論文の内容の要旨

論文題目: Random matrix model for dense QCD and complex Langevin dynamics

(有限密度ランダム行列模型と複素ランジュバンシミュレーション)

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We study chiral random matrix (ChRM) models for dense QCD.

We first study the phase diagram of a chiral random matrix model with three quark flavors at finite temperature and chemical potential, taking the chiral and diquark condensates as independent order parameters. Fixing the ratio of the coupling strengths in the quark-antiquark and quark-quark channels applying the Fierz transformation, we find that the color-flavor locked (CFL) phase is realized at large chemical potential, while the ordinary chirally-broken phase appears in the region with small chemical potential. We investigate responses of the phases by changing small quark masses in the cases with three equal-mass flavors and with 2+1 flavors. In the case with three equal-mass flavors, we find that the finite masses make the CFL phase transition line move to the higher density region. In the case with 2+1 flavors, we find the two-flavor color superconducting phase at the medium density region as a result of the finite asymmetry between the flavors, as well as the CFL phase at higher density region.

Next, we examine the complex Langevin simulation method using a ChRM model, by comparing the exact and numerical solutions. We can obtain the static solution without instability. However, typically around the phase transition, the obtained solution is wrong compared to the exact solution. As a challenge to understand the failure, we observe the determinant of the Dirac operator and find that the distribution on the complex plane in the process might be a clue for the correctness of the complex Langevin simulation.