Non-perturbative dynamics and charge fluctuations in effective chiral models*

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Lattice QCD (LQCD) results show that at finite temperatures, QCD exhibits restoration of chiral symmetry and deconfinement in a crossover transition. The LQCD equation of state indicates a clear separation between the confined hadronic phase and the deconfined quark–gluon plasma. The transition between the phases is accompanied by characteristic fluctuations of conserved charges [1].

At vanishing chemical potential the fourth order cumulants of both the net baryon number and the electric charge show peaked structures, while the sixth order cumulants are negative in a narrow temperature interval close to the transition region. These properties of the fluctuations for small masses of the up– and down–quarks can be attributed to the critical dynamics of the explicitly broken chiral symmetry, which is characterized by the O(4) universality class of two-flavor QCD [2].

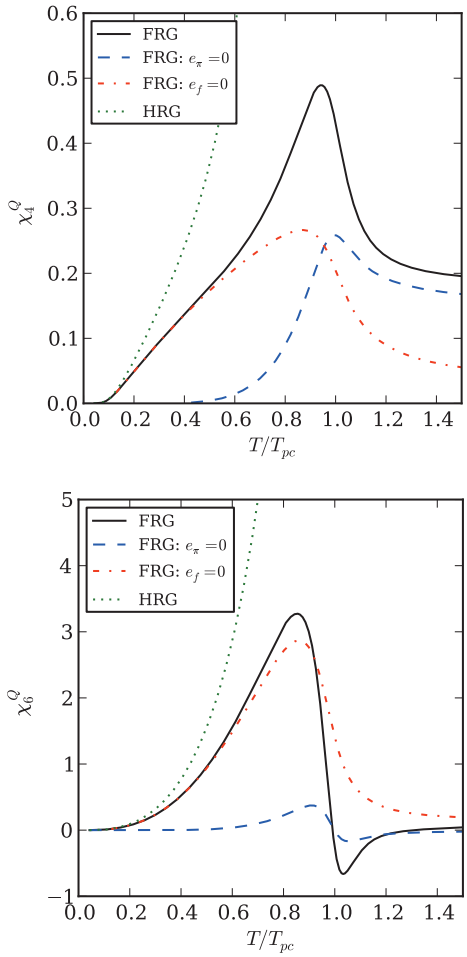
The critical behavior of strongly interacting matter related with chiral dynamics should be common to all models which reproduce the underlying chiral symmetry of QCD and the pattern of spontaneous chiral symmetry breaking at finite temperature. In this work we explore the characteristic behavior of fluctuations of the electric charge near the chiral transition at vanishing chemical potential within the functional renormalization group (FRG) approach to the linear sigma and Polyakov-loop extended quark (PQM) models.

The fluctuations of the electric charge are characterized by the generalized susceptibilities,

$$\chi_n^Q(T) = \frac{\partial^n [p\,(T,\mu_Q)/T^4]}{\partial(\mu_Q/T)^n}. \qquad (1)$$

The charge fluctuations reflect the critical behavior of the fluctuations of the net baryon density. However, in contrast to the net baryon number, an important contribution to fluctuations of the electric charge is due to pions.

In the region of the crossover transition, the fluctuations of the electric charge should reflect the critical scaling of the underlying O(4) symmetry. A scaling analysis shows that at vanishing baryon chemical potential, the second and fourth order cumulants remain finite, while for $n \geq 6$ the cumulants χ_n^Q diverge at the O(4) transition [3]. It is expected that this critical behavior is reflected in the cumulants at the crossover transition for small explicit symmetry breaking, corresponding to the QCD transition at physical values of the light quark masses.



The figures show the cumulants (top $n = 4$, bottom $n = 6$) of the electric charge fluctuations in the Polyakov loop extended quark-meson model calculated within the functional renormalisation group approach (solid lines). The results are also shown for only charged quarks $e_\pi = 0$ and only charged pions $e_f = 0$. The hadron resonance gas contributions are shown by the dotted lines. We note that the χ_6^Q is negative close to the transition temperature, and thus reflects the characteristic critical behavior of the net baryon density in the O(4) universality class.

References

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