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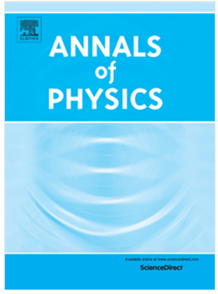

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Higher derivative corrections to the entropic force from holography

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The entropic force has been recently argued to be responsible for dissociation of heavy quarkonia. In this paper, we analyze R^2 corrections and R^4 corrections to the entropic force, respectively. It is shown that for R^2 corrections, increasing λ_{GB} (Gauss-Bonnet factor) leads to increasing the entropic force. While for R^4 corrections, increasing λ ('t Hooft coupling) leads to decreasing the entropic force. Also, we discuss how the entropic force changes with the shear viscosity to entropy density ratio, η/s, at strong coupling.

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I. INTRODUCTION

The experimental programs at LHC and RHIC have produced a new state of matter so-called "strongly coupled quark-gluon plasma (sQGP)" [1–3]. One of the main experimental signatures for sQGP formation is dissociation of quarkonia [4]. It was suggested earlier that the color screening is the main mechanism responsible for this suppression [5]. Subsequently, some authors argued that the imaginary part of the heavy quark potential may be a more important reason than screening [6–8]. Recently, it was proposed by D. E. Kharzeev [9] that the entropic force would be responsible for melting the quarkonia as well.

The entropic force is related to the increase of the entropy with the separation between the constituents of the bound state. It is an emergent force and does not describe other fundamental interactions. Based on the second law of thermodynamics, it stems from multiple interactions that drive the system toward the state with a larger entropy. The entropic force was developed in [10] to explain the elasticity of polymer strands in rubber. Subsequently, Verlinde argued [11] that it would be responsible for gravity, but this interesting idea may be controversial (see for [12]) and will not be discussed here. Recently, it was argued [9] that the entropic force can drive the dissociation process if one considers the process of deconfinement as an entropic self-destruction. This argument is based upon the Lattice results that show that there is a peak in the heavy quark entropy around the crossover region of the sQGP [13–15]. However, it should be noticed that the entropic force cannot be taken as a fundamental property of the system, but it allows us to understand the behavior of complicated microscopic systems not amenable to microscopic treatment. In this work, we will restrict ourselves to its application in dissociation of quarkonia in the sQGP.

AdS/CFT [16–18], the duality between a string theory in AdS space and a conformal field theory in the physical space-time, has yielded many important insights for studying different aspects of the sQGP. In this approach, K. Hashimoto et al have carried out the entropic force associated with a heavy quark pair for $\mathcal{N}=4$ SYM theory in their seminal work [19]. There, it is found that the peak of the entropy near the transition point is related to the nature of deconfinement and the growth of the entropy with the distance can yield the entropic force. Soon after [19], investigations of the entropic force with respect to a moving quarkonium appeared in [20]. It is shown that the velocity has the effect of increasing the entropic force thus enhancing the quarkonia dissociation. Recently, we have studied the effect of chemical potential on the entropic force and observed that the chemical potential increases the entropic force implying that the quarkonia dissociation is enhanced at finite density [21].

In general, string theory contains higher derivatives corrections due to the presence of stringy effects. Although very little is known about the forms of higher derivative corrections in string theory, given the vastness of the string landscape one may expect that generic corrections do occur [22]. As a concrete example, type IIB string theory on $AdS_5 \times S^5$ is dual to $\mathcal{N}=4$ SYM theory. Using the relation $\sqrt{\lambda}=\frac{L^2}{\alpha'}$ (L is the radius of AdS_5 and α' the reciprocal of the string tension), the $\mathcal{O}(\alpha')$ expansion in type IIB string theory becomes the $\frac{1}{\sqrt{\lambda}}$ expansion in SYM theory. The leading order corrections in $1/\lambda$ (R^4 corrections) come from stringy corrections to the type IIB tree level effective action of the form $\alpha'^3 R^4$. It was argued [23, 24] that R^4 corrections to η/s are positive, consistent with the viscosity bound [25, 26]. On the other hand, curvature squared interactions (corresponding to R^2 corrections) can be induced

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