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ABSTRACT

We analyze the ultraviolet (UV) emission properties of a sample of 13 quasars studied with the Hubble Space Telescope (HST). The quasars redshifts are in the range $0.165 \leq z \leq 2.06$ and their absolute magnitudes are in the range $-30.1 \leq M_V \leq -24.4$. The data were obtained with the Faint Object Spectrograph, have a spectral resolution of ~ 1300 and a signal-to-noise ratio $S/N \sim 20$ per resolution element. We include in the analysis optical spectra covering $H\beta$ and the narrow [O III] $\lambda\lambda 4959, 5007$ doublet for 7 of the 13 quasars.

We find that the profile of the O VI+Ly β blend can be reproduced well using a “symmetric Ly α ” template. The remarkable similarity of the Ly α and O VI profiles rules out significant line emission from a high velocity and high ionization level component inner to the broad line region (the very broad line region, VBLR), suggested in a number of earlier studies of active galactic nuclei.

The $H\beta$ line profile is in most cases different from the Ly α and C IV profiles, which indicates that $H\beta$ and the bulk of the UV lines are not produced by the same distribution of clouds in the broad line region (BLR).

The following previously unobserved emission features were found in our spectra: 1. $\lambda \sim 832$ Å, most likely O II $\lambda 833$ +O III $\lambda\lambda 833, 835$ emission. 2. $\lambda \sim 1070$ Å, most likely an Fe II multiplet. 3. $\lambda \sim 1175$ Å, probably due to C III*. Possible implications of these features are briefly mentioned.

The narrow [O III]-like components in both Ly α and C III] are generally significantly weaker than expected based on the observed [O III] $\lambda 5007$ flux. This result is consistent with the finding of Wills et al. (1993) and implies that the narrow line region (NLR) in quasars produces weaker UV/optical emission line ratios compared with the NLR in Seyfert 2 galaxies.

A study of a combined sample of 18 quasars observed with HST (including Paper I) suggests that the equivalent widths of all lines, excluding N V, decreases with increasing continuum luminosity. The slopes of the EW vs. luminosity relations for the different lines do not clearly favor explanations which invoke either a decrease in ionization parameter, or softening of the ionizing continuum, with increasing luminosity, as the single physical mechanism producing this effect.

We verify with our larger sample the conclusions of Paper I concerning the presence of N III $\lambda 991$, C III $\lambda 977$, and Ly β , the similarity of the C IV $\lambda 1549$ and Ly α profiles, and the generally small velocity shifts of the broad line peaks relative to the peak of [O III] $\lambda 5007$. In particular, we find a very small average shift for O VI (120 ± 270 km s $^{-1}$ relative to Ly α), which does not support the suggestion made in earlier studies that the line peak velocity shift

increases systematically with ionization level.

The software developed for the line profile fitting and template deblending is available upon request.

Subject headings: galaxies:nuclei—galaxies:Seyfert—ultraviolet: spectra—line profiles—quasars

1 INTRODUCTION

The objective of this paper is to extend to a larger sample the analysis of *Hubble Space Telescope* (HST) spectra of active galactic nuclei (AGNs) presented by Laor et al. (1994, hereafter Paper I). Here we analyze the emission properties of an additional sample of 13 quasars observed with the HST. The quasar redshifts are in the range $0.165 \leq z \leq 2.06$, and their absolute magnitudes are in the range $-30.1 \leq M_V \leq -24.4$ (for $H_0=50 \text{ km s}^{-1}$, $q_0=0$). The typical signal-to-noise ratio (S/N) per resolution element is ~ 20 (vs. ~ 60 in our previous study), and the spectral resolution (R) is ~ 1300 , or $\sim 230 \text{ km s}^{-1}$.

Pre-HST studies of ultraviolet (UV) emission properties of low-redshift AGNs were limited to low resolution ($R \sim 300$), low S/N ($\lesssim 10$) spectra, and were feasible only for relatively bright AGNs (e.g. Green et al. 1980; Ulrich et al. 1980; Kinney et al. 1985, 1987). A large number of high quality spectra of AGNs have been obtained with the HST (Wills et al. 1993; Bahcall et al. 1993b; Paper I; Wills et al. 1994; Weymann et al. 1994). The higher resolution of the HST spectra allowed the first constraints on the narrow component of the permitted UV lines and indicated a surprisingly small contribution from the narrow line region (Wills et al. 1993; Paper I). High S/N HST spectra permit a reliable identification of some far UV lines, in particular N III $\lambda 991$ and C III $\lambda 977$ (Paper I), which previously could only be rarely identified (Michalitsianos *et al.* 1993). In some objects Ly α was found to be remarkably symmetric, which argues strongly against significant radial motion of optically thick clouds in the BLR. The C IV and Ly α profiles are generally very similar, which rules out models for the broad line region (BLR) in which the cloud velocities are virialized and the ionization parameter (U) varies as R^{-1} or faster. Some excess emission was found in the O VI red wing, which suggested the presence of an inner, high velocity, optically thin component with $U > 1$ in the BLR (Paper I).

The emission line blends are analyzed in this paper as in our previous study. We find the best fit model for each line blend using a sum of Gaussian components, and use this model to get an accurate measure of the total flux in the blend, the full width at half maximum (FWHM) of the blend, and the position of the blend's peak. Unlike our analysis in Paper I, we do not use the Gaussian deblending as one of the ways to measure the contribution of each line to the blend. We use the model fit to the blue wing of Ly α (or C IV when Ly α is unavailable) to form a "symmetric Ly α " template, and test whether the profiles of the various lines which comprise each blend are consistent with the "symmetric Ly α " template. This template deblending scheme is also used to estimate the flux in the blended lines.

