Number Count of high-z LAEs and LBGs in the HSC Surveys: A Theoretical Model Prediction

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INTRODUCTION

Lyman Alpha Emitter (LAE)

LAE is one of the most important galaxy pop. because of the following two reasons. (1) detecting redshifted Lyα emission with narrow-band filter is a powerful strategy to seek for high-z galaxies (e.g., Iye+06), and (2) they can be used as a probe of cosmic reionization because the strength and profile of Lyα emission could significantly be affected by IGM HI.

OBSERVATIONAL DATA OF LAE

The nature of LAE pop. and connection with other high-z galaxy pop. (e.g., LBG) have been poorly understood. However, their statistical quantities (i.e., Lyα & UV luminosity functions (LFs), EW(Lyα) distributions) have been more firmly established because of the increase of survey fields and available samples (e.g, Ouchi+08, 10).

Important information about LAE can be obtained through comparisons between the observed statistical quantities and theoretical models of LAE.

PREVIOUS THEORETICAL MODELS FOR LAE

There are several theoretical models for LAE in the framework of hierarchical galaxy formation with different approaches: analytic (e.g, Thommes & Meisenheimer05), cosmological hydrodynamic sim. (e.g., Nagamine+08), and semi-analytic model (SAM; e.g., Orsi+09).

However, in all of them, the escape fraction of Lyα photons from their host galaxy ($f_{esc}^{Ly\alpha}$) is oversimplified, although it is the most important ingredient: constant regardless any phys. prop. of galaxy, or the same amount with that for continuum photons. These assumptions are clearly inconsistent with the implications from observations (e.g., Kunth+98) and theoretical results from radiative transfer for Lyα photons (e.g., Hansen & Oh06).

OUR MODEL FOR LAE

Our model (Kobayashi+07,10; KTN07,10) is a unique one because the following two effects are incorporated into $f_{esc}^{Ly\alpha}$ for the first time: (1) interstellar dust extinction, whose strength is not necessarily the same with that for UV continuum and (2) galactic outflow induced as a feedback of supernova (SN).

It has been shown that (1) all of the available observational data for Lyα & UV LFs and EW distributions of LAEs @ z=3-6 are reproduced well, and (2) those of LAEs @ z > 6 indicate IGM neutral fraction (x_{HI}) rapidly evolves from $x_{HI}(z<6)$ << 1 into $x_{HI}(z>6) \sim 1$.

AIM OF THIS RESEARCH

The new camera for the Subaru Telescope, Hyper-SuprimeCam (HSC), has a very wide FoV, 1.77 □°, which is wider than the FoV of the Subaru/SuprimeCam by a factor of ~7. This wide FoV is suitable for surveying rare and faint high-z galaxies (LAEs and LBGs) as well as QSOs.

Here we present our model prediction to the feasibility to detect the number of high-z galaxies via the HSC, although this is the workshop for SMBH and/or AGN.

MODEL DESCRIPTION

Model of Galaxy Formation

Our model is based upon a SAM, *"Mitaka model"* (Nagashima & Yoshii 04). It analytically computes merger history of DM halos based on ΛCDM, and then follows the evolution of baryons trapped in halos by using phenomenological models. As a result, the Mitaka model provides all of the physical quantities (e.g., SFH, Z, $M_\star$, dust amount) of galaxies at any redshift.

Extensions for LAEs

We developed a phenomenological model for $f_{esc}^{Ly\alpha}$ which is physically motivated by both of theoretical and observational studies. The effects of interstellar dust extinction and galactic wind are incorporated as the following way:

