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## First-order phase transitions in the heavy quark region of lattice QCD at high temperatures and high densities

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If there is a first-order phase transition in the light quark region of 2+1 flavor finite temperature and density QCD and if the region of the first-order phase transition expands with increasing density as suggested by several lattice studies, then, at very high densities, we may expect that the first-order phase transition region expands into the heavy quark region of QCD, where we can perform efficient large scale simulations by adopting an effective theory of heavy quark QCD based on the hopping parameter expansion.

In the heavy quark region of QCD, we have another first-order phase transition region around the heavy quark limit at zero density. By numerical simulations of effective heavy quark QCD, we found that, the first-order transition at zero density turns into a crossover as the chemical potential is increased, but, when we increase the chemical potential further, the change in the plaquette value near the crossover point becomes much steeper. This may be suggesting reappearance of the first-order phase transition.

In this talk, we first show the nature of the phase transition of phase-quenched finite-density QCD in the heavy quark region, and then study the effect of the complex phase to discuss whether the QCD phase transition changes again to a first-order phase transition at very high densities.

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