In this paper we test whether the new results obtained in Paper I apply to a larger sample of 13 quasars observed by HST, and use the total sample of 18 quasars to look for correlations

of equivalent width (EW) with luminosity (i.e. the Baldwin effect). In particular, we examine the observed O VI and He II $\lambda 1640$ equivalent widths for evidence of the Baldwin effect, since these lines can provide critical tests for some of the explanations of this phenomenon. The objects in this paper and in Paper I were selected for the study of intervening absorption lines (see Bahcall et al. 1991; 1992a, b; 1993a, b), therefore they comprise a heterogeneous sample in terms of their intrinsic properties, and the wavelength coverage obtained for each object is often not complete. However, the significant advantage of this data set is the relatively high S/N available, which is not typically obtained in other HST programs designed to study emission line properties. The outline of this paper is as follows, in §2, we describe the observations and data reduction, and in §3 we briefly describe the line and continuum fitting procedures, and explain how a “composite” AGN spectrum was calculated. Our results are presented in §4, and their implications are discussed in §5. We conclude in §6 with a summary of our main results.

2 OBSERVATIONS

The 13 quasars were observed using the R=1300 gratings of the Faint Object Spectrograph (FOS). Table 1 lists the 13 objects in our sample, together with their J2000 positions, redshift, V and M_V magnitudes (calculated for $H_0=50 \text{ km s}^{-1}$, $q_0=0$), Galactic reddening, and the source from which optical spectroscopy was obtained. The coordinates were measured with the Space Telescope Science Institute’s Guide Star Selection System Astrometric Support Package and should be accurate to $\simeq 1''$. The V magnitudes were taken from the Véron-Cetty & Véron (1993) catalog. The redshifts were measured using [O III] $\lambda 5007$ in all quasars with $z \leq 0.53$ (excluding PG 1444+407 where $H\beta$ was used since [O III] $\lambda 5007$ is too weak). Otherwise, we used the peak position of the model fit to $\text{Ly}\alpha$. In one quasar, S4 1435+63, neither $\text{Ly}\alpha$ or C IV $\lambda 1549$ were available, and we therefore used C III] $\lambda 1909$. The reddening was deduced from the neutral hydrogen column density N_H (taken from Stark et al. 1992, or when available from Elvis, Lockman, & Wilkes 1989), and the relation $E(B-V)=N_H/4.8 \times 10^{21}$ found by Savage & Mathis (1979).

Table 2 lists the dates of the observations, the detectors and gratings used, and exposure times for each object. All observations were made through the $0.25'' \times 2.0''$ slit (absolute spectrophotometry is therefore not guaranteed). The wavelength ranges covered by each grating are 1150-1606 Å for the G130H, 1600-2310 Å for the G190H, and 2230-3280 Å for the G270H. The dispersions in the G130H, G190H, and G270H data are respectively 0.25, 0.36, and 0.52 Å pixel $^{-1}$, with approximate spectral resolutions (full width at half maximum) of 1.1 Å, 1.5 Å, and 2.0 Å for the three gratings. The data were calibrated as described in Schneider et al.

(1993). The S/N per resolution element are in the range of 8 – 50, with a typical value of ~ 20 .

Optical spectra were provided to us in digital form for 12 of the 13 quasars from the following sources: Steidel & Sargent (1991), the five PG quasars with $z \geq 0.77$; Boroson & Green (1992), five quasars with $z \leq 0.33$; 3C 232 was provided by B. Wills (private communication); and 4C 73.18 was provided by C. Lawrence (private communication). The optical spectrum of the remaining quasar, HS 0624+6907, was published by Groote, Heber, & Jordan (1989), and we used the [O III] $\lambda 5007$ redshift measured by these authors. All of the seven optical spectra for the objects at $z \leq 0.53$ include the $H\beta$ $\lambda 4861$ + [O III] $\lambda 5007$ lines.

The optical spectra of NAB 0024+22, PG 1241+176, PG 1538+477, and PG 1634+706, overlap with the HST spectra, however, the flux levels of the HST and ground based spectra at ~ 3250 Å do not accurately match. To prevent discontinuity between the optical and UV spectra we multiplied the corresponding optical fluxes by 1.15, 0.75, 1.17, and 1.35, respectively. The optical spectrum of 3C 232 also overlaps with the HST spectrum, but here the fluxes agree to better than 2% and no flux adjustment was required. We were not able to intercalibrate the optical and UV spectra for the other seven objects due to lack of overlapping coverage. The Fe II optical blends were subtracted from the optical spectra of the 7 objects for which $H\beta$ + [O III] is available using the same method described by Boroson & Green (1992).

We use the optical spectra of the low redshift quasars in order to: 1. Define the redshift using the peak of the narrow [O III] $\lambda 5007$ line. 2. Measure the narrow component of the broad lines using the FWHM of the [O III] $\lambda 5007$ line. 3. Compare the low-ionization $H\beta$ profile to that of the high-ionization UV lines. The optical spectra of the high redshift quasars are used to get more complete coverage of the rest frame UV emission.

3 THE LINE AND CONTINUUM FITTING METHOD AND THE COMPOSITE SPECTRUM

Below we briefly review our method for fitting the line and continuum emission. A detailed description of the fitting algorithm is given in Paper I.

A major difficulty in the analysis of the emission line properties of quasars is that basically all prominent lines are blended to various levels. In particular, O VI is blended with $Ly\beta$, $Ly\alpha$ with N V, Si IV with O IV], C IV with He II, C III] with Si III], and Mg II with Fe II. Additional weaker lines typically also appear in these blends (see §4.2.1). We approach this problem in two stages. In the first stage we measure the emission parameters of each blend as observed, i.e. with no attempt to deblend the contribution of individual components. In the second stage

we deblend the contribution of individual components by using a template line profile, i.e. by assuming all components of the blend have the same profile. A further complication results from the fact that some of the lines are multiplets, and these multiplets have different number of components, and different velocity separations between those components. Thus different lines might not have similar profiles even if they are all emitted by the same distribution of clouds. This is taken into account by fitting each component of a multiplet with the template profile, as described in more details below.