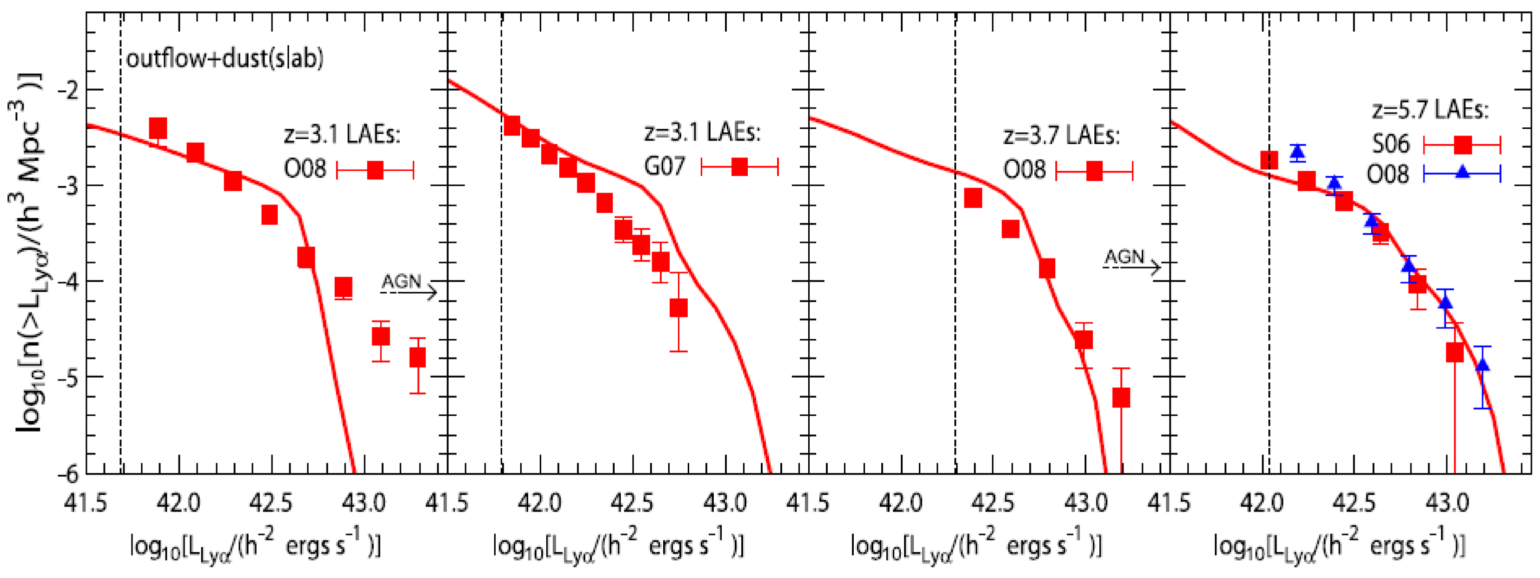
$$f_{esc}^{Ly\alpha} = f_0 \frac{1-\exp(-\tau_d^{Ly\alpha})}{\tau_d^{Ly\alpha}}, \quad \tau_d^{Ly\alpha} = \frac{N_{cold} Z_{cold}}{(N_{cold} Z_{cold})_0^{Ly\alpha}} \quad \text{... quiescent \& pre-outflow starburst}$$

