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STATISTICAL PROPERTIES OF GALAXIES AT $Z = 4$ AND 5 IN THE SUBARU DEEP FIELDS

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RESUMEN

Presentamos resultados preliminares sobre la densidad por número y las características de agrupamiento de tres muestras de galaxias: 2200 galaxias LBG con $z = 4.0 \pm 0.5$, 300 galaxias LBG con $z = 4.7 \pm 0.5$ y 87 galaxias con emisión en Lyman α (LAEs) con $z = 4.86$. Estas se encuentran en dos campos profundos del sondeo de gran campo, el Subaru Deep Field (616 arcmin^2: $z' < 26.0$) y el Subaru/XMM Deep Field (653 arcmin^2: $i' < 26.0$). Calculamos las funciones de luminosidad en el UV, así como las funciones de correlación angular para estas tres poblaciones. La función de luminosidad en el UV para las LBGs muestra una evolución moderada entre $z = 4$ y $z = 5$. Las funciones de correlación angular indican que estas galaxias muestran un agrupamiento mayor que el predicho para la materia oscura subyacente.

ABSTRACT

We present preliminary results on the number densities and the clustering properties of three galaxy samples; 2,200 Lyman Break Galaxies (LBGs) at $z = 4.0 \pm 0.5$, 300 LBGs at $z = 4.7 \pm 0.5$, and 87 Lyman α Emitters (LAEs) at $z = 4.86$. These are found in two deep and wide-survey fields, the Subaru Deep Field (616 arcmin^2: $z' < 26.0$) and the Subaru/XMM Deep Field (653 arcmin^2: $i' < 26.0$). We calculate UV-luminosity functions and angular correlation functions of these three populations. The UV-luminosity functions of LBGs show moderate evolution from $z = 4$ to $z = 5$. The angular correlation functions indicate that those galaxies show a stronger clustering than that predicted for underlying dark matter.

Key Words: **GALAXIES: HIGH-REDSHIFT — COSMOLOGY: OBSERVATIONS**

1. INTRODUCTION

According to the standard Cold Dark Matter (CDM) model, present-day galaxies have experienced a number of mergers, and have assembled stars during the mergers. In order to understand the galaxy formation, it is essential to know the evolutionary processes both in the number densities and clustering properties of galaxies. In this contribution, we report on the luminosity functions and the angular correlation of galaxies at z=4 and 5 which few studies have unveiled. Throughout this paper, magnitudes are in the AB system, and all calculations assume a Λ-dominated spatially flat cosmology, $(\Omega_m, \Omega_\Lambda) = (0.3, 0.7)$.

2. OBSERVATION AND SAMPLE SELECTION

In November 2000 - October 2001, we carried out multi-band, deep and wide-field optical imaging with the Subaru Prime Focus Camera (Suprime-Cam; Miyazaki, S. et al. 2002) in two blank fields. One is the Subaru/XMM Deep Field (SXDF: $2^h18^m00^s$,$-5°12'00''$[J2000]) covering a 653 arcmin^2 area with $i' < 26.2$. The other is the Subaru Deep Field (SDF: $13^h24^m21.4^s$,$-27°29'23''$[J2000]) covering a 616 arcmin^2 area with $i' < 26.9$. In addition to these broad-band images, we observed the SDF with a custom narrow-band filter, $NB711$ (λ_c=7126,$\Delta\lambda$ = 73Å), to identify LAEs at $z = 4.86$ (Ouchi et al. 2002). We detected 45,514 objects with $i' < 26.2$ for SXDF, and 65,928 objects with $i' < 26.9$ for SDF. On the basis of the colors given by the best-fit SEDs of the HDF photo-z catalog (Furusawa et al. 2000) for LBGs and those of GISSEL96 (Bruzual & Charlot 1993) population synthesis models for LAEs, we define photometric selection criteria for $z = 4.0 \pm 0.5$ LBGs ($\langle z \rangle \sim 4$ LBGs) , $z = 4.7 \pm 0.5$ LBGs ($\langle z \rangle \sim 5$ LBGs), and $z = 4.86$ LAEs ($z = 4.86$ LAEs :Ouchi et al. in preparation; Ouchi et al. 2002). Applying the selection criteria for all the detected objects, we find a total of 2,170 (1,440 and 730) objects satisfying the $\langle z \rangle \sim 4$ LBG criteria, 300 (250 and 50) objects satisfying the $\langle z \rangle \sim 5$ LBG criteria, and 87 objects satisfying the $z = 4.86$ LAE criteria from the data (SDF and SXDF). We carried out spectro-

