VARIABILITY OF EMISSION LINES IN QUASAR SPECTRA*

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ABSTRACT. Analysis of ultraviolet spectra of quasars obtained with IUE indicate that the permitted emission lines in quasar spectra are variable. The upper limit for the delay between a change in the continuum and the consequential change in the emission lines is about 9 months. This rapid response of the permitted emission lines to changes in the continuum leads to a number of problems in understanding the nature of quasars.

1. INTRODUCTION

Analysis of the integrated intensities of permitted emission lines in quasar spectra indicate that in the broad line region (BLR) of quasars the electron density is of the order of 10^9 cm^{-3}, the ionisation parameter (ratio of photon to gas density) is of the order of 0.02 and the covering factor is of the order of 0.1. These parameters along with the luminosity of ionising radiation determine the distance of the BLR from the source of the continuum radiation. In low luminosity (10^{41} - 10^{42} ergs s^{-1}) sources like Seyfert 1 galaxies, the BLR should be a few tenths of a parsec away from the source of ionising radiation and the variation of permitted lines over a few weeks have been detected (Ulrich et al 1984; Peterson et al 1985). In high luminosity (10^{46} - 10^{47} ergs s^{-1}) sources like quasars, the BLR should be light decades in size and the emission lines should not be rapidly variable. Evidence for rapid line variability in a small sample of quasars is presented here.

2. DISCUSSION

The details of observations and data reduction have been given by Gondhalekar et al (1985). The fractional change in the emission line intensities and the period over which these changes were observed have been given in Table 1. The intensities of strong lines like Ly α and C IV have been measured with an accuracy of better than 25% and the

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intensities of weaker lines like Ly β + O VI and Si IV + O IV] have been measured with comparatively lower accuracy.

TABLE 1 Changes in Emission Line Intensities in Quasar Spectra

ID	Interval Months	Changes % Ly β + O IV	Ly α	Si IV + O IV]	C IV
Q0414 - 06	10	+ 59	- 38		- 28
Q1317 + 28	18		0	- 80	
Q1512 + 37	8		- 42		
Q2201 + 31	9	- 45	0	- 70	
Q2344 + 09	11		+ 63		+ 41

The line intensities can change significantly over periods as short as 9 months. Gondhalekar et al (1985) have shown that changes in line intensities are accompanied by changes in line profiles. The present data are limited by the frequency of observations and it has not been possible to accurately establish the delay between a change in the continuum and the corresponding change in the line flux. At present it is only possible to say that the upper limit for this delay is 9 months. This would suggest that the BLR was less than 0.25 pc from the source of ionising radiation unless a contrived geometry was adopted.

The rapid variability of emission lines or the small extent of BLR poses severe problems in understanding the physics of BLR. For example, in a BLR 0.25 pc from the source of ionising radiation, the ionisation parameter would be ~ 1 for an electron density of 2×10^9 cm^{-3} and the luminosity of ionising radiation given by Gondhalekar et al (1985). This ionisation parameter is two orders of magnitude higher than the ionisation parameter generally assumed for photoionisation models of BLR (Kwan and Korlik, 1981). For such a high ionisation parameter high ionisation lines should be observed in the ultraviolet and these have not been detected. It is possible that the permitted lines are formed in the region of BLR where the electron density is high (and the ionisation parameter is low) and lines like C III] λ1909Å are formed in a low density region further from the source of ionising radiation. It has not been possible to study in detail this stratification of BLR.

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