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The Stellar Masses and Star Formation Histories of Galaxies at z ≈ 6: Constraints from Spitzer GOODS Observations

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Abstract

Using the deep *Spitzer* Infrared Array Camera (IRAC) observations of the Great Observatories Origins Deep Survey (GOODS), we study the stellar masses and star formation histories of galaxies at $z \approx 6$. Our study is based on the i_{775}-band dropout sample selected from the GOODS southern and northern fields ($\sim$ 330 arcmin^2 in total), several of which already have spectroscopic confirmations. In total, we derive stellar masses for 53 i_{775}-band dropouts that have robust IRAC detections. These galaxies have typical stellar masses of $\sim 10^{10} M_\odot$ and typical ages of a couple of hundred million years, consistent with earlier results based on a smaller sample of $z \approx 6$ galaxies in the HUDF. We also study 79 i_{775}-band dropouts that are invisible in the IRAC data and find that they are typically less massive by a factor of ten. These galaxies are much bluer than those detected by the IRAC, indicating that their luminosities are dominated by stellar populations with ages less than 40 million years. We discuss various sources of uncertainty in the mass estimates, and find that our results are rather robust. The existence of galaxies as massive as $10^{10} M_\odot$ at $z \approx 6$ can be explained by at least one set of N-body simulations of the hierarchical paradigm. Based on our mass estimates, we derive a lower limit to the global stellar mass density at $z \approx 6$. Considering the range of systematic uncertainties in the derived stellar masses, this lower limit is 1.1 to $6.7 \times 10^6 M_\odot$ Mpc^{-3} (co-moving), which is 0.2 to 1.1% of the present-day value. The prospect of detecting the progenitors of the most massive galaxies at yet higher redshifts is explored: a deep, wide-field near-IR survey using our current technology could possibly result in positive detections at $z > 7$. We also investigate the implication of our results for reionzation, and find that the progenitors of the galaxies comparable to those in our sample, even in the most optimized (probably unrealistic) scenario, cannot sustain the reionization for a period longer than $\sim$ 2 million years. Thus most of the photons required for reionization must have been provided by other sources, such as the progenitors of the dwarf galaxies that are far below our current detection capability.