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学 位 論 文 要 旨
Dissertation Summary

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論　文　名: THE EVOLUTION OF GALAXIES AND THE LARGE-SCALE STRUCTURE IN THE EARLY UNIVERSE TRACED BY DAMPED LY α ABSORPTION SYSTEMS

(和　　文) 減衰ライマンアルファ吸収線系から探る銀河と宇宙大規模構造の初期宇宙における進化

The formation and evolution of galaxies are important topics in the modern astrophysics. Especially, the process that cold gas is converted to stars in galaxies is important to understand the complete picture of the galaxy evolution. For this purpose, we focus on strong Lya absorbers ($\log N_{\rm HI}$>20.3 cm^{-2}) such as damped Ly α absorption systems (DLAs). The DLA is a key population to understand the early phase of the galaxy evolution in the following respects: (1) DLAs provide a powerful tool to investigate the nature of the cold gas at high-z since they trace the intervening gas along the sightline to quasars and can be detected as a strong Ly α absorption line on quasar spectra regardless of the luminosity of their stellar component, and (2) DLAs dominate the neutral-gas content in a wide redshift range and they are thought to be gas reservoirs for the star-formation in the high-z Universe. Although the DLA is such an important population, their nature is still under the debate. This is because galaxy counterparts of DLAs are difficult to observe due to their faintness. To date only 13 galaxy counterparts of DLAs at z>2 have been spectroscopically identified. Even at z<1, the identified DLA counterparts are less than 100. Therefore the statistical study to investigate the nature of DLAs is incomplete, and accordingly the relationship between DLAs and galaxies is still unclear. The identifications of DLA counterparts are gradually progressing thanks to recent observations using 8–10 m class telescopes, such as the Subaru telescope. In this dissertation, we report the study for the relationship between DLAs and young galaxies to understand the early phase of the galaxy evolution. Furthermore, to identify galaxy counterparts of high-z DLAs through wide-field optical imaging surveys, we study the selection method of galaxies around DLAs.

To investigate the physical relationship between DLAs and young star-forming galaxies at high redshift such as Ly α emitters (LAEs), we focus on the region where multiple DLAs distribute within a narrow area. Using a catalog of Ly α absorbers with $\log N_{\rm HI}$>20.0 cm^{-2} based on the Baryon Oscillation Spectroscopic Survey (BOSS), we found six fields where three or more absorbers are concentrated within a (50 Mpc)^3 cubic box in the comoving scale. Among them, we focus on the J1230+34 field, where 2 DLAs and 2 sub-DLAs at z~2.3 present. We have conducted narrow-band imaging observations of LAEs in this field with Subaru/Suprime-Cam using a

custom-made filter, *NB400* (λ_c=4003 Å and FWHM=92 Å). These observations yield a sample of 149 LAEs in the J1230+34 field. Based on this sample, we investigate physical properties of LAEs. In the entire target field with the scale of ~50 Mpc, we have found no differences between the obtained Ly α luminosity function and those in the blank fields at similar redshifts. We also compare the frequency distribution of the Ly α rest-frame equivalent width (EW_0) in the target field and other fields at similar redshift including both overdensity region and blank field, but find no differences. On the other hand, in the small scale (~10Mpc), we have found a possible overdensity of LAEs around a DLA with the highest H I column density ($\log N_{\rm HI}$=21.08 cm^{-2}) in the target field while there are no density excess around the other absorbers with a lower $N_{\rm HI}$. Based on these results, we propose two possible scenarios for the absorber-concentrated regions as follows. (1) The J1230+34 field harbors many young galaxies intrinsically. The reason why we have not found overdensity of LAEs around three among four absorbers in the J1230+34 field is that the Ly α emission is suppressed by the resonant scattering since this region harbors a large amount of the neutral gas. (2) There are not so many galaxies in the J1230+34 field. Since the neutral gas is not converted to stars but goes through H_2 molecules, a large fraction of gas in the J1230+34 field may not have been converted to stars. Both of these two scenarios suggest that the absorber-concentrated region may correspond to the birthplace of galaxies and thus the J1230+34 field is a good target for coming deep surveys to investigate the early phase of the galaxy evolution.

For further understandings of the nature of the DLA, we have to increase the sample of the identified counterparts of DLAs at high redshift. The counterparts of high-z DLAs are sparsely distributed in the sky and generally very faint in optical, and thus wide-field photometric surveys with a sufficiently high sensitivity are required to search for such high-z DLA counterparts. Since recent and near-future wide-field optical deep surveys offer an opportunity to carry out systematic searches for high-z DLA counterparts, preparatory works to understand how to utilize the wide-field deep imaging data to search for such counterparts are crucial. Therefore, we focus on an on-going survey performed with Subaru Hyper Suprime-Cam (HSC) through the Subaru Strategic Program (SSP). Within current footprint of the HSC-SSP survey, 3,577 BOSS DLAs that distribute around z~2. Therefore, the specific question is how to select faint galaxies at z~2 by utilizing the optical photometric data effectively. For investigating this topic, we examine the HSC-SSP photometric catalog and the COSMOS photometric redshift sample. As a conclusion, it is shown that the g'–r' vs. r'–y' color-color diagram is useful to select galaxies at z~2. Thanks to the large sample of BOSS DLAs and large telescopes such as the Subaru telescope, we are gradually understanding the relation between DLAs and galaxies. Ongoing and incoming spectroscopic surveys such as extended BOSS and surveys with Prime Focus Spectrograph on the Subaru telescope, will dramatically increase the number of high-z quasars. This will enable us to search for absorber-concentrated regions, important regions to understand the early stage of galaxy evolution, more effectively. The HSC-SSP will be completed in 2019. It enables us to identify a number of DLA counterparts and to investigate the nature of DLAs. Furthermore, in the coming era of 30 m class telescopes such as Thirty Meter Telescope (TMT), European Extremely Large Telescope (EELT), and Giant Magellan Telescope (GMT), the DLA will be casted a spotlight as one of the most interesting targets since we will be able to investigate fainter objects in the high-z Universe. This dissertation work provides useful methods and interesting target fields for such future observation.