Subaru Surveys for High-z Galaxies

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Abstract. We present a summary of optical/NIR deep surveys for very high-z galaxies using the 8.2m Subaru Telescope operated by National Astronomical Observatory of Japan. The prime focus mosaic CCD camera, Suprime-Cam, with a very wide field of view, $34' \times 27'$, allows us to carry out efficient optical deep surveys. In particular, the Subaru Deep Field project has provided us a number of Lymanα emitters beyond $z = 6$. We discuss the star formation history in the early universe based on this project.

1 Introduction

Since the discovery of Lyα emission from a galaxy at $z = 5.34$ [4], more than two dozen of Lyα emitters (LAEs) have identified spectroscopically; see for reviews, [27]; [23]. The most distant LAE known to date is SDF J132418.3+271455 at $z = 6.578$ [14]. Another very high-z LAE is HCM-6A at $z = 6.56$ [9]. These discoveries are actually thanks to the great observational capability of 8-10m class optical telescopes. Furthermore, the GOODS survey has provided a sample of very high-z Lyman break galaxies (LBGs) at $z \sim 6$, thanks to the high-quality imaging capability of the Advanced Camera for Surveys (ACS) on the Hubble Space Telescope (e.g., [8], [5], [24]). These exciting observations enable us to investigate the cosmic star formation history and mass assembly history in the early universe. In this review, we present a summary of recent deep surveys for very high-z (i.e., $z > 5$) galaxies based on the 8.2m Subaru Telescope.

2 Subaru Surveys for High-z Galaxies

2.1 The Subaru Deep Survey

The 8.2m Subaru Telescope [12] has seven instruments; see http://www. subarutelescope.org/Observing/Instruments/index.html. During the commissioning phase of three instruments (FOCAS, OHS/CISCO, and Suprime-Cam), these instruments team members organized a systematic deep survey using these three instruments to investigate high-z galaxies; the Subaru Deep Survey (SDS). All the observations were done during a period between 1999 and 2001. Their target fields are (1) the Subaru Deep Field (SDF) centered at RA(J2000) = $13^{\rm h}$ $24^{\rm m}$ $21.^{\rm s}38$ and DEC(J2000) = $+27°29'23''$, and (2) the Subaru XMM-Newton Deep Field (SXDF) centered at RA(J2000) = $2^{\rm h}$ $18^{\rm m}$ $00.^{\rm s}00$ and DEC(J2000) = $-5°12'00''$. The SDF is used to make a very deep imaging survey while the

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SXDF is used to make a wide-field, medium deep one; see for the SXDF project, [20], & [17].

(1) NIR Deep Imaging Survey: Very deep J and K' images of the central $2' \times 2'$ field of the SDF were obtained with use of CISCO [15]. The integration times of the J and K' bands were 12.1 hr and 9.7 hr, resulting in 5σ limiting magnitudes of 25.1 and 23.5 mag (the Vega system), respectively. These data are used to investigate the NIR galaxy number count, colors, and size distribution; see also [30]. They also found a population of hyper extremely red objects (HEROs) with $J - K' > 3 - 4$ [29]. These deep NIR data were also utilized to investigate the diffuse extragalactic background light (EBL) [28]. They found that ~ 90 % of the EBL from galaxies were resolved in their deep NIR images.

This NIR data set was also used to construct a K'-selected galaxy sample, consisting of 439 galaxies for which both optical (B, V, R, I, and z') and NIR photometric data are available [13]. Comparing the star formation rate density (SFRD) at $z \sim 3$ for their K'-selected sample with those based on previous LBG surveys, they found that a large fraction of SFRD at $z > 1.5$ may come from a faint blue galaxy population.

(2) Optical Narrowband Deep Survey: One of narrowband filters, NB711 centered at $\lambda_{\rm C} = 7126$ Å with $\Delta\lambda = 73$ Å was used to search for LAEs at $z \sim 4.9$ [16], [22]. They found 87 reliable LAE candidates at $z \sim 4.9$, and then analyzed their luminosity function and clustering properties [16]. They also found a large-scale clustering of LAEs with a scale of ~ 20 Mpc $\times$ 50 Mpc [22].

(3) Optical Broad Band Deep Survey: In order to investigate photometric and clustering properties of LBGs at $z \sim 4 - 5$, optical broad band data of both the SDF and the SXDF, covering 1200 sq. arcmin in total were carefully analyzed by [17], [18]. They obtained a large sample of LBGs (2600 objects) at $z \simeq 3.5 - 5.2$.

Their analysis shows that the correlation lengths are $\simeq 4.1\ h_{100}^{-1}$ Mpc and $5.9\ h_{100}^{-1}$ Mpc in co-moving units for all the detected LBGs at $z \simeq 4$ and $z \simeq 5$, respectively.They also found that a typical mass of dark matter halos hosting LBGs with $L > L^*$ amounts to $\sim 1 \times 10^{12} M_\odot$, being comparable to those of typical massive disk galaxies like our Milky Way.

Based on the CDM model, they also estimated the mass of dark matter halos which could form from such high-z objects. Since they obtained a mass range between $\sim 10^{13} - 10^{15} M_\odot$, they suggested that dark matter halos hosting high-z LBGs could evolve to groups and clusters in the local universe. On one hand, faint LBGs, LAEs, and K'-selected galaxies could evolve to present-day galaxies after experiencing a few merger events.

2.2 The Subaru Deep Field (SDF) Project

As outlined in the previous subsection, the SDS gave a number of important findings in the research field of galaxy evolution. This success seems to be attributed to the very wide-field of view of Suprime-Cam and excellent seeing conditions at Mauna Kea. In order to make the SDS much more fruitful, the