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Applicability of the complex Langevin method to QCD at finite density

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The complex Langevin method (CLM) is a promising approach to overcome the sign problem. Here we examine its applicability to QCD at finite density on a $24^3 \times 12$ lattice with four-flavor staggered fermions around the deconfinement phase transition line in the $(T - \mu)$-plane. While the CLM actually works at quite large values of μ, it fails in the confined phase, which appears at lower μ. This is due to the singular drift problem as one can understand through the generalized version of the Banks-Casher relation, which relates the Dirac zero modes to the chiral condensate. This problem was avoided in our previous work in the confined phase because of the chosen small spatial volume.

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