To obtain the first stage fit one needs to define and subtract off the continuum. The continuum fit is made locally for each emission blend. We divide each spectrum into sections that are $\sim 200 \text{ \AA}$ wide, centered around the six prominent emission blends (O VI, Ly α , Si IV/O IV], C IV, C III], and Mg II). For each section we define the local continuum as a power-law that intersects the spectrum at the two end points. In the next step we obtain an acceptable smooth model for the intrinsic line profiles. The smooth model allows an accurate determination of the basic emission line parameters (total flux, FWHM, and position of the peak emission) without being significantly affected by sharp absorption features. We model the observed emission line profiles as a sum of Gaussian components and use a χ^2 minimization routine (MRQMIN from Press et al. 1989) to allow the initial guess of the model parameters to converge on the best fit solution. The best fit Gaussian components can in principle be used in order to deblend the various lines contributing to a blend. A Gaussian deblending scheme is, however, unlikely to yield reliable results since different lines in a blend would generally be fit with rather different profiles, while as was shown in Paper I, the observed blend profile can be reproduced well in some objects using the simpler assumption that all lines have exactly the same profile. We therefore used the Gaussian deblending scheme only for measuring the total flux, FWHM, and position of the peak of each blend. We do not use the Gaussian deblending scheme as one of the ways to deduce the contribution of individual lines to a blend, as done in paper I.

To make the second stage fit we need to define a template line profile. The only strong relatively unblended part of a singlet line is the blue wing of Ly α . We use the model fit to the blue wing of Ly α to construct a symmetric template profile, and use this template to find the best fit model to each blend. In a few objects for which Ly α is not available, we use the blue wing of C IV $\lambda 1549$ instead. Note that since C IV $\lambda 1549$ is a doublet with an equivalent velocity separation of $\sim 500 \text{ km s}^{-1}$ the peak of the line is broader than the intrinsic width of each of the doublet components. The free parameters in the template fit are the flux and velocity displacement (i.e. peak position) of each line in the blend. Some of the lines in the blends are multiplets of two or more components. The multiplet profile is constructed as a sum of templates which represent the multiplet components. In the fitting process the velocity of the

multiplet is a free parameter, but all the multiplet components are constrained to have the same velocity displacement. The total flux in the multiplet is a free parameter, but the flux ratio of the multiplet components is fixed at the statistical weight ratio (e.g. 2:1 for the $\lambda\lambda$ 1548, 1551 components in C IV). This method allows us to test the significance of the apparent differences in the observed line profiles, even when these lines are multiplets. When an acceptable fit is possible the deblending result is likely to be reliable.

The template fitting algorithm requires an initial guess for the parameters of each lines. This guess is made subjectively, and a number of iterations with different initial guesses are made until the apparently best possible fit is achieved. In the case of strongly blended lines (e.g. Si III] λ 1892) or of very weak lines (e.g. C III λ 977) we generally fix the velocity shift a priori to be zero.

The use of the statistical weight ratio for the multiplet components flux ratio is justified if the lines are produced purely by collisional excitation and if they are not thermalized (e.g. Osterbrock 1989). These conditions are likely to apply for all the permitted metal lines (see discussion of line optical depths in Ferland et al. 1992). In the case of the semi-forbidden lines, in particular for the O IV] λ 1402 multiplet, the component ratios can have a more complicated dependence on temperature and density (e.g. Keenan et al. 1993), and will asymptotically approach unity for densities above 10^{10} cm^{-3} . For the sake of simplicity we ignored such effects in the fitting algorithm.

A composite spectrum was calculated by averaging at each frequency the logarithmic spectral slope of all objects, $\alpha_\nu^i = d \ln f_\nu^i / d \ln \nu$, where f_ν^i is the Gaussian smoothed (see §4.1) flux density of a given object. The average at each frequency, α_ν^{av} , is calculated in two iterations. In the first iteration all objects for which a slope is available are included, and the average slope α_ν^{av} , and dispersion from the mean, σ' , are calculated. In the second iteration only slopes within $2\sigma'$ of α_ν^{av} are included in calculating a revised average slope α_ν^{av} . The composite flux is then obtained by integrating back the derivatives spectrum, i.e.

$$f_\nu^{\text{comp}} = \int_{\nu_0}^{\nu} \alpha_{\nu'}^{\text{av}} d\nu' .$$

This method has two advantages over using a simple mean of $\ln f_\nu^i$. First, narrow absorption lines do not affect the shape of the composite, these lines produce very large values for α_ν^i , which get rejected by the 2σ clipping procedure. Second, the number of objects included in the average changes with frequency, and since our sample is rather small, the addition/subtraction of a single object can result in a noticeable discontinuity of the average. In our method the discontinuity is only in the value of α_ν^{av} , and f_ν^{comp} is continuous by construction.

The software developed for fitting the line profiles, for the template deblending, and for generating the composite is available from the first author upon request.

4 RESULTS

4.1 *The Continua*

Figure 1 displays the spectra of the 13 quasars in our sample. The spectra are shown using rest wavelengths; they are corrected for Galactic reddening using the extinction values given in Table 1 and the reddening law of Seaton (1979). The spectra were smoothed with a Gaussian with a FWHM of 4 pixels (i.e. one resolution element). This smoothing does not affect the emission features studied here as they are all well resolved (see Paper I), and it allows weak narrow absorption features to be more easily discerned.

The average spectrum of ~ 700 quasars observed from the ground by Francis et al. (1991, hereafter the Francis et al. composite) is also shown for comparison. Note the remarkable similarity of the spectra of many quasars at $\lambda \gtrsim 1300 \text{ \AA}$ (e.g. the low redshift quasars PG1302–102 and PG 1444+407), to the Francis et al. composite which represents redshift $z \sim 1 - 2$ quasars. Comparable similarity was found in our previous study of five small redshift ($z \leq 0.5728$) AGNs. The large discrepancy shortward of $\text{Ly}\alpha$ is most likely due to unresolved $\text{Ly}\alpha$ absorption systems which depress the continuum level in the Francis et al. composite. The broad emission feature on the red side of $\text{C IV } \lambda 1549$ (at $\lambda \sim 1600 \text{ \AA}$), which was noted in Paper I, is also seen here at various levels.

