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The QCD chiral phase transition for various numbers of flavors at imaginary baryon chemical potential

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In order to constrain the QCD phase diagram with physical quark masses, the QCD chiral phase transition in the massless limit is investigated, although this is a challenging problem for lattice QCD. In 1984, Pisarski and Wilczek predicted a first-order transition for $N_\mathrm{f} \geq 3$, based on RG investigations of a linear sigma model in three dimensions, which was supported by lattice QCD simulations on coarse lattices. However, recent lattice QCD results from our group provide strong evidence for a second order chiral phase transition for $N_\mathrm{f} = 2 - 6$ massless quark flavors. It was demonstrated that the first-order chiral transitions, observed on coarse lattices, terminate at a tricritical lattice spacing, and are thus not connected to the continuum chiral limit. As a consequence, the chiral transition in the continuum is of second order, as it is always approached from a crossover region. Adopting the same strategy, we investigate the nature of the chiral phase transition as a function of the number of quark flavors and the lattice spacing for a fixed imaginary baryon chemical potential. We find that first-order transitions, observed on coarse lattices, disappear towards the continuum limit, which coincides with the situation at zero density.

Authors: D'AMBROSIO, Alfredo; KAISER, Reinhold; PHILIPSEN, Owe

Presenter: KAISER, Reinhold

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