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# Statistical Properties of Gamma-Ray Burst Host Galaxies

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**Abstract.** A statistical analysis of gamma-ray burst host galaxies is presented and a clear metallicity-stellar mass relation is found in our sample. A trend that a more massive host galaxy tends to have a higher star-formation rate is also found. No correlation is found between $A_{\rm V}$ and $N_{\rm H}$. GRB host galaxies at a higher redshift also tend to have a higher star formation rate, however, even in the same redshift, the star formation rate may vary for three orders of magnitude.

*Key words.* Galaxy: abundances—gamma rays: bursts.

## 1. Introduction

GRBs are the most luminous events in the Universe. They were detected from local to high-$z$ universe. They may be probes for cosmography and high-$z$ galaxies (e.g., Dai *et al*. 2004; Ghirlanda *et al*. 2004; Liang & Zhang 2005; Kewley & Dopita 2002; Savaglio & Glazebrook 2009; Perley *et al*. 2013). We present the statistical properties of GRB host galaxies and explore possible correlations between these properties. We also investigate possible cosmic evolution of the GRB host galaxies.

## 2. Sample and results

Our sample includes 61 GRB host galaxies. We collected the stellar mass ($M^*$), star-forming rate (SFR), metallicity ($Z$), extinction ($A_{\rm V}$), and neutral hydrogen column density ($N_{\rm H}$) of these galaxies from literature. The distributions of $z$, $M^*$, the specified SFR that is defined as the star formation rate to the stellar mass, $Z$, $A_V$ and $N_H$ are shown in Fig. 1. It is found that their redshifts range from 0.0085 to

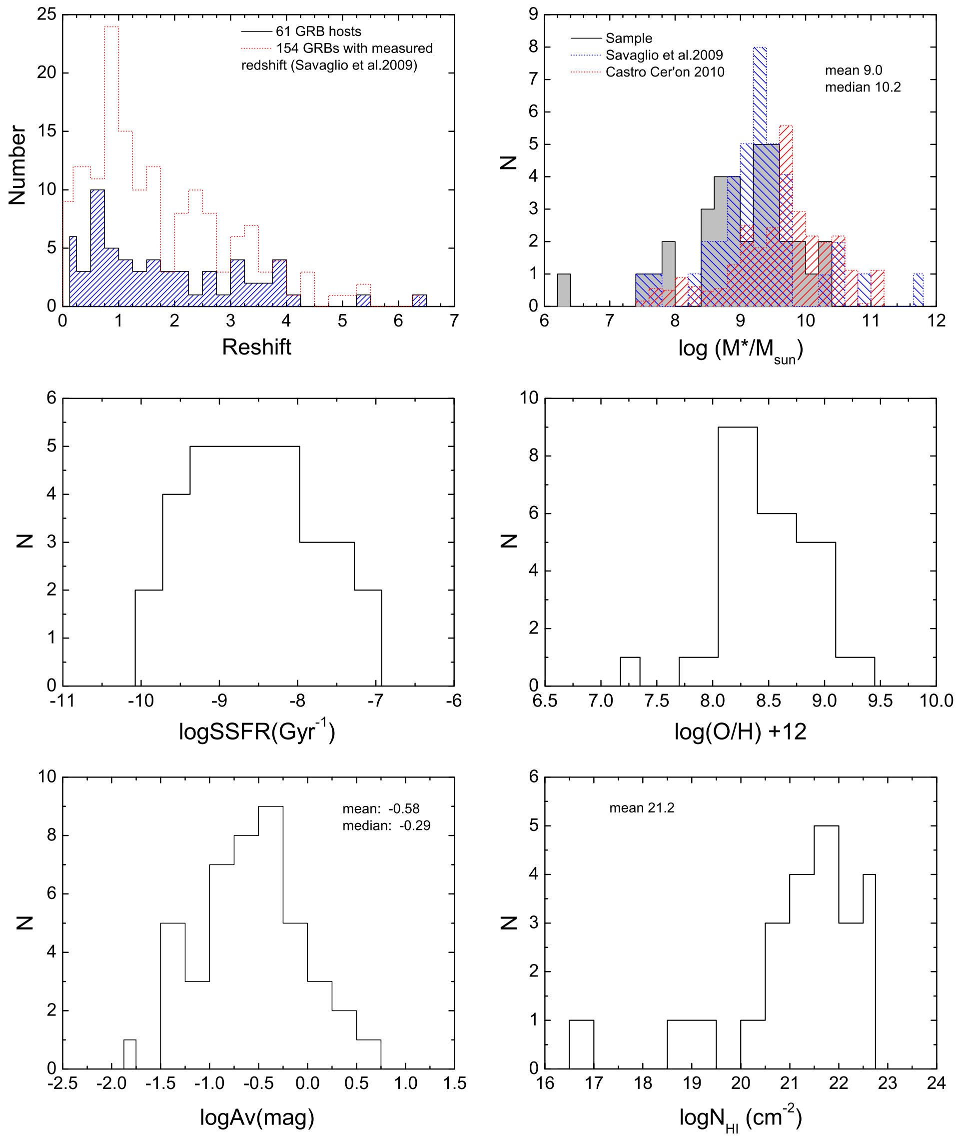


**Figure 1.** Distributions of the redshift, stellar mass, specific SFR, metallicity, extinction and hydrogen column density for the GRB host galaxies in our sample.

