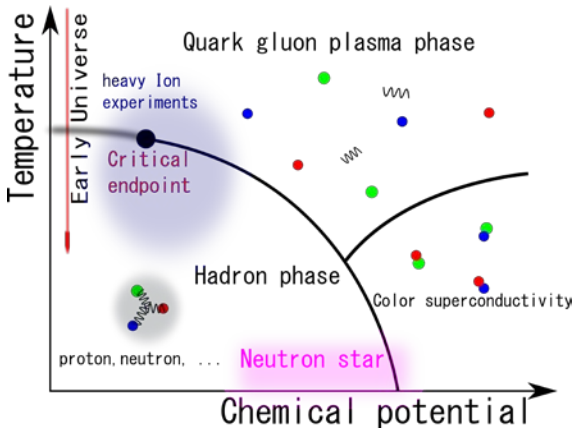
QCD phase diagram at zero and small chemical potential

Yoshifumi Nakamura
Application Development Team, Field Theory Research Team, RIKEN Advanced Institute for Computational Science

In current understanding, it is believed that the Universe is created by micro scale physics after Big Bang. Quantum chromodynamics (QCD) predicts existence of quark gluon plasma (QGP) phase in high temperature such as early Universe and hadron phase in low temperature as current Universe. It is expected that QCD has a rich phase structure as a function of temperature and chemical potential. To understand phase structure, first principle calculations by using Lattice QCD simulations are required so that its clarification is difficult only by experiments.



Right figure is a predicted phase diagram of QCD in temperature and chemical potential plane calculated by using effective models. The most characteristic feature is that a phase transition line running from low temperature and high chemical potential to high temperature and low chemical potential disappears at the critical endpoint and transition becomes crossover. Locating the critical endpoint is one of the important milestones in finite temperature and density QCD research.

In this presentation, I introduce recent our studies for finite temperature phase transition of QCD, especially for the Columbia phase diagram plot and phase transition at low density. As a final goal, our study is aiming for the precision measurement of the critical endpoint in temperature and chemical potential plane. It has not been determined precisely yet and is very important for understanding the early universe and heavy ion experiments. The Columbia phase diagram is the phase diagram of the finite temperature phase transition at zero chemical potential for 2+1 flavor QCD in up-down quark mass and strange quark mass plane. It is quite useful to determine the critical end line in the Columbia phase diagram plot to determine the critical end point of QCD in temperature and chemical potential plane.