論文内容の要旨

論文題目: Production of Direct Photons and Neutral Pions in Relativistic Au+Au Collisions

(相対論的金+金衝突における直接光子と中性パイ中間子の生成)

氏名: 磯部 忠昭

In modern particle physics, a standard model to describe the dynamics of elementary particles, quarks, leptons and gauge bosons, has been developed. Quantum ChromoDynamics (QCD) is known as the theory to describe behaviors of strong interaction among quarks and gluons. There are two kinds of important features in the QCD: "color confinement" and "asymptotic freedom". Ordinarily quarks and gluons, which have a degree of freedom of color, are confined in hadrons as a color-singlet state. On the other hand, the strong coupling constant (α_s) decreases at a large momentum transfer in high energy reaction, or in the environment of extremely high temperature or density. Thus, as the temperature or density of many-body system of hadrons are increased, a normal nuclear state is expected to transit into a new state of matter where quarks and gluons become color de-confined. The new state of matter is called "Quark Gluon Plasma" (QGP).

Such an extreme state of matter is expected to be formed in ultra-relativistic heavy ion collisions. Many heavy ion experiments have been carried out to find the signature of the state for a long time. Recently, Au+Au collisions whose center of mass energy per nucleon ($\sqrt{s_{\rm NN}}$) is 200 GeV have been performed at Relativistic Heavy Ion Collider (RHIC) in Brookhaven National Laboratory (BNL), USA. In this thesis, the measurements of neutral pions and direct photons in the relativistic Au+Au collisions using RHIC-PHENIX spectrometer are reported. Neutral pions and direct photons are measured up to high transverse momentum ($p_{\rm T}$) of 20 GeV/c at mid-rapidity. From the comparison with the p+p data measured at the same experiment, the nuclear modifications on the neutral pion and direct photon production in Au+Au collisions are studied.

In the most central collisions, the suppression of neutral pion production at high-$p_{\rm T}$ has been observed, compared to the yield in p+p collision at same $\sqrt{s}$ scaled by the number

of underlying nucleon-nucleon collisions in Au+Au. The suppression is very strong by a factor of ~ 5, and is almost constant from $p_{\mathrm{T}} \sim 1$ GeV/c up to $p_{\mathrm{T}} \sim 20$ GeV/c. In contrast, the direct photon yields in Au+Au collisions are in good agreement with the scaled p+p data.

Since most of high-p_{T} direct photons originate from initial hard-scattering processes and do not interact with the matter strongly, the agreement between measurement and the scaled p+p data of the direct photon yield suggests the initial hard-scattering probability is not reduced in the Au+Au collisions. It supports that point-like scaling, and binary scaling of high-p_{T} hadron production relative to p+p collisions is well represented by the Monte Carlo calculation which employs Glauber model. Therefore, the strong suppression of neutral pion production can be understood as due to the interaction of hard scattered partons in the created dense matter.

The suppression is interpreted as the consequence of parton energy loss through gluon bremsstrahlung in the created dense matter. Based on the comparison of neutral pion suppression pattern with a theoretical calculation by I. Vitev who employs GLV energy loss formalism, the effective gluon density ($\mathrm{dN}^{g}_{eff}/\mathrm{dy}$) of the dense matter produced in $\sqrt{s_{\mathrm{NN}}} = 200$ GeV Au+Au collisions are estimated quantitatively to be about 1300^{+300}_{-100}. On the assumption of the formation of gluon dominated plasma with the formation time of 0.6 fm, it corresponds to the energy density of 18 GeV/fm^3.