論文の内容の要旨

論文題目: Search for Supersymmetric Partners of Gluons in Proton-Proton Collisions at $\sqrt{s} = 13$ TeV
(重心系 13 TeV の陽子-陽子衝突を用いたグルーオンの超対称性粒子の探索)

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Supersymmetry (SUSY) is one of the most promising theories which could explain physics beyond the standard model (SM). SUSY is the theory which introduces a transformation between a fermion and a boson. This could solve the grand unification, hierarchy problem, and the existence of dark matter. SUSY theory predicts supersymmetric partners (superpartners) of the SM particles. The minimal extension of the SM with SUSY is called Minimal Supersymmetric Standard Model (MSSM). If supersymmetry is not broken, the superpartners of the SM particles have the same mass. However, such SUSY particles are not observed. Therefore, a SUSY breaking is needed to explain the experimental fact. One of the idea is that SUSY breaks spontaneously. However, there is no theoretical mechanism to break SUSY spontaneously within MSSM. With any term which could break SUSY spontaneously, one of the SUSY particles with mass lighter than the SM particles is predicted after the SUSY breaking, and such particles are not observed. Therefore, SUSY breaking term should be added explicitly. Such terms are added as "hidden sector". It is assumed that the SUSY breaks in this hidden sector. The interaction between particles of MSSM and hidden sector is mediated only by "messenger interaction". There are some models of mechanisms with different "messenger interactions", and each model predicts different mass spectrum of SUSY particles. In some of the representative theory, the superpartner of gluon (gluino) is heavier than the superpartner of electroweak gauge bosons (electroweakinos). According to phenomenological expectations, SUSY partners of quarks (squarks) are likely to have large masses ($\sim$O(10) TeV) which provide large radiative corrections to make the Higgs boson as heavy as 125 GeV. On the other hand, it is expected that SUSY partneres of gluons (gluinos) are possibly light because there is no theoretical constraint for the gluino mass.

The Large Hadron Collider (LHC) provides proton-proton collisions at the world's highest energies, where production of coloured SUSY particles is highly expected. The $R-$parity conserved Minimal Supersymmetric Standard Model (MSSM) is phenomenologically motivated. Under $R-$parity conservation, SUSY particles are pair produced from the collision of SM particles and the lightest SUSY particle (LSP) is stable. This LSP could be a candidate of dark matter. Because sfermion masses are assumed to be large, gluino pair-production in the proton-proton collision at the LHC is highly expected. Each gluino decays into two quarks and a SUSY partner of electroweak gauge boson (electroweakino). The electroweakino decays to lighter SUSY particles until the LSP is finally produced. Since light gluinos with masses up to ~ 1.3 TeV were already excluded by the previous SUSY searches at the LHC, a focus is now on heavier gluinos whose production may be characterized by non-planar multi-jet with large missing transverse energy (E_T^{miss}).

In this thesis, gluino pair-production is searched for using events with large E_T^{miss}, jets, and no lepton in the final states of the proton-proton collisions recorded by the ATLAS detector at $\sqrt{s}$= 13 TeV in 2015. The total amount of data used correspond to an integrated luminosity of 3.2 fb^{-1}.

To optimize the event selection for non-planar multi-jet events, a variable "aplanarity" is newly introduced, which results in better signal selection efficiencies over the previous searches. Four different event selections are prepared to cover a large region of gluino mass and event kinematics.

To estimate the number of SM background (BG) events after the event selection, a new method has been developed which does not rely on Monte Carlo (MC) simulations as much as possible. The main SM background events in the SR is Z boson($\rightarrow \nu\nu$)+jets process. The idea to estimate this background events is to use γ+jets events since both processes are very similar except for the difference of masses. With high boson p_T requirement, the difference of Z and γ masses are negligible and the residual difference is the acceptance and the cross section. In this thesis, the difference is normalized using $W(\rightarrow \ell\nu)$+jets events and $Z(\rightarrow \ell\ell)$+jets events. First, a scale factor (SF) from γ+jets events to $W(\rightarrow \ell\nu)$+jets events are acquired in high boson p_T regions. Secondly, a SF from $W(\rightarrow \ell\nu)$ events to $Z(\rightarrow \ell\ell)$+jets events are acquired in low boson p_T regions. $Z(\rightarrow \ell\ell)$+jets in high p_T regions cannot be used since the number of events are very small. With these SFs, the γ+jets events are normalized to $Z(\rightarrow \ell\ell)$+jets events. Finally, the normalization factor from $Z(\rightarrow \ell\ell)$+jets events to $Z(\rightarrow \nu\nu)$+jets events from Monte Carlo (MC) simulation is applied and the number of events of $Z(\rightarrow \nu\nu)$+jets could be estimated. The regions to get each pure process are called control regions (CRs).

This method is carefully validated with data outside the signal regions. The number of events estimated with the method and that of observed data show good agreement. This means the new BG estimation method is evaluated to be effective.

When γ+jets events are used, the purity of γ+jets events is very important. The purity of γ is estimated in this thesis. The estimated purity is high enough and the contaminating events are found to be negligible.

No significant excess is observed after the event selections. This result is interpreted using simplified models of gluino decays, where gluinos are pair-produced and decay in a way to preserve $R-$parity. For massless LSPs, gluinos with masses up to $\sim$ 1530 GeV are excluded with 95% confidence level. This represents the most stringent constraint on SUSY models to date.