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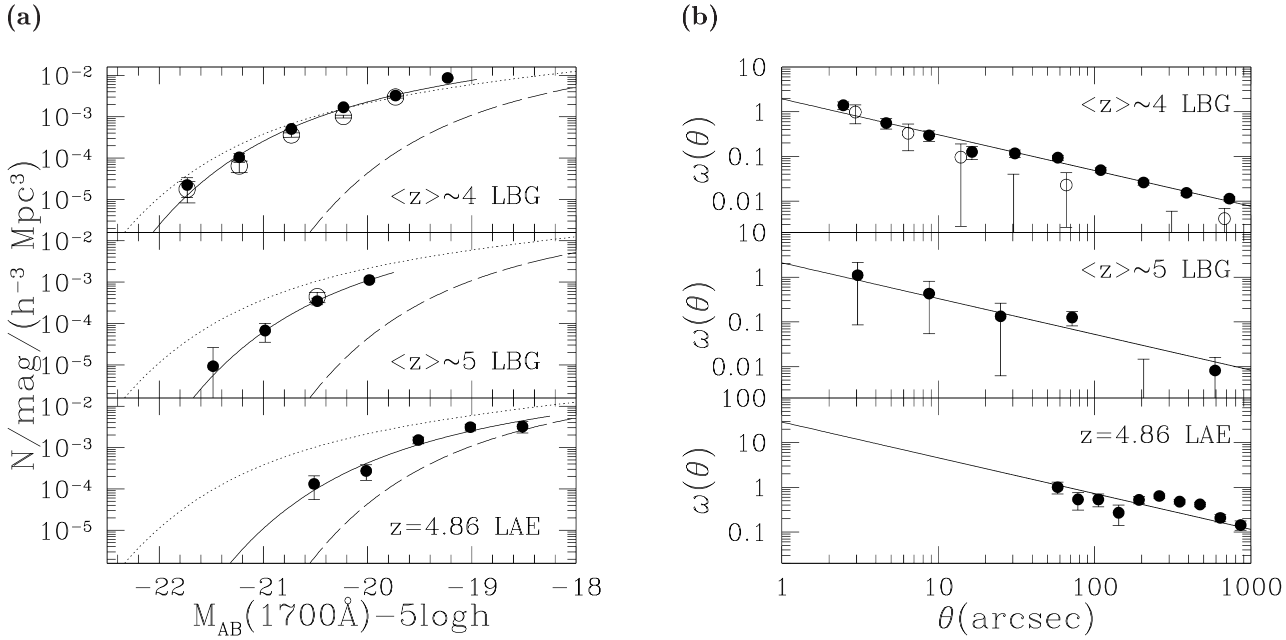

Fig. 1. (a) Luminosity functions (LFs) derived from three galaxy samples. Filled (Open) circles show the LFs calculated from SDF (SXDF) data. Solid lines are the best-fit Schechter functions. Dashed and dotted lines indicate the LFs of the galaxies at $z = 0$ and $z = 3$, respectively (Sullivan et al. 2000, Steidel et al. 1999). (b) Angular correlation functions (ACFs) derived from three galaxy samples. Filled (Open) circles show the ACFs calculated from SDF (SXDF) data. Solid lines indicate the best-fit power law functions.

scopic follow-up observations for these galaxies from each sample in March - June 2002, and we have already confirmed eight objects located at $z = 3.8$ to $z = 4.9$ (Kashikawa et al. in preparation). We estimate the contamination and completeness of those samples with Monte Carlo simulations, generating artificial objects that mimic real high-z galaxies and distributing them on our original images.

3. LUMINOSITY FUNCTIONS

The UV-luminosity functions (LFs) of the LBGs and the LAEs are derived from the sample defined in §2. The LFs are shown in Figure 1a, together with those at $z = 0$ (Sullivan et al. 2000) and $z \sim 3$ (Steidel et al. 1999). The LF of our $z \sim 4$ LBGs is consistent with the one derived by Steidel et al. (1999). It is found from Figure 1a, that the LFs moderately evolve from $z = 3$ to 5.

4. ANGULAR CORRELATION FUNCTIONS

We derive the angular correlation functions of these sample galaxies, and we find a clear clustering signal with a significant level in each galaxy sample (Fig. 1b). We fit a power law, $\omega(\theta) = A_\omega \theta^{-\beta}$, to the data points, and we calculate the correlation lengths, r_0, from the best-fit A_ω. We find the correlation lengths, r_0, of the $\langle z \rangle \sim 4$ LBGs, $\langle z \rangle \sim 5$ LBGs, and z=4.86 LAEs to be $4.3^{+0.4}_{-0.5} h^{-1}$Mpc, $4.2^{+0.5}_{-0.5} h^{-1}$Mpc, and $3.5^{+0.3}_{-0.3} h^{-1}$Mpc respectively. These correlation lengths, r_0, are about ~ 6 times larger than the value, $\sim 0.7h^{-1}$Mpc, predicted for dark matter at these redshifts by the analytic model (Peacock & Dodds 1996). These results indicate that the galaxy distribution is strongly biased against the dark matter distribution at $z = 4$ and 5. The details of the analysis and the discussions are found in Ouchi et al. 2001, 2002 and in a forthcoming paper (Ouchi et al., in preparation).

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