Photometric Hα and [O II] Luminosity Function of SDF and SXDF Galaxies: Implications for Future Baryon Oscillation Surveys

Masanao Sumiyoshi[1], Tomonori Totani[1], Shunsuke Oshige[1], Karl Glazebrook[2], Masayuki Akiyama[3], Tomoki Morokuma[4], Kentaro Motohara[5], Kazuhiro Shimasaku[6,7], Masao Hayashi[6], Makiko Yoshida[6], Nobunari Kashikawa[4], and Tadayuki Kodama[4]

[1] Kyoto Univ., [2] Swinburne Univ., [3] Tohoku Univ. , [4] NAOJ, Univ. of Tokyo ([5] Institute of Astronomy, [6] Department of Astronomy, [7] Research Center for the Early Universe)

Abstract

Efficient selection of emission line galaxies at $z \sim 1$ by photometric information in wide field surveys is one of the keys for future spectroscopic surveys to constrain dark energy using the baryon acoustic oscillation (BAO) signature. Here we estimate the Hα and [O II] line luminosity functions of galaxies at z = 0.5-1.7 using a novel approach where multi-wavelength imaging data is used to jointly estimate both photometric redshifts and star-formation rates. These photometric estimates of line luminosities at high-redshift use the large data sets of the Subaru Deep Field and Subaru XMM-Newton Deep Field (covering ~ 1deg^2) and are calibrated with the spectroscopic data of the local Sloan Digital Sky Survey galaxies. The derived luminosity functions (especially Hα) are in reasonable agreement with the past estimates based on spectroscopic or narrow-band-filter surveys. This dataset is useful for examining the photometric selection of target galaxies for BAO surveys because of the large cosmological volume covered and the large number of galaxies with detailed photometric information. We use the sample to derive the photometric and physical properties of emission line galaxies to assist planning for future spectroscopic BAO surveys. We also show some examples of photometric selection procedures which can efficiently select these emission line galaxies.

Introduction

- Dark Energy is …
  - approximately 70% of the energy density of the universe.
  - consistent with cosmological constant in recent observation.
  - What is the nature of dark energy ??
- Spectroscopic BAO surveys of large scale structure
  - One of the most promising method of strongly constraining the nature of dark energy by precise measurement of cosmic expansion (D_A, H).
  - Selecting line emission galaxies efficiently at $z \sim 1$ by photometric information is a key to these surveys.

➡ We discuss the photometric and physical properties of emission line galaxies by estimating Hα and [O II] line luminosities of galaxies at $z \sim 1$ based on star formation rate estimates using photometric redshift method, by using large data sets of the SDF and SXDF covering ~ 1 deg^2 in total.

The Sample and Photometric Redshifts

Here, we describe the basic information of SDF and SXDF, listed the table.

BVR$_C$i'z' -band : SuprimeCam (Subaru)
JK -band : WFCAM (UKIRT)
3.6μm 4.5μm : IRAC (Spitzer)

We calculate the photometric redshift, SFR, stellar mass, etc. using *hyperz*. (Bolzonella et al. 2000)

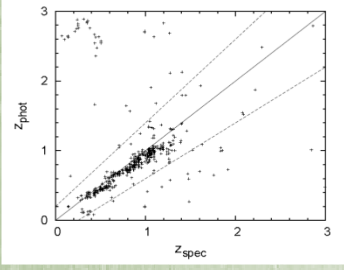
- Population synthesis : Bruzal & Charlot 2003
- IMF : Salpeter 1955
- Extinction law : Calzetti et al. 2000

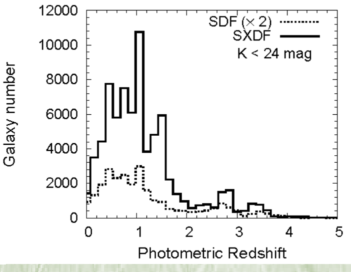
Table 2.1: Basic Information of SDF and SXDF

Field	Area [deg^2]	Number	Limiting magnitudes [mag] [1]								
			B	V	R_C	i'	z'	J	K	3.6μm	4.5μm
SDF	0.114	17408	28.5	27.7	27.8	27.4	26.6	23.4	23.7	—	—
SXDF	0.732	76193	28.1	27.8	27.6	27.6	26.6	24.5	24.0	23.1	22.4

[1] The limiting magnitudes are 3σ at 2″aperture for B, V, R_C, i', and z' bands, and 3σ at 3″.8 aperture for 3.6 and 4.5μm bands. For the J and K bands, they are 5σ at 2″aperture (SDF) and 3σ at 2″.3 aperture (SXDF).

These figures below show the comparison with phot-z and spec-z and redshift distributions of SDF and SXDF galaxies.