6.295. The stellar masses are mainly in the range of $10^8$–$10^{11} M_\odot$, and the specific star formation rates are in the range of $10^{-10}$–$10^{-7}$ Gyr$^{-1}$. The typical $Z$ measured with log(O/H) + 12 is ∼8.5. The $A_V$ measured from the optical afterglows is typically 0.6 mag and the typical $N_H$ values measured from the X-ray afterglows is $\sim 10^{22}$ cm$^{-2}$.

We explore the correlations between these data. They are shown in Fig. 2. A clear metallicity–stellar mass relation is seen in the current sample, which is $Z \sim M^{*0.4}$. A tentative SFR–mass relation is also observed, i.e., SFR $\sim M^{0.75}$. The host

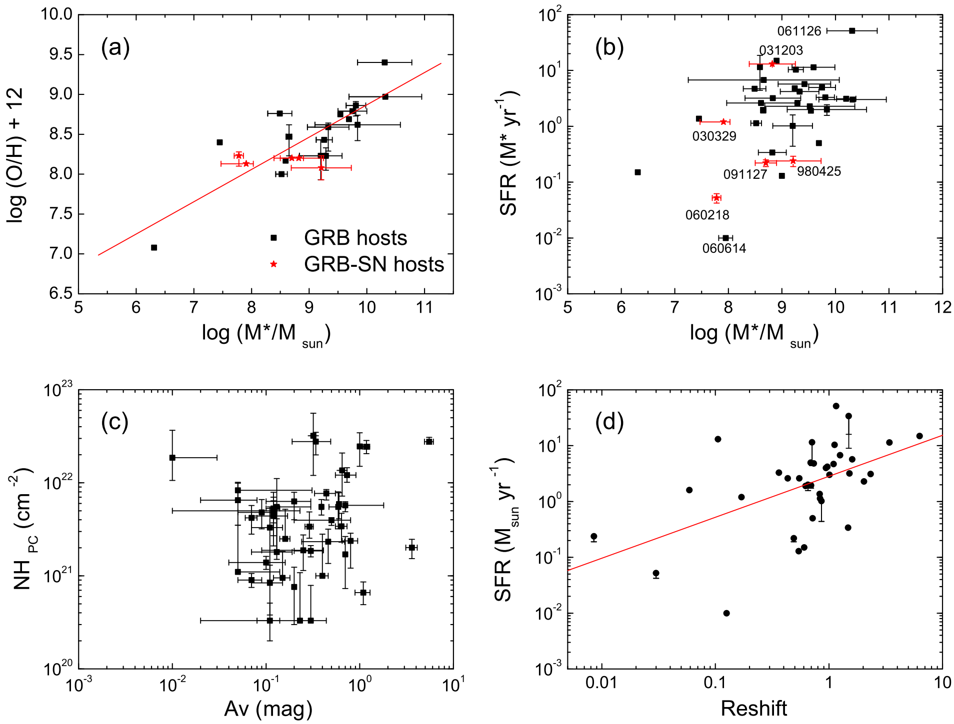


**Figure 2.** Possible correlations between the data of the GRB host galaxies in our sample. (**a**) and (**b**) Metallicity and star formation rate as a function of stellar masses, (**c**) $N_H$ value as a function of $A_V$ for the GRB host galaxies, where $N_H$ and $A_V$ are measured from X-ray and optical observations, respectively. (**d**) Star formation rate as a function of redshift. Lines are best fit to the data. Red stars are for the host galaxies of local GRBs with detection of accompanied supernovae.

galaxies of local GRBs with detection of accompanied supernovae share the same relation with high-$z$ GRB host galaxies. A trend that a more massive host galaxy tends to have a higher star-formation rate is found. $N_H$ value is not correlated with $A_V$. The star-formation rate also weakly depends on the redshift with large scatter. However, even in the same redshift, the SFR may vary for three orders of magnitude. It is unclear whether this is an observational selection effect or not (Savaglio 2012).

## 3. Conclusions

We have presented statistical analysis of gamma-ray host galaxies for a sample of 61 GRBs. A clear metallicity–stellar mass relation is found in our sample, which is $Z \sim M^{0.4}$. A more massive host galaxy tends to have a higher star-formation rate. The best fit gives SFR $\sim M^{0.75}$. No correlation is found between $A_V$ and $N_H$. A GRB host galaxy at a higher redshift also tends to have a higher SFR, however, even in the same redshift, the SFR may vary for three orders of magnitude.

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