$$f_{esc}^{Ly\alpha} = f_0^{wind} \quad \text{... outflow starburst}$$

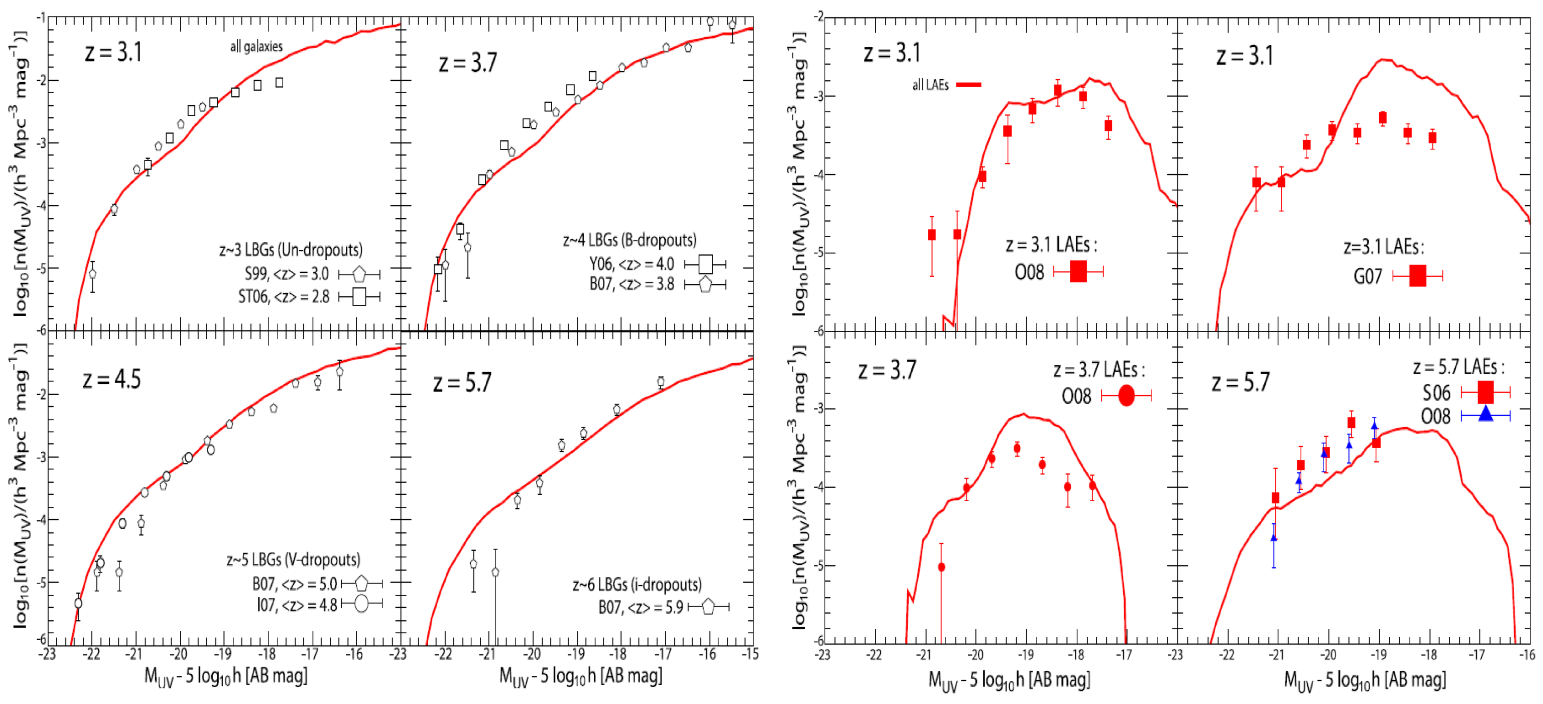
f_0, $(N_{cold}Z_{cold})_0^{Ly\alpha}$ and f_0^{wind} are free parameters, which has been determined by obs. Lyα LF at $z = 5.7$ (Shimasaku+06). $(N_{cold}Z_{cold})_0^{Ly\alpha}$ controls the strength of extinction for Lyα and this parameter can be different from that for UV continuum photons, which has already been determined by the Mitaka model.

By using the parameter values fixed via the observed Lya LF of the LAEs at $z = 5.7$, our model nicely reproduces all of the available observed data (i.e., Lyα and UV LFs, EW distribution) at $z = 3$-6.

Those at $z > 6$ are also reproduced if the IGM transmission for Lyα is decreased by a factor of $T_{Ly\alpha}^{IGM} \sim 0.6$ compared to that at $z < 6$. This is consistent with the observational constraints to the cosmic reionization.



[Fig.1] Lyα LFs of LAEs at $z = 3$-6 (Fig. 2 of KTN10). The curves are predictions by our model, while the symbols w/ error-bars are the obs. data. Here, we select model LAEs by the same criteria of EW as those adopted in each observation. The arrows are taken from Ouchi+08 which represent the $L_{Ly\alpha}$ range where Lyα LFs are dominated by LAEs w/ AGN activities. All of the Lyα LFs of LAEs at $z = 3$-6 are reproduced well by our model w/ only 3 free parameters.