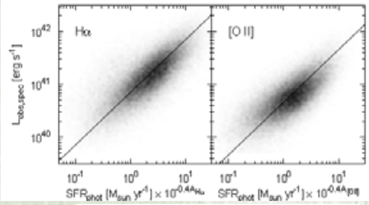


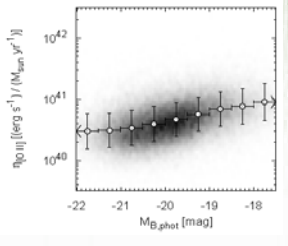
Line Luminosity Calibration by SDSS Galaxies

We compare the line luminosities estimated by phot-z with the spectroscopic line luminosities with SDSS galaxies. (see right-top figure.)

We see a tight correlation between SFR and Hα luminosities. On the other hand, the correlation with SFR is not as good as that of Hα emission.

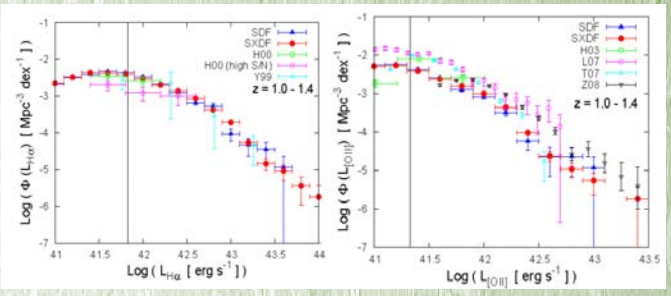
Then we calibrate the conversion law from SFR to [O II] luminosities as a function of absolute *B*-band magnitude *in order to remove the dominant* luminosity dependence of these effects. (see right-bottom figure.)





Line Luminosity Functions

Figures below shows our photometric estimates of Hα and [OII] LFs of SDF and SXDF galaxies, compared with the past spectroscopic and NB estimates.



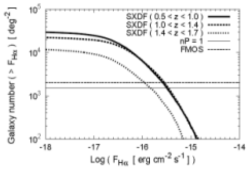
Implications of Future BAO Surveys

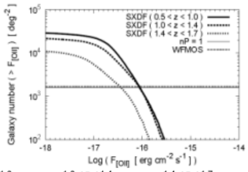
First we calculate the cumulative number counts of emission line galaxies used for future BAO surveys as functions of Hα and [OII] flux. (aee right figures.)

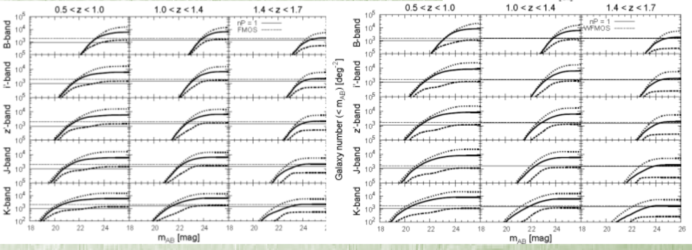
Next, we estimate the cumulative galaxy number of the Hα and [OII] emission-line galaxies as a function of magnitudes in popular band filter. (see figures below.)

The three lines in the left panel are for the three threshold Hα fluxes 10$^{-15.5}$, 10$^{-16.0}$, and 10$^{-16.5}$ erg/cm^2/s, respectively. The three lines in the right panel are for the three threshold [OII] fluxes 10$^{-16.0}$, 10$^{-16.5}$, and 10$^{-17.0}$ erg/cm^2/s, respectively.

We can find how deep photometric surveys we need in order to pre-select spectroscopic target galaxies efficiently for BAO surveys.





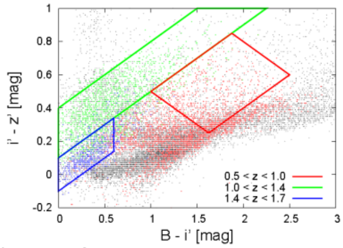


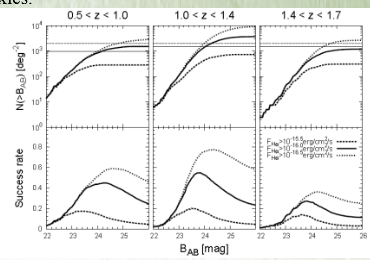
Example of Color Selection

Actual selection procedures in a particular BAO survey will depend on various conditions that are unique to the survey, such as available band filters of input imaging surveys. Therefore it is difficult to derive generally useful results, but here we test some simple two-color selection methods to select emission line galaxies brighter than $F_{Hα}$ = 10^{-16} erg/cm^2/s. One example is using only optical photometries (*Biz-selection).*

Figures below show the *Biz* two-color diagram and the number of emission-line galaxies brighter than three threshold Hα line fluxes as a function of the threshold *B* magnitude when we select galaxies by these color criteria.

It can be seen that for the two low redshift bins sufficient galaxies are obtained at a depth of B = 24 with a 10^{-16} erg/cm^2/s threshold. For the highest redshift bin we need to go deeper (*B = 25) to attain sufficient* galaxies.





Joint Subaru/Gemini Science Conference@Kyoto University, Japan