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Extended Nambu--Jona-Lasinio Model with covariant regularization

Content :

The Nambu--Jona-Lasino Model has long been regarded as an interesting tool for the study of the low energy non-perturbative regime of QCD as it shares with it the global symmetries and contains a mechanism for the dynamical breaking of chiral symmetry. It has been shown that in the light quark sector (u, d and s) the inclusion of the 't Hooft determinantal interaction which explicitly breaks the unwanted axial symmetry introduces a ground state stability problem [1]. This problem can be solved by the addition of general non-derivative spin-zero eight quark interaction terms (one of which violates the OZI rule) [2]. The model parameters can be fitted in such a way that the low lying scalar and pseudoscalar spectra is left relatively unchanged (apart from a decrease in the sigma meson mass) throughout a wide range of values for the OZI-violating part of these 8q interactions [3]. They were however shown to have a significant impact in the position of the critical endpoint where the transition goes from crossover to first order (the CEP is moved to lower chemical potential and increasing temperature with stronger 8q interactions) [4] as well as the temperature at which the transition occurs (lowered for stronger 8q interactions) [5]. The extension of this model to include the Polyakov loop can be done straightforwardly [6] and enables the simultaneous study of chiral restoration and deconfinement (at least approximately).
As has been recently shown [5, 6], the use of a covariant regulator (with two Pauli-Villars subtractions in the integrand) results in the correct asymptotic behavior of several thermodynamic quantities when temperature goes to infinity, a feature that had been reproduced using a 3D momentum cutoff only by eliminating the cutoff in the convergent parts of the relevant integrals, while here it can be done while consistently maintaining the cutoff over all contributions for the relevant integrals. Using this procedure several undesirable features are eliminated, such as the asymptotic solution for the Polyakov loop deviation from the value dictated by the pure gluonic term that is added to the potential (the Polyakov potential) and the dynamical mass of the quark going below the current mass value.

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