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Measuring star formation in high-z massive galaxies: a mid-infrared to submillimetre study of the GOODS NICMOS Survey sample

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ABSTRACT

We present measurements of the mean mid-infrared to submillimetre flux densities of massive ($M_\star \gtrsim 10^{11}\,\mathrm{M}_\odot$) galaxies at redshifts $1.7 < z < 2.9$, obtained by stacking positions of known objects taken from the GOODS NICMOS Survey (GNS) catalogue on maps at 24 μm (*Spitzer*/MIPS); 70, 100 and 160 μm (*Herschel*/PACS); 250, 350 and 500 μm (*BLAST*); and 870 μm (LABOCA). A modified blackbody spectrum fit to the stacked flux densities indicates a median [interquartile] star formation rate (SFR) of $\mathrm{SFR} = 63[48, 81]\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$. We note that not properly accounting for correlations between bands when fitting stacked data can significantly bias the result. The galaxies are divided into two groups, disc-like and spheroid-like, according to their Sérsic indices, n. We find evidence that most of the star formation is occurring in $n \leq 2$ (disc-like) galaxies, with median [interquartile] $\mathrm{SFR} = 122[100, 150]\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$, while there are indications that the $n > 2$ (spheroid-like) population may be forming stars at a median [interquartile] $\mathrm{SFR} = 14[9, 20]\,\mathrm{M}_\odot\,\mathrm{yr}^{-1}$, if at all. Finally, we show that star formation is a plausible mechanism for size evolution in this population as a whole, but find only marginal evidence that it is what drives the expansion of the spheroid-like galaxies.

Key words: galaxies: evolution – galaxies: high-redshift – infrared: galaxies.

1 INTRODUCTION

The observed structural properties of massive galaxies ($M_\star \gtrsim 10^{11}\,\mathrm{M}_\odot$) at high redshift ($z \gtrsim 1$) are difficult to reconcile with those of galaxies that populate the local Universe. Most strikingly, they are on average much more compact in size than local galaxies of similar mass (Daddi et al. 2005; Trujillo et al. 2006). For the spheroid-like galaxy population, this size evolution has been particularly dramatic (a factor of 4–5 since $z \sim 2$, see e.g. Trujillo et al. 2007; Buitrago et al. 2008; Damjanov et al. 2009), with subsequent observations confirming these findings (e.g. Muzzin et al. 2009; Trujillo, Ferreras & de la Rosa 2011). Only a tiny fraction of massive galaxies in the local Universe have sizes comparable to those found at high redshift (Trujillo et al. 2009). The absence of similar mass counterparts in the local Universe (Trujillo et al. 2009) implies that some mechanism is acting on those high-redshift galaxies to make them grow in size (Bezanson et al. 2009; Hopkins et al. 2009).

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