IS THERE A RELATION BETWEEN OPTICAL EMISSION LINE STRENGTHS AND CONTINUUM SHAPES?

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ABSTRACT. Until recently there have been very few measurements of the ionizing continuum in quasars. With the combination of *Einstein* X-ray slopes and IUE spectra for a sample of quasars, this continuum can now be better constrained. Here we take a preliminary look for relations between the shape of this continuum and the emission lines produced over the observed range of continuum properties.

1. Introduction.

Photoionization models for the Broad Emission Line Region (BELR) of quasars are generally fairly successful in reproducing the observed emission lines of an *average* quasar. However it is clear that the normalization and shape of the soft X-ray spectra and thus of the ionizing continua, vary substantially from quasar to quasar (Wilkes and Elvis 1987, WE87). This opens up the question of how such an average model applies to real quasar continua. Until recently lack of data has prevented any study of the relation between observed ionizing continuum and the emission lines although a tantalizing relation between the FeIIλ4570 equivalent width and the soft X-ray slope has been suggested (Wilkes, Elvis and McHardy 1987). We have now completed observing full energy distributions, from 100 μ to 1200 $\AA$, for a sample of 40 quasars with well-determined soft X-ray slopes (0.2-3.5 keV) (WE87). Using as templates those objects which demonstrate the range of continua exhibited by quasars, a preliminary look for relations between the various prominent line ratios and the input continuum shape was made using Ferland's photoionization code (Ferland and Osterbrock 1986).

2. Full Energy Distributions.

The quasar input continuum was characterized by a power law ($f_\nu \alpha \nu^{-\alpha}$, $\alpha \sim 1.0$) in the IR region, a thermal, "blue bump", component in the optical and UV (approximated by an $\alpha = 0$ power law smoothly joining a black body), and a power law ($\alpha \sim 0.5 - 1.2$) in the X-ray. Crucial for determining the emission line ratios is the relative strength of the X-ray continuum. The observed range in α_{ox}(effective x-ray-to-optical slope) for the sample is $\sim$ 1.1 - 2.0. This is a range of 1-400 in relative optical to X-ray luminosity. Since strong X-rays are required to solve the Lyα/Hβ problem (α_{ox}=1, Kwan and Krolik 1981), an increase in $\alpha_{ox}$is likely to have a major effect on model predictions. An ultra-soft excess above a single power law is generally present at energies $\lesssim$0.2 keV (WE87, Pounds and Turner 1988) and is interpreted as the high energy tail of the "blue bump". A wide range of strengths for the optical/UV "blue bump" component is also seen.

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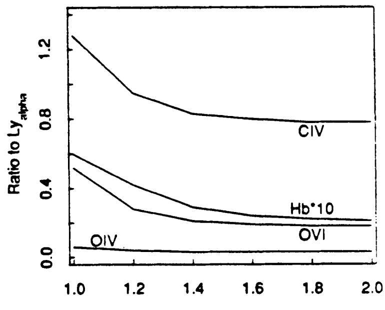

Figure 1: Line ratios vs. $alpha_{ox}$.

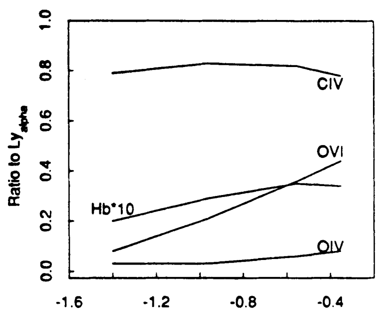

Figure 2: Line ratios vs. log U.

3. Photoionization Models.

A gas density of $10^{9.6}$ cm^{-3} and ionization parameter ($U = Q(H)/4\pi r^2 N_H$, Q(H) = no. of ionizing photons) ranging from 0.04 - 0.4 were used. Initial runs of the photoionization code showed the strength of OVIλ1035 to be sensitive to the relative soft X-ray flux (0.05-0.2 keV) (see also Krolik and Kallman 1987). The temperature of the thermal component was fixed such that it extends into the soft X-ray region without seriously over-predicting the observed OVI/Lyα ratio. A temperature of 2.10^5 K gives a ratio of 0.44 for $\alpha_{ox} = 1.4$ and U=0.4. The X-ray normalization (α_{ox}) was varied (U constant) to investigate the behavior of the predicted emission lines over the observed range. We concentrate on the high-ionization lines since the lower-ionization lines are expected to be generated predominantly in clouds with different physical conditions (Wilkes 1984).

4. Discussion.

A sequence of models covering the observed range of $\alpha_{ox}$was run for two different ionization parameters: 0.1,0.4 with similar results. The ratios of CIVλ1549, Hβ and the oxygen lines: OVIλ1035, OVλ1218 and OVI]λ1402 are sensitive to α_{ox}particularly for $\alpha_{ox} < 1.6$ (see Fig. 1, U=0.1). The oxygen lines and Hβ are also a function of U while CIV is not (Figure 2). Thus, for a known continuum, observation of CIV/Lyα and OVI/Lyα would serve to determine U (Krolik and Kallman (1987), Netzer 1987). The highest ratios of Hβ/Lyα ($\sim$ 0.06), obtained for flat $\alpha_{ox}$and high U with the current continuum, are still significantly lower than those observed. We conclude that photoionization models predict relations between continuum shape and emission line ratios which we plan to investigate.

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