SuprimeCam LAE Survey at Redshift 7.3 : — A progress report —

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Abstract

We made a survey for Lyman-α emitters (LAE) at z~7.3 in the Subaru Deep Field using a new filter NB1006 (λ_c=1004nm, FWHM=21nm) and SuprimeCam with new red-sensitive CCDs having 5 times higher QE at 1004nm. This would be the ultimate survey feasible with Si-CCDs to break the current limit of the most distant galaxy. Our 17 hr integration yielded as yet no promising photometric candidate for LAE at z=7.3. The 5σ detection limit is tentatively estimated at NB1006~24.4, about 0.6 mag shallower than our expectation and the lack of candidates, so far, cannot be an additional significant constraint for the increasing neutral hydrogen fraction beyond z=7.0. Analysis on the photometric zero-point calibration is under way.

1. LAE evolution and cosmic reionization

The WMAP results and the G-P tests of quasars up to z=6 indicate the reionization of the universe at some epoch in the range 6<z<20. The Suprime-Cam enabled efficient surveys of distant galaxies practical owing to its wide field (34'x27'), high image quality and sensitivity. Subaru Deep Field (SDF) project (1) compiled deep images in five broad bands and several narrow bands. Among others, the NB921 and NB816 imaging observations yielded a fairly large sample of LAEs at z=6.6 and z=5.7, respectively (2).

Based on these large sample, we have shown the presence of a striking decline in the Ly-α luminosity density from z=5.7 to z=6.6 and the lack of similar decline in the UV continuum luminosity density and argued that this could be due to the variation of intergalactic neutral hydrogen content over this period which selectively attenuates the Ly-α photons (2,3,5).

2. z=7.0 LAE survey with NB973

Our previous NB973 imaging survey yielded the 5σ limiting mag 24.90 for a 2".0 aperture in 14.5 hours integration. Only one LAE, IOK-1 (=J132400+272451), was confirmed at z=6.964 by spectroscopy (4). This is only 1/5 the number that is expected in case the intergalactic neutral hydrogen content stays constant between 6.6<z<7.0.

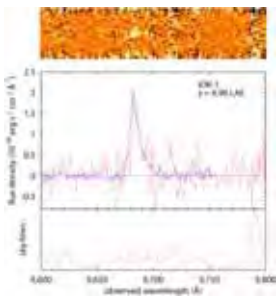

Fig.1 FOCAS spectrum of IOK-1 at z=6.96 detected by NB973

3. z=7.3 LAE survey with NB1006

The Ly-α emitters beyond z=7.5 can only be confirmed with near infrared instruments. The survey volumes for infrared observations, however, would be inevitably much smaller.

The SuprimeCam NBF survey in the blank field, therefore, remains the only practical approach to study the unlensed population of LAEs. The new SuprimeCam CCDs, having 40% QE at 1000nm, opened a last chance to extend the redshift limit up to z=7.3. We made a new narrow band filter NB1006 and carried out an imaging survey at Subaru Deep Field in Feb. and Apr. 2009. Total integration time of 22 hrs was secured of which 17 hrs data under a seeing condition better than 1".0 were used to produce a combined data.

Tentative photometric calibration shows that the 5σ limiting magnitude attained for a 2" aperture was NB1006(AB)=24.4, about 0.6 mag shallower than our expectation to reach 25.0. Figure 2 shows a color-magnitude diagram (z'-NB1006, NB1006) of all the objects detected in NB1006 above 2σ.

Red-crosses in Figure 2 show objects that are not detected in z'-band image above 2 σ. The z'-band limiting magnitude is assigned for drawing these objects in this plot. Upon quick inspection, however, most of these "object" appear to be artifacts as they are seen at the edge of the imaging field. Hence, no promising photometric candidate for z=7.3 LAE has yet been identified. The light blue curves show 3σ distribution limits for z'-NB1006 color.

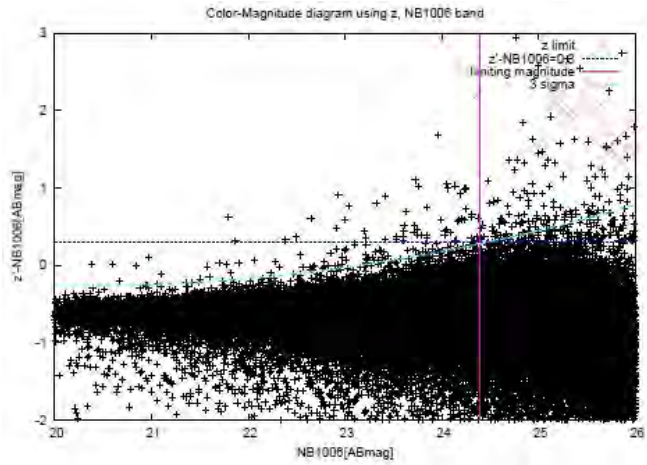

Fig.2. z'-NB1006 vs NB1006 diagram for isolation of photometric candidates for z'~7.3 LAEs.

4. Discussion

Figure 3 shows the measured number of LAEs at z=6.6 (black circles) as a function of the 5σ NBF921 limiting AB magnitude. Also shown is the expected maximum number of LAEs at z=7.3 (red circles), where galaxy populations and IGM HI fraction are assumed to show no significant evolution during 6.6<z<7.3 and survey volume increase by 1.6 due to wider band width is taken into account, whereas neglecting all the associated difficulties for the survey at z=7.3.

Whether the current LAE survey at z=7.3 provides additional evidence for the increasing fraction of neutral hydrogen at z>7.0 relies on further analysis, especially on the zero-point calibration.

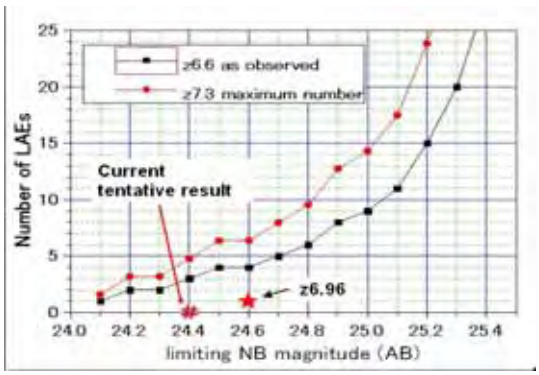

Fig.3 Expected maximum number of LAEs at z=7.3 (red circles) as a function of 5σ limiting NBF1006 magnitude. Black circles show observed count of LAEs at z=6.6. ★ indicates the IOK-1 at z=6.96. # shows current tentative limit.

References

1)Kashikawa,N. et al. 2004, PASJ 56, 1011
2)Kashikawa,N. et al. 2006, ApJ, 648, 7
3)Shimasaku,K. 2006, PASJ, 58, 313
4)Iye,M. et al. 2006, Nature, 443, 186
5) Ota, K. et al.,2007, arXiv:0707.1561