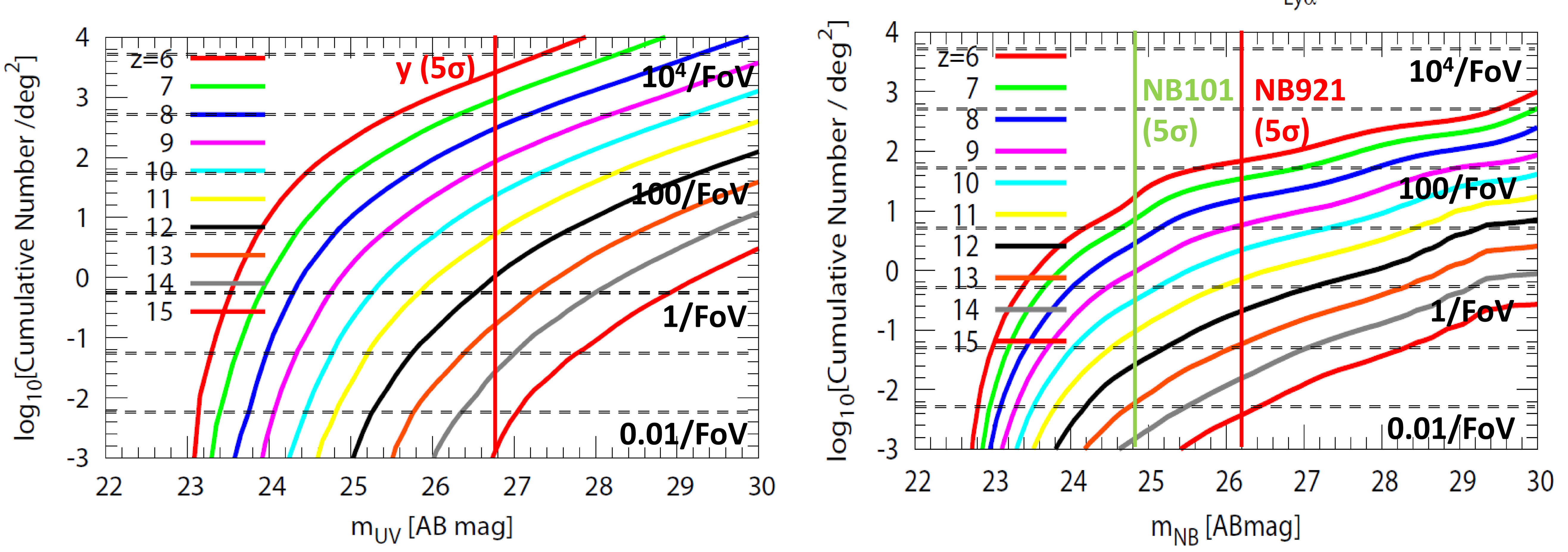


[Figs. 2 & 3] Rest-frame UV (λ = 1,500 A) LFs of all (i.e., incl. non-LAEs) galaxies (*left*; Fig. 3 of KTN10) and LAEs (*right*; Fig. 4 of KTN10) at z ~ 3-6. The curves are predictions by our model, while the symbols w/ error-bars are the observed data of the LBGs at similar redshifts (Fig.2) and LAEs at the redshift (Fig.3). In Fig.3, the model LAEs have been selected with the same criteria of $L_{Ly\alpha}$ and EW with those adopted in each observation. It is shown that our model nicely reproduces all of the observational data of UV LFs for not only LBGs but also LAEs at z ~ 3-6.

RESULTS

We show predictions to the number count of high-z galaxies from our SAM.

FWHM = 100 [A], $T_{Ly\alpha}^{IGM}$ = 0.6



[Figs. 4 & 5] Predicted cumulative number densities of the high-z galaxies in the redshift range of $z = 6$-15.
(*Left*) the number densities of UV-bright galaxies. Here we have selected all of the rest frame 1500 A-bright galaxies w/o any selection for the continuum slope longer than the Lyman-break like the usual LBG-selections. The expected 5σ limiting magnitude for y-band ($z_{UV} \sim 6$) in the Ultra Deep (UD) survey, which survey area will be 1 FoV of the HSC (1.77 □°), is shown by the vertical solid line.
(*Right*) the number densities of the galaxies w/ strong Lyα emission. The selection criterion for the model galaxies is $EW_{Ly\alpha} > 20$ A. Here we adopt $T_{Ly\alpha}^{IGM} = 0.6$ for Lyα transmission through IGM, which is the best-fit for the Lyα LF at z = 6.6 (Kashikawa+06). The FWHM of the NB filter is adopted to be constant (= 100 A) regardless of redshift. The expected 5σ limiting magnitudes for NB921 ($z_{Ly\alpha} = 6.6$) and NB101 ($z_{Ly\alpha} = 7.3$) in the UD survey are shown by the vertical solid lines.

In the UD survey, it is predicted by our model that ~ 10,000 UV-bright galaxies at $z \sim 6$ and ~ 100 and ~ 10 LAEs at z = 6.6 and 7.3, respectively, will be detected. This predicted number of UV-bright galaxies can be an upper-limit because here we have not adopted any selection criterion for the continuum slope.

A more realistic calculation w/ the expected filter set in the forthcoming HSC survey can also be done by using our model as well as w/ that in other proposed survey programs. If you want to have the results of such calculation, don't hesitate to ask it to MARK!!