The monochromatic luminosity νL_ν at $1350 \text{ \AA}$ and spectral slopes $\alpha_{\lambda_1-\lambda_2}$ in different parts of the spectrum are given in Table 3. We also include in Table 3 the five AGNs from Paper I, as their slopes were not previously reported. The slope $\alpha_{1350-2200}$ is available for most objects and the average is $\langle \alpha_{1350-2200} \rangle = -0.58 \pm 0.33$. Both $\alpha_{\lambda < 1350}$ and $\alpha_{\lambda > 2200}$ are generally steeper than $\alpha_{1350-2200}$ and show a larger dispersion, with $\langle \alpha_{\lambda < 1350} \rangle = -1.25 \pm 0.92$ and $\langle \alpha_{\lambda > 2200} \rangle = -1.06 \pm 0.44$. The fact that $\alpha_{\lambda < 1350} < \alpha_{1350-2200}$ probably results from the overall convex continua of quasars in the optical-UV range, while the fact that $\alpha_{\lambda > 2200} < \alpha_{1350-2200}$ is most likely due to significant contribution of Fe II blends at $\lambda > 2200 \text{ \AA}$, which increase the apparent continuum level (see Wills, Netzer, & Wills 1985).

Figure 2a shows the HST composite vs. the Francis et al. composite. The HST composite is based on a total of 18 quasars reported here and in Paper I (note it also includes optical spectra of the rest frame UV of five high-redshift quasars), and it was generated by slope averaging, as

described in §3. The two composites are remarkably similar, despite the fact that the Francis et al. composite is based only on high redshift ($z \sim 2$) quasars, and was derived using a much larger sample (~ 700 optically selected quasars). Note that even some very weak features, e.g. between O III] $\lambda 1664$ and Al III $\lambda 1857$, appear to be present in both sets of spectra.

Figure 2b presents the luminosity dependence of the emission properties. The quasars were divided to three equal groups according to their (νL_ν) at 1350 Å (see Table 3). The average luminosity difference between adjacent groups is about an order of magnitude. Note how the EW of essentially all the emission features gets weaker with increasing luminosity. This is the well known Baldwin effect (Baldwin 1977), first observed for the C IV line. We explore this effect more quantitatively in sections 4.2.5, and 5.6.

4.2 The Lines

4.2.1 Emission line parameters

Table 4 gives the total flux, EW, FWHM, and position of the peak emission for the following blends in each spectrum: 1. O VI+Ly β +N III+C III+Ly γ , 2. Ly α +N V+O I+C II, 3. Si IV+O IV], 4. C IV+He II+O III]+N IV], 5. C III]+Si III]+Al III, and 6. Mg II, which is blended with Fe II. The fit parameters were measured using the best fit model derived using the sum of Gaussian components (see §3). The measurement errors have been estimated by repeated fittings with the continuum level displaced by $\pm 1\sigma$, as described in Paper I. The line fluxes given in Table 4 are in the observed frame, and the EW are given in the rest frame, i.e. they are equal to the observed EW divided by $(1+z)$. The O VI and the Si IV+O IV] blends have the broadest profile, having an average FWHM= 5590 ± 1300 and 5860 ± 1040 km s $^{-1}$, respectively (error is dispersion about the mean). The Ly α and C IV blends have the narrowest profiles with FWHM= 3730 ± 1420 , and 4250 ± 1270 km s $^{-1}$ respectively. Note that some of the velocity shifts reported in Table 4 are strongly affected by blending, in particular in the O VI and the Si IV+O IV] blends, and probably do not reflect actual velocity shifts. More reliable measurements of the true velocity shifts can be deduced using the template deblending results given in the following section.

The local continuum slope defined for each blend is usually different from the values in Table 3 which were measured over larger wavelength ranges. This indicates, as mentioned in Paper I, the presence of as yet unidentified broad quasi-continuum emission features in the spectra.

Table 5 presents measurements of the weaker UV lines; O I $\lambda 1303$, C II $\lambda 1335$, N III $\lambda 1750$, and Si II $\lambda 1814$, which can be discerned in some of the spectra. Note that due to the weakness

of these lines the associated measurement errors are significantly larger than the errors in Table 4.

The spectrum of NAB 0024+22 extends down to 770 Å, and a broad emission feature is apparent at 820-840 Å. A single Gaussian fit to this feature yields $\lambda_{\text{center}} = 831.6$ Å, $F_{\text{line}} = 1.9 \times 10^{-14}$ erg s⁻¹, EW=3.4 Å, and FWHM=5490 km s⁻¹. This feature is probably due to the O II λ833 triplet + O III λλ833, 835 quartet. This wavelength range is unobservable in the other quasars studied here. This wavelength range is observable in PKS 0405–123 studied in Paper I, however, the strong geocoronal O I λ1303 emission line does not allow features near 830 Å to be reliably identified.

4.2.2 Template deblending

Figures 3-8 present the template fits to the prominent UV blends whose integrated parameters are given in Table 4. The χ^2 and the number of data points included in each fit are indicated in each panel. Some of the lines were obtained from ground based observations. In these cases, we do not have a measurement of the flux uncertainty as a function of wavelength, and therefore only the number of points is indicated. In six objects, Lyα is not available, in four of these we use C IV instead, and in the other two two objects, HS 0624+6907 and S4 1435+63, where neither Lyα or C IV are available, we use C III] or the best fitting template of another quasar instead.

Table 6 gives the best fit total flux and velocity shift for each line in the blends measured in Table 4 (excluding Mg II, which is blended with a large number of Fe II multiplets). The contribution of the individual lines in these blends was measured using the template deblending scheme mentioned above. The velocity shifts are measured with respect to rest wavelengths determined using the redshifts given in Table 1 (measured mostly using [O III] λ5007 or Lyα). We arbitrarily fixed the velocity shifts of Lyβ and Lyγ at the best fit value of Lyα, and for other weak components we generally fixed the velocity shift at zero. In some cases the template method provides a very bad fit to the observed blend profile (e.g. He II in PG 1216+069, see Fig.6), and an appropriate comment is made in Table 6.

The profile of the O VI blend in eight quasars is presented in Figure 3. This blend is generally fit remarkably well with the template method in the ~ 950-1050 Å wavelength range. As found in Paper I, essentially all the difference in FWHM between the Lyα and O VI blends can be explained by the wide separation of the O VI doublet components (1651 km s⁻¹) and some additional blending with Lyβ (at -2348 km s⁻¹). An excess flux with respect to the best fit template is present at $\lambda \sim 1060$ -1090 Å. A similar excess was noted in Paper I (see

Fig.6 there). This broad excess appears to have a peak at $\lambda \sim 1070 \text{ \AA}$, and it is therefore most likely a distinct component unrelated to O VI. Possible identification of this feature is discussed in §5.3. The excess flux at $\lambda < 1000 \text{ \AA}$ is well fit by contributions from N III $\lambda 991$, Ly β , C III $\lambda 977$, and Ly γ . Note that since the lines at $\lambda < 1000 \text{ \AA}$ are weak and strongly blended their actual fluxes could be different than reported in Table 6, in particular if their velocity shifts are different than assumed here.

