Faint Galaxies at $z = 5 - 10$ for UV Luminosity Functions and Cosmic Reionization

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Abstract

We present the comprehensive analyses of faint dropout galaxies up to $z \sim 10$ with the first full-depth data set of Abell 2744 lensing cluster and parallel fields observed by the Hubble Frontier Fields (HFF) program. We identify 54 dropouts at $z \sim 5 - 10$ in the HFF fields, and enlarge the size of $z \sim 9$ galaxy sample obtained to date. Although the number of highly magnified ($\mu \sim 10$) galaxies is small due to the tiny survey volume of strong lensing, our study reaches the galaxies' intrinsic luminosities comparable to the deepest-field HUDF studies. We derive UV luminosity functions with these faint dropouts, carefully evaluating the combination of observational incompleteness and lensing effects in the image plane by intensive simulations including magnification, distortion, and multiplication of images, with the evaluations of mass model dependences. Our results confirm that the faint-end slope, α, is as steep as -2 at $z \sim 6 - 8$, and strengthen the evidence of the rapid decrease of UV luminosity densities, $\rho_{\rm UV}$, at $z > 8$ from the large $z \sim 9$ sample. We examine whether the rapid $\rho_{\rm UV}$ decrease trend can reconcile with the large Thomson scattering optical depth, $\tau_{\rm e}$, measured by CMB experiments allowing a large space of free parameters such as average ionizing photon escape fraction and stellar-population dependent conversion factor. No parameter set can reproduce both the rapid $\rho_{\rm UV}$ decrease and the large $\tau_{\rm e}$. It is possible that the $\rho_{\rm UV}$ decrease moderates at $z > 11$, that the free parameters significantly evolve towards high-z, or that there exist additional sources of reionization such as X-ray binaries and faint AGNs.