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Hiroaki Kohyama

Study results

[1] Quantum field theories in nonextensive Tsallis statistics

Quantum choromodynamics (QCD) is believed to be the fundamental theory of quarks and gluons and its ultimate goal is to describe the strongly interacting phenomena at all energies, high and low. QCD is an asymptotic free theory and the interaction between quarks and gluons becomes small at high energy. When the interaction is small, quarks and gluons are expected to behave as free particles, and this system is called quark-gluon plasma (QGP). It is pointed out by early studies that the interaction in QGP may be of long range. In such systems, the conventional finite temperature QCD is not applicable, and we need the theory which can describe the physics of QGP with long range interaction.

In the paper "Quantum Field Theories in Nonexensive...", we applied the nonextensive Tsallis statistics to thermal field theory and calculated the fundamental quantities of field theory: partition function, propagator and thermal masses. This theory can be applied to the systems of QGP with long range interaction. Through performing the required calculation, we have found that the initial correlations appear in the nonextensive case, which were not seen in the usual extensive systems.

[2] Thermal operator representation of finite temperature field theory

Study of quark matters at finite temperature and density is carried out through using finite temperature field theory. However the difficulties arise when we actually evaluate the physical quantities by applying finite temperature field theory to some systems. Required calculations are usually complicated, then the theoretical predictions of thermal system is a challenge to the theorists.

We have completed the thermal operator representation of finite temperature field theory which should be applied to the systems at finite temperature and density. It is expected that this representation simplifies the required calculation for thermal systems.

[3] Phase diagram of $q\bar{q}$ and qq in the 3-dimensional Gross Neveu model

QCD phase structure has stirred great interest to the theorists. In the QCD phase diagram, hadronic phase appears at low temperature and density, and QGP phase is realized at sufficiently high temperature and density. In1970's, these states were believed to be the important phases in the QCD phase diagram. However in 1975, the possibility of the new phase "color superconductivity" was pointed out and this is now believed as an important state of quark matter.

The above mentioned aspect of the QCD phase diagram was successfully described by the Nambu Jona-Lasinio (NJL) model which is a low energy effective field theory of QCD. In the paper "Phase diagram of quark-antiquark...", I have focused on the Gross Neveu model, the counterpart of the NJL model in lower dimensions (D), and study the phase structure of the model. The obtained phase diagram shows the following phases: (I)The quark-antiquark ($q\bar{q}$) phase at low temperature (T) and chemical potential (μ), (II)The diquark (qq) phase at low T and high μ, (III)Normal phase at high T and μ. Thus the phase diagram of the 3D Gross Neveu model bears close resemblance to that of 4D NJL model. The important qualitative difference between the 3D Gross Neveu model and 4D NJL model is that there does not appear the $q\bar{q}$ and qq double broken phase in the 3D Gross Neveu model.