Figure 4 presents the Ly α blend profile in seven quasars. The Ly α blend is generally fit well with a template, excluding PG 1241+176, where N V is significantly less peaked, and 3C 232, where Ly α is distinctly asymmetric. We also included a component at $\sim 1263 \text{ \AA}$ in four of the seven quasars, most likely due to Si II emission (see also Paper I). A weak excess flux centered at $\sim 1175 \text{ \AA}$ is apparent in three of the 7 quasars. Its flux is 2-5% of the Ly α flux. We tentatively identify this feature as emission from the collisionally excited metastable level of C III, as predicted by Bahcall & Sargent (1967).

The template fit to the Si IV+O IV] blend in 10 quasars is presented in Figure 5. The Si IV was modeled as a doublet at 1393.76 and 1402.46 $\text{\AA}$, with a 2:1 flux ratio. The O IV] multiplet was modeled with five components at 1397.23, 1399.78, 1401.16, 1404.81, and 1407.38 $\text{\AA}$, and a 2:1:6:4:2 flux ratio (see Morton 1991). The Si IV+O IV] blend is generally fit quite well with the template method, the Si IV/O IV] flux ratio is typically one, and the velocity shift is generally consistent with zero. Note that since Si IV and O IV] are strongly blended, and the observed profile is relatively noisy, the Si IV/O IV] flux ratio could be significantly different than found here if a different velocity shift is assumed.

Figure 6 presents the template fit to the C IV blend in 11 quasars. Some deviations of the observed profile from the best fit are apparent in most objects. The most common discrepancy is some excess flux at $\sim 1600 \text{ \AA}$. The amplitude of this excess varies significantly among the objects. It is particularly strong in PG 1241+176 and PG 1444+407, and is absent in PG 1116+215 and PG 1202+281. A similar feature was described in Paper I. The C IV profile appears to be significantly asymmetric in some objects (e.g. 3C 232, PG 1634+706), and both red excess, and blue excess asymmetries are present.

Figure 7 presents the template fit to the C III] blend in 12 quasars. Both the Si III] line and the Al III doublet are apparent in most blends. Significant deviations from the template fit are present in most objects, in particular C III] tends to have a weaker red wing compared with the template profile, and a somewhat stronger core emission. However, in some objects (e.g. PG 1302-102, 4C 73.18) the template provides a rather good fit.

The Mg II profile is presented for six objects in Figure 8. The profile is generally rather noisy, however its profile appears to deviate significantly from the template in all cases. These

large deviations are likely to result from blending with the underlying Fe II emission which could not be subtracted.

Figure 9 presents a comparison of the $H\beta + [\text{O III}] \lambda\lambda 4959, 5007$ profile with the template profile in seven quasars. Excluding the case of 4C 73.18, the $H\beta$ and template profiles are very different, with $H\beta$ significantly narrower than the template in four of the seven quasars. The emission from Fe II blends was subtracted from the $H\beta + [\text{O III}] \lambda\lambda 4959, 5007$ profile using the template method of Boroson & Green (1992). The S/N of the optical spectra are quite high, and the narrow $[\text{O III}] \lambda\lambda 4959, 5007$ doublet should have a negligible effect on the $H\beta$ profile. Thus the observed profile differences must reflect intrinsic differences in the $H\beta$ vs. the $\text{Ly}\alpha$ and the C IV $\lambda 1549$ profiles.

4.2.3 Velocity shifts

Table 7 summarizes the average velocity shifts measured here (from the values in Tables 4, 5, and 6), the shifts found in Paper I, and the shifts deduced for the combined sample of 18 quasars. The uncertainties in the mean values represent the dispersion about the mean, rather than the error in the value of the mean (which is smaller by a factor of $\sqrt{N_{\text{objects}}}$).

Most of the emission line peaks are shifted by no more than a few hundred km s^{-1} with respect to their expected position based on either $[\text{O III}] \lambda 5007$ or $\text{Ly}\alpha$. Note that the velocity shift of O VI cannot be measured directly from the shift of the observed peak of the O VI blend (given in Table 4) from its expected position since the expected peak position of the blend is not known a priori. The expected peak position is strongly dependent on the amount of blending of the O VI doublet components, and the blending is determined by the intrinsic profile of the doublet components. The expected peak position could also be affected by blending with $\text{Ly}\beta$. The low value of $\langle V_{\text{shift}} \rangle$ for O VI found here ($130 \pm 270 \text{ km s}^{-1}$) is consistent with the low shift ($230 \pm 60 \text{ km s}^{-1}$) found in three objects in Paper I.

We find similar $\langle V_{\text{shift}} \rangle$ in Paper I and here for $\text{Ly}\alpha$, C IV, and C III] vs. $[\text{O III}] \lambda 5007$, and for the combined sample we get $\langle V_{\text{shift}} \rangle = -200 \pm 150$, -240 ± 320 , and $-115 \pm 330 \text{ km s}^{-1}$ respectively. The average C IV and C III] vs. $\text{Ly}\alpha$ shifts in the combined sample are smaller and consistent with zero (-35 ± 140 and $55 \pm 210 \text{ km s}^{-1}$ respectively).

The low ionization lines, Mg II, O I and C II have an average redshift of 200-300 km s^{-1} with respect to $\text{Ly}\alpha$, and the values obtained in the combined sample are 250 ± 110 , 470 ± 620 , and $310 \pm 590 \text{ km s}^{-1}$ respectively. These low ionization lines are at roughly zero shift with respect to $[\text{O III}]$. For the high ionization He II line we find the highest $\langle V_{\text{shift}} \rangle$ in both Paper I and here, with $\langle V_{\text{shift}} \rangle = -470 \pm 280 \text{ km s}^{-1}$, relative to $[\text{O III}] \lambda 5007$ obtained for the combined

sample.

