VLT/X-SHOOTER ABSORPTION SPECTROSCOPY OF THE GRB 120327A AFTERGLOW

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Abstract. We analyze two X-shooter spectra of the GRB 120327A afterglow, acquired 2.1 and 30 hrs after the trigger. The ISM in the GRB host galaxy at $z = 2.8145$ is extremely rich in absorption features, with three components contributing to the line profiles. The hydrogen column density associated with GRB 120327A is $\log N_{HI}/\text{cm}^2 = 22.01 \pm 0.09$, and the metallicity of the host galaxy is in the range $[X/H] = -1.7$ to -1 with respect to the solar values, *i.e.*, a typical value for a GRB host galaxy. In addition to the ground state lines, we detect in the first observation several excited absorption features, which disappeared in the second observation. Using these features, we derive that component I is at $d_I = 200_{-60}^{+100}$ pc from the GRB, while component II is located closer, at $d_{II} = 100_{30}^{+40}$ pc. These values are among the lowest found in GRBs. Comparing the abundances with star formation history models, we find that the GRB 120327A host galaxy abundances are compatible with a star formation efficiency of 10 Gyr^{-1} , typical of spheroids (elliptical or bulge).

1 Introduction

For a few hours after their onset, Gamma Ray Bursts (GRBs) are the brightest beacons in the far Universe, offering a superb opportunity to investigate both GRB physics and high redshift galaxies. Early time spectroscopy of GRB afterglows can give us precious information on the kinematics, geometry, ionization and metallicity of the interstellar matter of GRB host galaxies up to a redshift $z \sim 5$, and of intervening absorbers along the line of sight. Our dataset comprises two X-shooter spectra of GRB 120327A, acquired 2.1 and 30 hrs after the trigger. The resolution of our data is $R = 5000 - 9000$, corresponding to $20 - 35 \text{ km/s}$, the wavelength range is $3000 - 25000 \text{ \AA}$, and the signal-to-noise ratio of the first observation is $S/N = 15 - 30$.

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2 Results

2.1 Detected lines

The host galaxy of GRB 120327A appears to be extremely rich in metals (Fig. 1). Metallic features are apparent from neutral (NI, OI, MgI, PI, ArI, CaI), low-ionization (CII, MgII, AlII, AlIII, SiII, PII, SII, CaII, CrII, FeII, NiII, ZnII), and high-ionization (CIV, NV, OVI, SiIV, PV, SIV) species. All lines can be fitted with a three component Voigt model. Component II (*i.e.*, the central one) is taken as the reference redshift for the GRB host galaxy, since it is the most rich in excited features (see next sections). Component I is blue-shifted by 41 km/s, while component III is red-shifted by 35 km/s.

Fig. 1. A selection of lines detected in the GRB 120327A spectrum.

2.2 Abundances

We compute the abundances of the metallic column densities with respect to the Hydrogen one, and the GRB 120327A metal content with respect to solar values. CII, OI and AlII are heavily saturated, thus the corresponding abundances are not reliable. The HI column has been estimated using Hydrogen features from the Ly α to the Ly δ . $\log N_{HI}/\text{cm}^2 = 22.01 \pm 0.09$, and the host metallicity is in the range $[X/H] = -1.7$ to -1 .

2.3 GRB/absorber distance

A plethora of excited levels, mainly from FeII, but also NiII, CII, OI, SiII (Fig. 1) are detected in the first epoch spectrum, while they are not present any longer in epoch 2. They are probably produced through indirect UV pumping by the GRB afterglow. Comparing the column densities of these levels with the predictions of time dependent, photo-excitation codes, it is possible to determine the GRB/absorber distance (Vreeswijk *et al.* 2007; D’Elia *et al.* 2009). This is $d_I = 200^{+100}_{-60}$ pc, and $d_{II} = 100^{+40}_{-30}$ pc for component I and II, respectively. Component III does not feature excited lines, so it should be located far away from the GRB.

2.4 Host galaxy characterization

Comparing the abundance ratios with star formation history models (Fan *et al.* 2010), information about the GRB host galaxy can be derived. In particular, the GRB 120327A host abundances are compatible with a star formation efficiency of 10 Gyr^{-1} , typical of spheroids (elliptical or bulge). Theoretical curves fail to reproduce O and C abundances because the corresponding absorption lines are heavily saturated. The models take into account dust evolution in the host galaxy.

3 Conclusions

We presented X-shooter spectroscopy of the GRB 120327A afterglow, at $z = 2.8145$. The ISM in the GRB host galaxy is extremely rich in absorption features, with three components contributing to the line profiles. The hydrogen column density associated with GRB 120327A is $\log N_{HI}/\text{cm}^2 = 22.01 \pm 0.09$, and the metallicity of the host is in the range $[X/H] = -1$ to -1.7 with respect to the solar values, *i.e.*, a typical value for a GRB host galaxy. In addition to a plethora of ground state lines, we detect in the first observation CII, OI, SiII, FeII, and NiII-excited absorption features, which disappeared in the second observation. We used these features to derive information on the distance between the host absorbing gas and the site of the GRB explosion. The distance of component I is found to be $d_I = 200^{+100}_{-60}$ pc, while component II is located closer to the GRB, at $d_{II} = 100^{+40}_{-30}$ pc. These values are among the lowest found in GRBs. Comparing the abundances with star formation history models, we find that the GRB 120327A host galaxy abundances are compatible with a star formation efficiency of 10 Gyr^{-1} , typical of spheroids (elliptical or bulge).

References

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