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Chiral phase transition of (2+1)-flavor QCD

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Understanding the properties of strong interaction matter with its physical spectrum of light and strange quarks near the pseudo-critical temperature of (2+1)-flavor QCD is one of the central goals of high energy nuclear physics. It generally is expected that the analytic crossover transition in QCD is sensitive to properties of the true chiral PHASE transition at vanishing quark masses [1,2]. This sensitivity is increased in higher order cumulants of net charge fluctuations which currently are being measured by STAR and PHENIX at RHIC and by ALICE at the LHC.
In order to connect these experimental findings to predictions arising from QCD in the chiral limit it is mandatory to establish the properties of QCD in this limit. While there are many indications that the chiral PHASE transition is a second order transition in the universality class of O(4) sigma models [3], this is by no means established in lattice QCD calculations as in none of these cases continuum extrapolated results exist [4].
In this talk we will present the status of our calculations for (2+1)-flavor QCD with the Highly Improved Staggered Quarks (HISQ) on three different lattice sizes ($N_\tau = 6, 8, 12$) and with 5 values of light quark masses that are up to a factor 6 smaller than in nature. This allows us to systematically control the chiral and continuum limit of QCD. We show that our results are consistent with O(N) scaling in the chiral limit, supporting the existence of a second order phase transition. We will also present first continuum extrapolated results for the PHASE transition temperature in the chiral limit and discuss the relevance of corrections to scaling that need to be controlled when extrapolating to QCD with its physical quark mass spectrum.

[1] A. Bazavov et al., PRD 85 (2012) 054503
[2] A. Bazavov et al., PRD95 (2017) 074505
[3] S.-T. Li and H.-T. Ding, PoS LATTICE2016 (2017) 372
[4] H.-T. Ding, F. Karsch, and S. Mukherjee, IJMPE24 (2015) 1530007

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