論文の内容の要旨

Search for a heavy scalar resonance decaying into a pair of photon-jets in pp collisions at $\sqrt{s}$ = 13 TeV
（重心系エネルギー13 TeVの陽子陽子衝突における
光子ジェット対に崩壊する重いスカラー粒子の探索）

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The Standard Model of particle physics is well established, but several unsolved problems remain, such as the hierarchy problem and the strong CP problem. They suggest the existence of physics beyond the Standard Model, but hints of new physics are not yet observed by past researches. At the energy-frontier pp collision experiments at the LHC, it is all the more important to search for new physics in a completely new final state. This thesis describes such a search in a novel final state called a "photon-jet" using pp collisions at $\sqrt{s}$ = 13 TeV. A photon-jet is a group of collimated photons that share close trajectories. Photon-jets can arise from a boson with a mass of $O(100)$ GeV decaying into lighter bosons with a mass of $O(1)$ GeV, that consecutively decays into photons. In such a case, the lighter boson is boosted, leading to collimated photons. The existence of photon-jets is well motivated by several beyond-the-Standard-Model scenarios that predict two or more new bosons, including the supersymmetry and the Peccei-Quinn mechanism. This research aims to look into a parameter space which conventional searches had limited sensitivity to, by employing an optimized event selection strategy based on shower shapes observed in the electromagnetic calorimeter.

The result of a search for a new heavy scalar resonance decaying into a pair of photon-jets using pp collisions at $\sqrt{s}$ = 13 TeV is presented. The dataset was collected with the ATLAS detector in 2015 and 2016, corresponding to an integrated luminosity of 36.7 fb^{-1}. Candidate events of a resonance decaying into a pair of photon-jets are selected from events with two high-momentum reconstructed photons, where each reconstructed photon corresponds to a photon-jet in the case of signal events. This search is performed in a largely model-independent way, so that the search is sensitive to beyond-the-Standard-Model scenarios leading to a pair of photon-jets in general. No significant excess of events from the Standard Model expectation is observed.

The result of a null observation is interpreted in the context of beyond-the-Standard-Model scenarios which assume a scalar resonance decaying into a final state with photons. One scenario assumes a scalar resonance X with a mass of $O(100)$ GeV, with a narrow width, and produced by the gluon–gluon fusion process; X decays into a pair of spin-0 particles a with a mass of $O(1)$ GeV that decays into a pair of photons, via $X \rightarrow aa \rightarrow 4\gamma$. Another scenario assumes the decay of the a particle into three neutral pions, via $X \rightarrow aa \rightarrow 6\pi^0 \rightarrow 12\gamma$. Upper limits on the product of the production cross section and the branching ratios are evaluated for the region 200 GeV $< m_X <$ 2 TeV and $m_a < 0.01 \times m_X$ using an asymptotic approximation. They are found to be as low as 0.2 fb for $m_X = 2$ TeV. Some scenarios predict photon-jets produced from a decay of a long-lived boson; the results are interpreted for such a case as well. The results are interpreted in the context of the Next-to-Minimal Supersymmetric Standard Model for the process $H \rightarrow aa \rightarrow 4\gamma$, where H is a new scalar Higgs boson with a mass larger than 200 GeV, and a is a pseudoscalar Higgs boson with a mass of $O(1)$ GeV.

This thesis presents the first result of a search for a heavy ($>$ 200 GeV) resonance decaying into photon-jets. The important feature of this research is the optimization of the search strategy utilizing the shower shape observed in the electromagnetic calorimeter. This research is a new frontier of direct searches using a novel final state. This result places constraints on the subset of the parameter space of the Next-to-Minimal Supersymmetric Standard Model that has not been looked into before.