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

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The chiral phase transition temperature T_c is a fundamental quantity of QCD. To determine this quantity, we have performed simulations of (2 + 1)-flavor QCD using the Highly Improved Staggered Quarks (HISQ) action on $N_\tau = 6, 8, 12$ lattices and aspect ratios N_σ/N_τ ranging from 4 to 7.
In our simulations, we fix the strange quark mass value to its physical value $m_s^{\rm phy}$, and the values of two degenerate light quark masses m_l are varied from $m_s^{\rm phy}/160$ to $m_s^{\rm phy}/20$ which correspond to a Goldstone pion mass m_π ranging from 55 MeV to 160 MeV in the continuum limit.
By investigating the light quark mass dependence and volume dependence of various chiral observables, e.g. chiral susceptibilities and Binder cumulants, we didn't find any evidence for a first order phase transition in our current quark mass window.
By looking at the crossing point of $\chi_\sigma/\chi_\pi = m_l\chi_{tot}/\left\langle\bar{\psi}\psi\right\rangle_l$ which is the ratio of light quark mass times chiral susceptibilities and chiral condensates as a function of T and m_l, we are able to extract the value of T_c in the chiral & continuum limit without referring to critical exponents of a particular universality class. The uncertainty in the determination of T_c is also discussed.

Primary author: Mr LI, Sheng-Tai (Central China Normal University)

Co-authors: Dr LAHIRI, Anirban (Bielefeld University); Prof. KARSCH, Frithjof (Brookhaven National Laboratory); Prof. DING, Heng-Tong (Central China Normal University); Prof. KACZMAREK, Olaf (Bielefeld University); Prof. PETRECZKY, Peter (BNL); Dr HEGDE, Prasad (Indian Institute of Science, INDIA)

Presenter: Mr LI, Sheng-Tai (Central China Normal University)

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