論文の内容の要旨

論文題目 : Transport properties of quark-gluon plasma
（クォーク・グルーオン・プラズマの輸送的性質）

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Abstract

Quark-gluon plasma (QGP) is a novel state of matter expected to be realized at ultra-high temperature because of the asymptotic freedom of QCD. In QGP, quarks and gluons are liberated from hadrons and behave as dynamical degrees of freedom. Experimentally, QGP has been and is being produced by the relativistic heavy-ion collisions at the Relativistic Heavy Ion Collider (RHIC) and at the Large Hadron Collider (LHC). Studies on the QGP created in heavy-ion collisions in this decade have revealed its unexpected nature, in particular, its exotic transport property. The most famous and remarkable discovery at RHIC is that the QGP behaves almost as a perfect fluid. Perfect fluidity indicates a strongly interacting nature of the QGP. This discovery was made by the success of the hydrodynamic description of the heavy-ion collision events.

In this thesis, we study transport properties of the QGP by using rare signals, such as heavy quarks and electromagnetic radiations, in heavy-ion collisions. These signals probe transport properties of the QGP. Heavy quarks probe the drag force acting on them caused by the light constituents of the QGP. We describe the dynamics of heavy quarks under the influence of dynamically expanding QGP by means of relativistic Langevin equation combined with a solution of relativistic hydrodynamics that describes heavy-ion collisions. We parameterize the drag force and extract its strength by fitting the single electron spectra with our model calculation. From the fit, we obtain a much stronger drag force than that predicted by weak coupling QCD calculation.

Electromagnetic radiation, in particular dilepton radiation, probes the spectral function of the hot QCD medium. Conventionally, the spectral function at finite temperature is expected to be governed by the in-medium property of vector mesons. However, we show that the spectral functions that simulate standard scenarios proposed so far cannot explain the experimental data of dielectron spectra. We examine a novel possibility that a certain transport property of the plasma dominates the spectral function in the low-frequency and long-wavelength region. We parameterize the spectral function with two transport coefficients: the electric charge diffusion coefficient and the relaxation time for the diffusive electric current. By detailed comparison with the dielectron spectra, we find that a transport theoretical approach to the spectral function is a promising ingredient, although we have not yet reached conclusive understanding of the experimental data.

These studies on the heavy quark drag force and the spectral function for dilepton radiation at RHIC will provide important information on the properties of the QGP at LHC in the near future.