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Effective chiral lagrangian with thermal field fluctuations and broken scale invariance

We investigate the finite-temperature equation of state (EOS) within an effective Lagrangian framework, where a dilaton field accounts for the breaking of scale symmetry in QCD. We start by extending a previous investigation in the pure gauge $SU(3)_c$ sector [1], describing the dynamics of the gluon condensate in terms of a dilaton Lagrangian. Below the critical temperature, the condensate is dominated by the dilaton field, whereas at higher temperatures, it evaporates in the form of quasi-free gluons. Additionally, for the first time, we incorporate into the calculations the lightest glueballs, i.e. J = 2, 4, 6, assuming that their masses lie on a linear Regge trajectory, as suggested in Ref. [2]. The masses of the exciteted glueballs are affected by the presence of a string tension term [3]. In this context, we explore the role of thermal fluctuations of the dilaton field using the technique proposed in Refs. [4, 5], which successfully reproduces lattice QCD results for thermodynamic quantities such as pressure and energy density [6]. Furthermore, we extend our study to an EOS that includes additional degrees of freedom, namely the σ, π, ω and ρ mesons, along with nucleons, at finite chemical potential. This is achieved through an effective Lagrangian incorporating both broken scale symmetry and explicitly broken chiral symmetry [7, 8]. Beyond the mean-field approximation, we consider the effects of thermal fluctuations of the scalar glueball, other than the contributions of the σ, π, ω and ρ meson fields, to gain insights of the thermodynamic properties of the phase transition.

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