark potential, show together with the $T = 0$ potential, and with the singlet free-energy, F_1. (Left panel) $T = 178$ MeV, (Right panel) $T = 370$ MeV. This plot is from Ref. [7].

In what concerns non-perturbative techniques, advances in lattice QCD calculations were reported at the meeting. One result highlights progress in the study of quarkonium suppression as a signal of the quark-gluon plasma (QGP). It addresses some of the ambiguities in extracting a static quark potential at finite temperatures, by identifying the static $Q\bar{Q}$ energy using a spectral decomposition of the temporal Wilson loop [7]. That work shows, on Figure 2, that the singlet free energy and the actual potential are only similar at high temperatures, and at that temperatures commensurate with that of the crossover transition the potential deviates only slightly from it zero temperature behavior. This step forward should impact some of the phenomenological studies presented at the meeting [8] (some of these results will be shown in sections to follow). Still in the context of the in-medium modifications of quarkonium, another lattice communication reported