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C IV ABSORBERS ALONG THE SIGHTLINES TO GAMMA-RAY BURSTS

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RESUMEN

En este trabajo presentamos la estadística de absorbentes de C IV preponderantes ($W_r > 0.15$) a $z = 1.5 - 3.5$ hacia estallidos de rayos gamma (*gamma-ray bursts*, GRBs) a alto corrimiento al rojo (*redshift*). En contraste con un resultado reciente sobre la estadística de absorbentes de Mg II preponderantes ($W_r > 1$ Å) a $z < 2$, nosotros encontramos que el número de absorbentes de C IV por unidad de redshift dN/dz no muestra ninguna diferencia significativa con respecto a estadísticas previas realizadas usando QSOs para obtener los espectros. Aunque estos resultados para absorbentes de Mg II y C IV parecen contradictorios, notamos que ambos estudios contienen diferencias intrínsecas: el de C IV corresponde a un mayor redshift y a un grado mayor de ionización del gas que para el de Mg II. No obstante, análisis en muestras estadísticas mayores restringirán propiedades de las galaxias anfitrionas de estos metales (e.g. masa, contenido de polvo) y/o escala de tamaños de las nubes de gas que producen estas absorciones.

ABSTRACT

We report on the statistics of strong ($W_r > 0.15$ Å) C IV absorbers at $z = 1.5 - 3.5$ toward high-redshift Gamma-Ray Bursts (GRBs). In contrast with a recent survey for strong Mg II absorption systems at $z < 2$, we find that the number of C IV absorbers per unit redshift dN/dz does not show any significant deviation from previous surveys using QSOs as background sources. Although the results for Mg II and C IV absorbers along GRB sightlines appear to contradict one another, we note that the surveys are nearly disjoint: the C IV survey corresponds to higher redshift and more highly ionized gas than the Mg II survey. Nevertheless, analysis on larger statistical samples may constrain properties of the galaxies hosting these metals (e.g. mass, dust content) and/or the coherence-length of the gas giving rise to the metal-line absorption.

Key Words: gamma rays: bursts

1. INTRODUCTION

Recently, Prochter et al. (2006) have found a significant overabundance (a factor of ~ 4) of strong Mg II absorbers in lines-of-sight toward Gamma-ray Bursts (GRBs) when compared to the statistics drawn from lines-of-sight toward QSOs. This result is striking because a key hypothesis of this experiment is that intervening absorbers are independent from the background source. Several physical effects have been proposed to explain the overabundance: (1) dust within the Mg II absorbers may obscure faint QSOs, (2) the Mg II gas may be intrinsic to the GRBs, (3) the GRBs may be gravitationally lensed by these absorbers, and (4) the absorbers are small enough that different 'beam sizes' between GRBs and QSOs may affect the statistics (Prochter et al. 2006; Frank et al. 2007; Hao et al. 2007). Prochter et al. (2006) and Porciani et al. (2007) have argued that none of these explanations is likely to explain the full effect but it may be possible for several to contribute together to resolve the discrepancy.

Here, we revisit 5 high-resolution GRBs spectra (this data was obtained with the MIKE/Las Campanas, UVES/VLT and HIRES/Keck echelle spectrographs, R 40000) and look for C IV absorbers to obtain the first statistics of such absorbers in this type of lines-of-sight. Because the C IV has a much higher potential than Mg II, the C IV doublet is likely to trace more diffuse and hotter gas. Therefore, C IV systems may represent a different 'population' of larger 'cross section' absorbers and the study of their statistics may help address resolve the problem opened by the Prochter et al. (2006).

2. RESULTS

To compare the statistics of C IV absorption along GRB sigthlines with that one for QSO sightlines, we assume as a standard statistics of C IV absorbers the (Steidel 1990) report (66 QSO low-resolution spectra were used). Therefore we use the same criteria and cutoffs in our survey:

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TABLE 1

RESULTING $dN/dz|^{\rm CIV}_{\rm GRB}$ FOR THE STATISTICAL SAMPLE

Redshift Bin	$N_{\rm abs}$	Δz	$dN/dz\|^{\rm CIV}_{\rm GRB}$	$dN/dz\|^{\rm CIV}_{\rm QSO}$
$[1,2]$	2	0.93	$2.2^{+2.8}_{-1.4}$	$2.7^{+0.5}_{-0.4}$
$[2,3]$	4	1.74	$2.3^{+1.8}_{-1.1}$	$2.5^{+0.4}_{-0.4}$
$[3,4]$	1	0.90	$1.1^{+2.6}_{-0.9}$	$1.1^{+0.7}_{-0.4}$
$[1,4]$	7	3.57	$2.0^{+1.1}_{-0.7}$	$2.4^{+0.3}_{-0.2}$

- The search was performed outside the Lyα forest and we define $z_{\rm end}$ at 5000 km s^{-1} from $z_{\rm GRB}$.
- Both members of the C IV doublet must have $W_r > 0.15$ in the rest frame with a significant level of 5σ or better.
- Since that previous surveys were made at lower spectral resolution we consider a multi component system as an unique system if their components are within 500 km s^{-1} in the rest frame.

Finally we found 7 C IV absorption systems in the 5 lines of sight. Equivalent widths were calculated using both a Gaussian fit and a pixel integration.

Table 1 shows the resulting C IV-GRB statistics for each (arbitrary) redshift bin and comparison with Steidel (1990) result (see fifth column). These numbers are consistent with previous C IV surveys using QSOs spectra. In Figure 1 we plot this results. In this figure we also compare with another published survey by Misawa et al. (2002) (18 QSO low-resolution spectra). It can be seen that, within errors, our result on C IV perfectly matches the previous surveys. Therefore, there appears to be no significant difference between GRBs and QSOs statistics.

3. DISCUSSION

For a complete discussion about this result please read § 5 of Tejos et al. (2007).

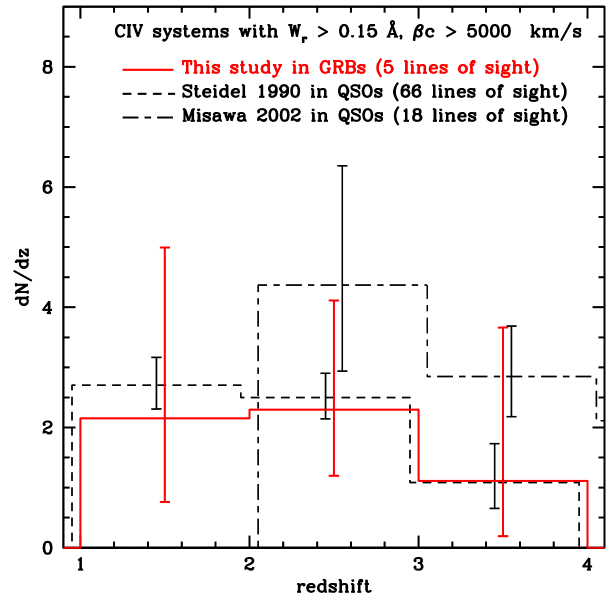

Fig. 1. Distribution of the number of C IV absorption systems per unit redshift in our GRB Statistical Sample. As a comparison (dashed line) we show results from QSO survey by Steidel (1990) and Misawa et al. (2002) using the same binning as that for the GRB-C IV analysis. The bins have been slightly offset in redshift for clarity.

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