As mentioned in Paper I, we expect the HST absolute wavelength calibration to be accurate to $\sim 60 \text{ km s}^{-1}$. Thus measured velocity shifts between optical and UV lines of this order or less are not statistically significant.

4.2.4 *The Narrow-Line contribution*

Table 8 presents upper limits on the contribution of a narrow [O III] $\lambda 5007$ -like component to the total flux in Ly α , C III] and H β for each object. This contribution is measured by repeating the Gaussian fitting process described above with the further constraint that the velocity dispersion of the narrowest Gaussian component be equal to that of [O III] $\lambda 5007$, as measured for each object. We did not attempt to measure upper limits on a narrow component in either O VI, C IV or Mg II since all these lines are doublets with velocity separations of $500 - 1600 \text{ km s}^{-1}$, which results in broadening of the observed peaks of these lines, and a possibly significant reduction in the apparent narrow component.

The typical upper limit for all three lines is 1-4% with an average of $\sim 3\%$. In a few cases (Ly α and H β in 3C 232, and H β in PG 1444+407) much higher contributions of about 15-25% are possible. A similar upper limit of typically 3% was found for H β in Paper I, but somewhat larger values, $\sim 5 - 6\%$ were found there for Ly α and C III].

The typical EW upper limit on the narrow component is $\sim 3 \text{ \AA}$ in Ly α , $\sim 1 \text{ \AA}$ in C III], and $\sim 3 \text{ \AA}$ in H β . Note that the very high upper limit of 25% on the contribution of a narrow component to H β in 3C 232 does not result from a particularly strong narrow component, but rather from the unusually weak broad H β in this object. In the cases of Ly α in 3C 232 and H β in PG 1444+407 the large upper limits reflect a particularly strong narrow component.

Also indicated in Table 8 are the narrow component to [O III] $\lambda 5007$ flux ratio for each line, together with the expected ratio if the quasars had a Seyfert 2 like narrow line region. The Seyfert 2 flux ratios are taken from the composite Seyfert 2 emission line spectrum presented by Ferland & Osterbrock (1986). The observed upper limit on the narrow H β /[O III] $\lambda 5007$ flux ratio is always comparable or larger than the expected ratio, where the expected ratio is based on the assumption that quasars have a Seyfert 2 like narrow line region. Note that in the case of PG 1202+281 the narrow component of H β is well resolved (Fig.9), and its flux matches well the flux predicted based on the Ferland & Osterbrock composite.

The upper limit on the narrow C III] component in four of the seven quasars is smaller than the expected value, in three of which it is smaller by a factor of about 5. The upper limit on the narrow Ly α component in all three available quasars is smaller than the expected ratio by

up to a factor of three.

Note that the [O III] $\lambda 5007$ fluxes obtained from Boroson & Green (1992) are based on narrow slit spectra. A comparison with the low resolution, broad slit, spectrophotometry of Neugebauer et al. (1987) of the same objects suggests that the Boroson and Green absolute flux calibrations are systematically lower (by typically $\sim 30\%$). This implies that the predicted fluxes in the narrow UV lines should actually be higher, and would therefore imply a higher discrepancy than found above. Such a calibration offset has no effect on the predicted narrow component fraction of $H\beta$, since the narrow [O III] $\lambda 5007$ flux and $H\beta$ were measured from the same spectrum.

4.2.5 *The EW vs. luminosity correlation*

Figure 10 presents the EW vs. luminosity relation for 10 of the emission lines measured here. We also included in the analysis the 5 AGNs reported in Paper I. The equivalent widths of $Ly\beta$, O VI, $Ly\alpha$, N V and He II were taken from the results of the template deblending, and the equivalent widths of the other lines were taken from Tables 4 and 5 since blending is either insignificant, or because template deblending cannot be made accurately. The best fit slope $\alpha = d \log EW / d \log \nu L_\nu$, obtained by a least square fit, and the associated error, are indicated in each panel. This slope should only serve as a rough estimate for the possible strength of the EW vs. luminosity dependence. More detailed statistical analysis is not carried out here since only 10-15 data points are typically available for each line. Note also that our small sample is neither complete or well defined, and it is not clear whether the EW vs. luminosity dependence is affected by selection effects.

All lines, except N V, appear to show a significant Baldwin effect (i.e. $\alpha < 0$). We typically find $\alpha = -0.15$ to -0.25 , excluding the case of N V, where α is clearly consistent with zero. Note also the remarkably small scatter in the EW vs. luminosity relation for the Si IV+O IV] blend.

5 DISCUSSION

5.1 *Relative Line Fluxes*

In Paper I we reported the first relatively accurate measurements of S VI $\lambda\lambda 933, 945$, $Ly\gamma$, C III $\lambda 977$, N III $\lambda 991$, and $Ly\beta$ in four quasars. Here this wavelength range is observable in

up to eight more quasars. Below we compare the results found here for these weak or strongly blended lines with the results of Paper I.

The S VI $\lambda\lambda 933, 945$ wavelength region is observable in five of the 13 quasars, but this line was not reliably detected in these spectra. However, these spectra have a lower S/N ratio at rest frame 940 Å region, compared with the spectrum of PKS 0405–123, where this feature was detected with EW=3 Å (Fig.2 in Paper I). A somewhat weaker feature would be unobservable in our five spectra.

All seven quasars observable at 970-980 Å show some emission excess which can be attributed to Ly γ + C III $\lambda 977$. This excess is fit with the template method in five objects, where the S/N in the feature allows some rough fit to be made. We find Ly γ /Ly α = 0.015 and 0.05 in two objects and zero in two other others, vs. a ratio of 0.017 for one object in Paper I. We find C III/O VI= 0.10 ± 0.04 (all uncertainties are dispersions about the mean) in four objects, and zero in one object, vs. a much larger, but rather uncertain, ratio of 0.35 found for one object in Paper I. The C III $\lambda 977$ line is predicted to be strong in high density clouds, where other efficient coolants become effectively optically thick (Netzer 1990). Its relative strength should therefore allow constraints on high density clouds in the inner parts of the BLR.

