New Cosmological Data and the Values of the Fundamental Parameters
IAU Symposium, Vol. 201, 2005
Anthony Lasenby and Althea Wilkinson, eds.

Galaxy Luminosity Function: Applications and Cosmological Implications

Tsutomu T. Takeuchi

Division of Particle and Astrophysical Sciences, Nagoya University, Nagoya, 464–8602, Japan

Kohji Yoshikawa

Department of Astronomy, Kyoto University, Kyoto, 606–8502, Japan

Takako T. Ishii

Kwasan Observatory, Kyoto University, Kyoto, 607–8471, Japan

Abstract. We studied the statistical methods for the estimation of the luminosity function (LF) of galaxies by Monte Carlo simulations. After examining the performance of these methods, we analyzed the photometric redshift data of the Hubble Deep Field prepared by Fernández-Soto et al. (1999). We also derived luminosity density $\rho_{\rm L}$ at B- and I-band. Our B-band estimation is roughly consistent with that of Sawicki, Lin, & Yee (1997), but a few times lower at $2.0 < z < 3.0$. The evolution of $\rho_{\rm L}(I)$ is found to be less prominent.

1. Introduction

Galaxy luminosity function (LF) is one of the most fundamental statistical properties in observational cosmology. However, estimating galaxy luminosity function from an observational galaxy catalog is not a trivial task. In this work, we examined and made practical improvements for the statistical estimation methods of the LF. After checking the reliability of each method, we finally applied the methods to the photometric redshift catalog and studied the evolution of the LF at the very large redshift.

2. Examination of the Statistical Methods by Simulations

We focused on four nonparametric estimators: $1/V_{\rm max}$ estimator, maximum-likelihood estimator of Efstathiou et al. (1988), Chołoniewski's estimator, and improved Lynden-Bell's estimator and extensively studied their performances by Monte Carlo simulations. Full details of the mathematical formulations are given in Takeuchi et al. (2000)

We found that $1/V_{\rm max}$ estimator yields a completely unbiased result if there is no inhomogeneity, but is not robust against clusters or voids. We also found that the other three maximum-likelihood type estimators are quite robust and give consistent results with each other. In practice we recommend Chołoniewski's estimator for two reasons: 1. it simultaneously provides the shape and normal-

https://doi.org/10.1017/S007418090021694X Published online by Cambridge University Press

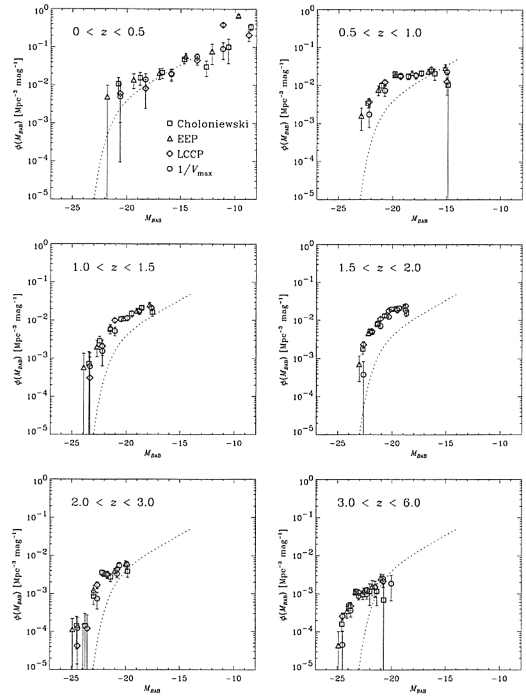

Figure 1. The evolution of the B-band luminosity function in the HDF.

ization of the LF; 2. it is the fastest among these four estimators, because of the algorithmic simplicity.

3. Results from the HDF

After we examined their performance and limitation, we analyzed the photometric redshift data of the Hubble Deep Field prepared by Fernández-Soto et al. (1999) using the above four methods. The B-band LF is presented in the Figure 1. We also derived luminosity density $\rho_{\rm L}$ at B- and I-band.

As a whole, our result is consistent with that of Sawicki et al. (1997), except for $2.0 < z < 3.0$. In this redshift range, $\rho_{\rm L}(B)$ of Sawicki et al. is several times larger than our estimate. The evolution of $\rho_{\rm L}(I)$ appears to be flat. At the longer wavelength, the observed light is dominated by the contribution from lower-mass stars, and the temporal change of the SFR is less prominent.

References

Fernández-Soto, A., Lanzetta, K. M. & Yahil, A. 1999, ApJ, 513, 34
Sawicki, M. J., Lin, H. & Yee, H. K. C. 1997, AJ, 113, 1
Takeuchi, T. T. Yoshikawa, K. & Ishii, T. T. 2000, ApJS, in press

https://doi.org/10.1017/S007418090021694X Published online by Cambridge University Press