Emission Line – Continuum Correlations in Low-Redshift Quasars

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We investigate the relation between the *observed* optical emission line strengths, widths and ratios and the *observed* continuum properties for two samples of quasars: 43 *Einstein* observed quasars for which we have obtained IR–soft-X-ray data to define the spectral energy distribution (SED); 23 PG quasars: z<0.4; $N_H<1.9\times10^{20}$ cm^{-2} of which a random subset of 10 has been observed by ROSAT to date (Laor *et al.* 1994).

Introduction.

The strong, broad emission lines that characterise quasar spectra are generally believed to be generated in gas photoionized by the central continuum source of the quasar, the broad emission line region (BELR). Photoionization models, although reasonably successful in predicting the average emission line properties of a quasar with a 'standard', somewhat X-ray-loud continuum shape, have not been tested with the wide range of quasar properties, either in the continuum (Elvis *et al.* 1994) or the emission lines. The emitted line strengths are sensitive to SED shape, particularly in the ultraviolet (UV)/soft X-ray and IR bands (Krolik and Kallman 1988, Ferland and Persson 1989, Mathur *et al.* 1994). Thus, if photoionization models are generally applicable, we would expect systematic relations between the observed lines and continuum in different objects. Along with our collaborators, we have now collected sufficient SED and emission line data to study continuum/line relations for individual objects (Mathur *et al.* these proceedings) and for samples, as we report here.

PG Sample Results

The following significant correlations were found in the initial subset of 10 quasars from this sample (Laor *et al.* 1994). References indicate earlier reports of a similar correlation/trend in each case (L_x = X-ray luminosity at 2 keV)

L(FeII)/L(Hβ) $\sim \alpha_x$	Wilkes, Elvis and McHardy (1987)
FWHM(Hβ) $\sim \alpha_x$	Puchnarewicz *et al.* (1992)
L([OIII]) $\sim \alpha_x$	
L(Hβ) $\sim L_x$	Kriss *et al.* (1980), Blumenthal *et al.* (1982)
L([OIII]), L(HeII), L(FeII) $\sim L_x$	Boroson and Green (1992), HeII$\sim L_{opt}$,$\alpha_{\rm ox}$

The small sample size prevents multivariate analysis at this stage so it is not clear whether the X-ray or some other parameter (L_{opt}(Optical luminosity at 2500Å), $\alpha_{\rm ox}$(effective optical-to-X-ray slope, 2500Å– 2 keV)) is the fundamental one with which the lines correlate. Similarly, since FWHM(Hβ) and L(FeII) also correlate (Zheng and O'Brien 1990), it is not clear which is the fundamental correlation between FWHM(Hβ), L(FeII) and α_x.

Einstein Sample

The continuum parameters measured for the *Einstein* sample are as follows: $\mathbf{L}_{opt}$; $\mathbf{L}_x$; $\alpha_{\rm ox}$; α_x (energy index of soft X-ray spectrum); $C_{\rm UV/IR}$ (blue bump strength: log[L_{UV}/L_{IR}], McDowell *et al.* 1989); $\mathbf{R}_{\rm L}$ >< **1** (radio-loud/quiet).

The following correlations/lack of correlations were found in the data. Multivariate analysis was performed to determine the dominant correlation in each case:

L(MgII) $\sim$ L_x, L_{opt}, $\alpha_{\rm ox}$	L_x is fundamental
L(Hβ), L(Hγ), L(Hδ) $\sim$ L_x, L_{opt}, $\alpha_{\rm ox}$	L_x is fundamental
Line L $\not\sim$ α_x, $C_{UV/IR}$	No relation between lines and blue bump
W_λ $\not\sim$ L_x, L_{opt}, $\alpha_{\rm ox}$ α_x, $C_{UV/IR}$	No Optical Baldwin effect (Zamorani *et al.* 1992)
W_λ(FeII) $\not\sim$ α_x ($R_L < 1$)	Contrary to PG sample and Shastri *et al.* (1993)

Discussion

While these results generally agree with earlier correlations found between line and continuum properties, we also conclude that the X-ray luminosity is more strongly correlated with the low ionization line luminosities than the optical luminosity or $\alpha_{\rm ox}$. This provides support for models in which the low-ionization lines are generated at high optical depth in the emitting gas where the ionization structure is determined predominantly by X-ray heating (Netzer 1990). The lack of a correlation with the blue bump is understandable in the same scenario. This predicts that the high-ionization UV lines should be more sensitive to the blue bump (and soft X-ray emission). Alternatively it is possible that the BELR 'sees' a different continuum than that which reaches us (as for PHL909, Mathur *et al.* these proceedings). Our study will now be extended to include the UV lines in order to discriminate between these two scenarios.

The existence of a relation between FeIIλ4570 and the soft X-ray slope has been disputed for some time (Wilkes, Elvis and McHardy 1987, Zheng and O'Brien 1990, Boroson 1989, Shastri *et al.* 1993). The results are conflicting even in the two samples presented here: positive for the PG sub-sample and negative for the *Einstein* sample. It is likely that the correlation applies to some sub-class of AGN that has not yet been identified by other properties.

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