The N III line is detected here in six quasars, and the N III/O VI flux ratios are similar to those obtained in Paper I. Using 9 objects in the combined sample we find an average N III/O VI= 0.16 ± 0.10 . A non-zero contribution of Ly β is deduced in seven of the eight quasars where O VI was measured. We find an average Ly β /O VI= 0.34 ± 0.26 , which is consistent with the 0.24 ± 0.10 measured in four quasars in Paper I. The combined sample yields Ly β /O VI= 0.30 ± 0.21 . Both Ly α and Ly β are available here for five objects, and we find Ly β /Ly α = 0.059 ± 0.04 , which is very similar to the average of 0.062 ± 0.04 found in four quasars in Paper I. We should note, however, that Ly β is not clearly resolved from O VI in any of our spectra. Thus if O VI is somewhat broader than Ly α , and if its peak is somewhat shifted to the blue, then the actual flux in Ly β will be significantly smaller than estimated here.

For the combined sample we get an average Ly γ /Ly β /Ly α decrement of 0.03:0.06:1.0 (using four detections of Ly γ and nine detections of Ly β), which is similar to the decrement obtained in Paper I using a smaller sample.

The average O VI/Ly α and N V/Ly α ratios found here (0.21 ± 0.09 , 0.15 ± 0.10) are similar to those found in Paper I (0.23 ± 0.09 , 0.135 ± 0.01), although a much larger dispersion in the N V/Ly α ratio is found here. The weak Si II $\lambda 1263$ triplet was measurable here in four quasars, yielding Si II/Ly α = 0.023 ± 0.010 , and the combined sample with 7 objects yields 0.027 ± 0.013 .

The average Si IV+O IV]/Ly α in both samples is generally similar, and for the 10 objects in the combined sample we get 0.098 ± 0.034 . We find here an average He II/Ly α = 0.030 ± 0.006

(6 objects), which is significantly larger than $= 0.018 \pm 0.007$ (4 objects) found in Paper I. Note that in Paper I the He II flux was measured with the Gaussian deblending method, and not with the template fitting method as done here, which might introduce some systematic difference.

A detailed comparison with pre-HST results of the UV line ratios is given in Paper I.

5.2 *Line Velocity Shifts*

As found in Paper I, the peaks of Ly α C IV and C III] are on the average blueshifted with respect to [O III] $\lambda 5007$, and for the complete sample we find average blueshifts of -200 ± 150 , -240 ± 320 and -115 ± 330 km s $^{-1}$ (see Table 7). The velocity shift of Ly α deviates from zero by 3.5σ , the shift for C IV is 2.6σ and is therefore only marginally significant, and the shift for C III] is insignificant (1.2σ). As already noted in earlier studies (e.g. Steidel & Sargent 1991), the dispersion in the velocity shifts is generally large and comparable to the mean values of the velocity shifts. This implies, for example, that the peaks of Ly α , C IV, and C III] can be redshifted, rather than blueshifted with respect to [O III] $\lambda 5007$, in a significant number of objects in a given sample.

He II shows the highest average blueshift relative to [O III] $\lambda 5007$ in our combined sample (-470 ± 280 km s $^{-1}$). The low ionization lines; Mg II, O I, C II and H β , have an average shift in the combined sample which is consistent with zero, or possibly with a small shift to the red.

These results are qualitatively consistent with the earlier studies of Gaskell (1982), Wilkes (1984, 1986), Uomoto (1984), Espey et al. (1989) and Corbin (1990), who found that the low ionization lines are on the average redshifted with respect to the high ionization lines. However, the average velocity shifts measured here are significantly smaller than those found in most of these studies. Our results are consistent with the average velocity shifts found by Tytler & Fan (1992) in a detailed analysis of a large sample of quasars. Corbin (1990) and Tytler & Fan (1992) suggested that the velocity shift increases with increasing ionization state, this trend implies that O VI should be blueshifted by ~ 300 km s $^{-1}$ or more. However, here we find a small shift (40 ± 80 km s $^{-1}$) for O VI relative to [O III] $\lambda 5007$ which is consistent with zero. The N V line is also typically redshifted, rather than blueshifted, as would be expected from the velocity shift vs. ionization level correlation. However, the velocity shift of N V is a less reliably measured compared with the shift for O VI, since it is strongly blended with Ly α .

The deduced velocity shifts depend on the assumed flux ratio in the multiplet components. As shown in Paper I (Table 7 there), a negative velocity shift of a few hundred km s $^{-1}$ is obtained for O VI if the doublet components are assumed to have an equal flux, compared with

the zero velocity shift which is deduced assuming the statistical weight flux ratio, as done here. However, if O VI is produced by UV photoionization, then the O VI $\lambda 1034$ line is very unlikely to have a large enough optical depth to produce a flux ratio of one.

5.3 *New Emission Features*

Three new emission features are apparent in our spectra. We detect an emission feature in the spectrum of NAB 0024+22, centered at $831.6 \text{ \AA}$, with an EW of $3.4 \text{ \AA}$, and 5% of the Ly α flux. As mentioned above, this feature is most likely to be due to emission of O II $\lambda 833$, and O III $\lambda\lambda 833, 835$. Bruhweiler, Kafatos & Sofia (1986) suggested the presence of this feature in IUE spectra of 3C 232 (included in our sample), however, they note this feature might not be real since it coincides with an artifact feature sometimes seen in SWP images. Unfortunately, our HST spectrum of 3C 232 extends only down to rest frame $1050 \text{ \AA}$, and the presence of this feature cannot be verified. As noted by Bruhweiler et al., if this feature is mostly due to O II $\lambda 833$, it indicates that charge transfer has a significant effect on populating the O II excited levels (see discussion in Dalgarno & Sternberg, 1982). However, Rees, Netzer & Ferland (1989, Table 1) predict O III $\lambda\lambda 833, 835/\text{Ly}\alpha = 0.04$ for a relatively high density and a low ionization parameter ($U = 0.01$, $n = 10^{12}$), which is close to the value of 0.05 found here. The exact identification of this feature would therefore allow interesting constraints on the physical conditions in the BLR.

