論文の内容の要旨

論文題目　Phenomenology of
Bino-Higgsino Resonant Dark Matter

(Bino-Higgsino共鳴暗黒物質の現象論)

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The standard model (SM) is a well-established model which can explain many experimental results in the particle physics. In addition, the Higgs boson was discovered at the LHC. Although all particles have been found in the SM, there are still many problems and mysteries about the SM. Supersymmetric (SUSY) model is one of the promising candidates for the new physics models beyond the SM which can solve the hierarchy problem and contains the candidate for the dark matter (DM).

SUSY model contains the SUSY scalar partners of the SM particles (SUSY particles). Although the LHC has been searched these SUSY particles, there is no sign of new particles yet. These results set the constraints on the masses of the SUSY particles. In addition, the masses of the stops are required to be heavier than $\mathcal{O}$(1–10) TeV to explain the Higgs boson mass 125GeV in the minimal SUSY extension of the SM. From these facts, the heavy sfermion scenarios, or the SUSY scenarios in which the scalar partners of the SM fermions (sfermions) are heavy $>$ $\mathcal{O}$(1–10) TeV, have attracted attentions. In these scenarios, not only the Higgs boson mass can be explained but also the constraints from the LHC can be evaded. In addition, the constraints from the flavor changing neutral current (FCNC) problem are also relaxed.

Although the heavy sfermion scenario is one of the attractive SUSY scenarios, the sfermions are heavy and it is difficult to search them directly by the experiments. Thus, the studies about the neutralinos/charginos, especially the DM, become necessary. In the heavy sfermion scenario,

the neutralino lightest SUSY particle (LSP) can be the candidate for the DM only in the limited cases. The Bino-Higgsino resonant DM model is one of the attractive models. In this model, the DM candidate is the Bino LSP which mixes with the Higgsino slightly. When the mass of the LSP is half of the Higgs boson mass or the Z boson mass, the current relic abundance can be explained with the resonant annihilation. This model contains the $\mathcal{O}(10)$ GeV DM (Bino LSP) and the $\mathcal{O}(100)$ GeV neutralinos and chargino (Higgsinos). These relatively light neutarlinos/chargino are the special property of the Bino-Higgsino resonant DM model. It makes the phenomenology rich in many experiments even though all the sfermions are heavy. Studying such phenomenology is important not only theoretically but also experimentally since the combining the results of various experiments is shown to be important to reveal this SUSY scenario.

In this thesis, we investigate the phenomenology of the Bino-Higgsino resonant DM model comprehensively. We consider the case that the gluino and the Winos are heavier than a few TeV. This is because the Wino with the mass $\gtrsim$ 500–700 GeV and the gluino do not affect the DM phenomenology. In addition, since the existence of $\mathcal{O}(100)$ GeV gluino and Winos enlarges the covered region of the constraints and the future prospects of the LHC SUSY searches, to evade the constraints and to give the conservative future prospects, we assume they do not contribute to the LHC SUSY searches. Thus, we do not consider their effects. Then, the phenomenology of this model is determined only by three parameters, the Bino mass M_1, the Higgsino mass μ and $\tan\beta$. We investigate the current constraints and the future prospects comprehensively for essentially all the parameter space. We include the following phenomena: the relic abundance, the direct detection for the SI scattering, the direct detection for the SD scattering, the Higgs boson invisible decay, the Z boson invisible decay, the mono-photon/jet processes at the collider, the heavy neutralinos/charginos productions at the LHC and the indirect detections.

As a result, it is shown that there is still a large viable parameter space and almost all the parameter space will be covered complementarily by the direct detection experiments, the Higgs invisible decay searches and the LHC searches. It is interesting that, depending on the parameters, different combinations of positive and negative signals from different experiments may appear. Especially, the blind spot where the DM-Higgs coupling vanishes is rich in the phenomenology. In this thesis, it is shown that the current constraints come from all of the SI scattering, the SD scattering and the invisible decay. The combination of these experiments is important not only for the current constraints but also for the future prospects. The experiment which can probe the given parameter point depends on its parameter. The direct detection for the SI scattering can probe the large region except the tip of the Higgs resonant region and the blind spot. The direct detection for the SD scattering is sensitive to the lighter Higgsino region $|\mu| < 300$ GeV even in the blind spot. The Higgs invisible decay can cover the Z resonant region except the blind spot. The 14 TeV LHC searches can reveal almost all region for $200 < |\mu| < 800$ GeV. Thus, exploring these experiments is important to investigate this model.

In this thesis, we investigate the phenomenology of the Bino-Higgsino resonant DM model. It is shown that the comprehensive analyses is necessary. The combination of the future experiments can reveal the Bino-Higgsino resonant DM model.