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A parameter-free analysis of the QCD chiral phase transition and its universal critical behavior.

One of the outstanding questions in studies of the QCD phase diagram is to determine the order of the QCD phase transition and, in case it turns out to be second order, determine the underlying universality class that controls its universal critical behavior in the vicinity of chiral phase transition temperature T_c . Previous works estimate this T_c by extrapolating pseudo-critical temperatures obtained at non-zero values of the light quark masses from maxima in the chiral susceptibilities or the inflection point of the relevant, suitably renormalized, order parameter i.e. the 2-flavor light-quark chiral condensate M_l.
In order to extrapolate the thus obtained pseudo-critical temperatures to the chiral limit one however, generally makes use of information and properties of the associated universality class in the form of critical exponents and scaling functions.
In this work we aim to study as a function of T, the behavior of an improved, renormalized 2-flavor light chiral condensate M which is obtained as $M = M_l - H\chi_l$, with the light quark chiral susceptibility χ_l and the light-to-strange quark mass ratio $H = m_l/m_s$. Aside from having no additive and multiplicative divergences as well as no $\mathcal{O}(H)$ regular terms, the thus defined order parameter has the advantage that its behavior at small values of the quark masses is related to a universal scaling function. This allows to extract information on the underlying universality class.
We construct the ratio of M for two different values m_l (or H). Within the scaling region around T_c , we observe a unique intersection point for this ratio for different values of smaller-than-physical m_l. This common point of intersection provides a determination of T_c and the critical exponent δ without the need of referring to a particular universality class.
This approach followed here will allow to constrain the influence of the axial anomaly on universal critical behavior in (2+1)-flavor QCD and will also help to further constrain the quark mass region in which a first order phase transition in 3-flavor QCD may arise. This will require careful extrapolations to the continuum limit. At present in this new work, we attempt to demonstrate the suitability of this approach in the framework of (2+1)-flavor QCD on lattices with fixed temporal extent $N_t = 8$.

Field of contribution

Theory

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