

A population of massive and evolved galaxies at high redshift

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Abstract

We report results from a search for massive and evolved galaxies at $z > 5$ in the Great Observatories Origins Deep Survey (GOODS) southern field. Combining optical (HST/ACS), near-infrared (VLT/ISAAC) and mid-infrared (Spitzer/IRAC) broad band photometric data, we use a color selection technique to identify candidates for being evolved galaxies at high redshifts. The color selection is primarily based on locating the Balmer-break using the K- and $3.6\mu\text{m}$ bands. Stellar population synthesis models are fitted to the color selected galaxies to identify the final sample. We find 18 candidate galaxies at $z = 5 - 7$. The spectral energy distributions of the candidates imply that the galaxies are dominated by an old stellar population, with ages 0.2–1.0 Gyr, and stellar masses in excess of $10^{11} M_{\odot}$. Most of the candidates have no or modest amounts of internal dust extinction. The majority of the stars in these galaxies have formation redshift in the range $z \sim 9 - 25$. At the observed redshifts, $z = 5 - 7$, the galaxies exhibit very low levels of star formation activity. The confidence limits of the spectral synthesis fits are determined using Monte Carlo simulations. One candidate galaxy has a spectroscopically confirmed redshift, which agrees well with our photometric redshift. The candidate galaxies are small and compact, with a mean half-light radius of $0.34''$, corresponding to a radius ~ 2 kpc. We define a core sample of 10 candidate galaxies with the highest confidence limits and an estimated completeness of 50%. We derive the number density of massive galaxies and discuss the implication for standard Λ CDM models.