

## GAS IN COSMIC VOIDS\*

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**ABSTRACT.** Absorption lines at the redshifts of cosmic voids in Perseus-Pisces and Böotes have been detected in the ultraviolet spectra of background quasars. The detection of Si IV and C IV lines besides Ly  $\alpha$  suggests chemical enrichment of gas in the voids. Additional observations of three sight-lines through the void in the Böotes suggests that the gas in the void is clumped in large clouds.

### 1. INTRODUCTION

The large-scale structure of the Universe is characterised by filamentary distribution of groups and clusters of galaxies (eg Davis et al 1982). The filaments delimit voids in space in which the density of galaxies is very low. The spatial scale of these voids is (10 - 40)  $h^{-1}$  Mpc ( $h$  is the Hubble constant in units of  $100 \text{ kms}^{-1} \text{ Mpc}^{-1}$ ). Krumm and Brosch (1984) searched for H I protogalactic clouds in the voids of Perseus-Pisces and Hercules. They determined that in these voids clouds of mass less than  $10^{10} h^{-2} M_{\odot}$  were not present.

The advantage of ultraviolet observations to detect small quantities of gas has been demonstrated by Brosch and Gondhalekar (1984). These authors, following the suggestion of Brosch and Greenberg (1983), analysed the ultraviolet spectra of quasars and Seyfert galaxies beyond the voids of Perseus-Pisces and Böotes. Absorption lines of Ly  $\alpha$ , Si IV and C IV, at the redshifts of voids, were detected in the spectra of three objects. In order to determine the distribution of gas in the voids additional observations were made along three sight-lines through the void of Böotes. The results of these observations are presented here.

### 2. DISCUSSION

Three quasars beyond the void in Böotes were observed with the International Ultraviolet Explorer. Two short wavelength (1200Å - 1900Å) spectra of each quasar were obtained.

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The spectra were analysed with the aid of a suite of programmes available on the SERC VAX Computer at the Rutherford Appleton Laboratory. The two spectra of each quasar were merged, with equal weights, to enhance the signal-to-noise ratio in the spectra and the signal-to-noise ratio was determined in the region of the spectrum free of emission lines. Absorption lines due to Ly  $\alpha$ , Si IV and C IV, in the redshift interval of the void in Böotes, were identified in these spectra and only lines stronger than  $3\sigma$  were considered. The equivalent widths of these lines and the derived column densities are given in Table I.

TABLE I

Equivalent Widths and Column Densities in the Böotes Void

QSO	Observed Line		
	Ly $\alpha$	Si IV	C IV
1512+37	<sup>1</sup> 0.036 <sup>2</sup> $3.09 \pm 0.77$ <sup>3</sup> $2.08 \pm 1.07 \times 10^{19}$	0.036 $1.49 \pm 0.37$ $2.20 \pm 0.50 \times 10^{14}$	0.039 $1.43 \pm 0.35$ $4.82 \pm 1.20 \times 10^{14}$
1444+41	Only weak lines detected		
1415+45	No absorption lines detected		
1315+64*	0.04 $2.55 \pm 0.01$ $1.20 \pm 0.06 \times 10^{19}$	0.03 $2.92 \pm 0.02$ $3.20 \pm 0.02 \times 10^{14}$	0.04 $1.60 \pm 0.05$ $3.90 \pm 0.12 \times 10^{14}$

<sup>1</sup>redshift of absorption line<sup>2</sup>equivalent width in  $\text{\AA}$ <sup>3</sup>column density in  $\text{cm}^{-2}$ 

\*from Brosch and Gondhalekar (1984)

The presence of absorption lines at the redshift of the void in Böotes demonstrates the presence of gas in this void. The absence of absorption lines along some sight-lines seems to suggest that the gas in the void is concentrated in large clouds. The detection of Si IV and C IV lines confirms the conclusion reached previously that the gas in the voids is enriched.

## REFERENCES

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