We also detect here a broad emission feature at $\lambda \sim 1060 - 1090 \text{ \AA}$, which peaks at $\lambda \sim 1070 \text{ \AA}$ (Fig.3). The He II $\lambda 1085$ line (the “H γ ” line of He II) might have a small contribution to this feature. It is not likely to explain a significant fraction of the flux because of the large velocity shift required (4000 km s^{-1}), and since it is predicted to be significantly weaker than He II $\lambda 1640$. Similarly, the N II $\lambda 1085$ multiplet is very unlikely to dominate this feature. We find two other possible identifications for this feature. The first option is the S IV $\lambda 1070$ triplet, the other option is a blend of Fe II multiplets. It seems to us that the Fe II identification is more likely since this feature tends to lack a narrow core (e.g. NAB 0024+22 in Fig.3) as expected for an emission blend, and also since the other S IV multiplet at $1410 \text{ \AA}$ was not reliably detected and must therefore be rather weak. Detailed calculations of Fe II emission in AGNs were presented by Netzer & Wills (1983), and were compared with observations at $\lambda > 1500 \text{ \AA}$ by Wills, Netzer, & Wills (1985). These models do not predict significant Fe II contribution below Ly α (Netzer 1994, private communication), and it remains to be tested whether the $1070 \text{ \AA}$ feature can be reproduced in improved Fe II models (e.g. by including enhanced Fe II pumping by Ly α photons, as discussed for example by Netzer & Wills 1983,

and Elitzur & Netzer 1985).

The third feature identified here at $\lambda \sim 1175 \text{ \AA}$ in three quasars (Table 6) is tentatively identified here as C III* $\lambda 1176$. This line was predicted by Bahcall & Sargent (1967), but has not previously been identified in emission of other quasars. This is a collisionally excited line which originates from a metastable level of C III which is most likely populated by collisions. This line was identified in absorption by Kriss et al. (1992) in the UV spectrum of NGC 4151. As discussed by Bahcall (1967) and Kriss et al., a significant population of C III* can be obtained for an electron density $n_e \gtrsim 10^{10} \text{ cm}^{-3}$, and temperature $T \gtrsim 2 \times 10^4 \text{ K}$, which are similar to the typical parameters in the BLR clouds. Detailed photoionization models will allow us to understand whether the combined data set for the C III] $\lambda 1909$, C III $\lambda 977$, and C III* $\lambda 1176$ lines, can be reproduced using a unique solution for the temperature and density in the C III layer, or whether a population of different clouds is essential.

5.4 Line Profiles

Most line profiles cannot be accurately compared by simply plotting or measuring the observed profiles. This results, as described in §3, from the fact that most lines are either doublets or higher multiplets, and since most lines are blended with other emission features. Thus for example, if all lines originate from clouds with the same velocity distribution then the apparent O VI profile will appear broader than N V, N V broader than C IV, and C IV broader than Ly α . In order to make a meaningful comparison of the intrinsic line profiles we form a symmetric template line profile (using the blue wing of Ly α), and use it to form templates for lines which are multiplets. We then test whether the observed blend profiles can be fit with a sum of line templates, where the free parameters are the fluxes and velocity shift of each line.

We find that the O VI blend profile is fit remarkably well using the template in the six quasars where an intrinsic Ly α template is available. The high O VI/Ly α flux ratio found here and in earlier studies (discussed in Paper I) requires a rather high ionization parameter ($U > 0.1$). Baldwin & Netzer (1978) suggested this might indicate the presence of a low column density (N) high U ($U \sim 1$) component in the BLR, where O VI is one of the main coolants. More recently Ferland, Korista, & Peterson (1990) and Peterson et al. (1993) also suggested the presence of an optically thin component, presumably with a high ionization parameter ($U \gtrsim 1$) inside the BLR, which they called the very broad line region (VBLR). Additional support for such a component was found in Paper I in which we noted the excess flux in the red wing of O VI over the template fit. However, with the addition of eight more high-quality O VI profiles, it now appears that the excess flux is actually a distinct feature, peaked at about 1070 $\text{\AA}$, and

is unrelated to O VI.

The O VI line is one of the strongest coolants for $U \gtrsim 1$ (e.g. Ferland et al. 1992), and the O VI/Ly α flux ratio is 10 times larger (or more) than found for more typical BLR parameters ($U \sim 0.1$). The VBLR is then expected to produce strong O VI emission with a broad profile. The similarity of the Ly α and O VI profiles rules out a significant O VI emission from such a VBLR component, and therefore a VBLR component with $U \gtrsim 1$ is unlikely to exist. We cannot rule out a high U component if it has the same velocity distribution as the rest of the gas in the BLR, or if it has a significantly larger velocity dispersion ($\text{FWHM} > 10,000 \text{ km s}^{-1}$), in which case it becomes very difficult to detect.

The H β profile is significantly different from the profiles of Ly α and C IV in six of the seven quasars for which a comparison can be made. Considerable differences were found in Paper I only in two of the five AGNs. The differences are not systematic, although a narrower H β is more common. The presence of these profile differences implies that most of the H β emission is produced by clouds in the BLR with significantly different kinematics compared with the clouds which produce the bulk of the UV emission lines. Corbin (1991) found a correlation between the H β and C IV FWHM in low-redshift AGNs. The scatter about this correlation is generally consistent with the differences in the two line profiles found here. The differences in profiles is consistent with studies of the emission lines response to continuum variations in low luminosity AGNs which indicate that H β generally varies on longer time scales than either Ly α or C IV (see a recent review by Peterson 1993). Note, however, that if the line widths are proportional to the depth of the potential well, then the line variability studies would imply that H β should be narrower, which is not always the case here (e.g. PG 1216+069, see also PKS 0405–123 and H1821+643 in Paper I). Collin-Souffrin et al. (1988) and Dumont & Collin-Souffrin (1990) suggested that the low ionization lines, in particular H β , originate in a different population of clouds than the higher ionization lines, which is consistent with the different profiles found here. However, since the H β production mechanism is not clearly established, in particular its large strength relative to Ly α , and since the difference between H β , Ly α and C IV are not systematic in all objects, one cannot yet draw clear conclusions concerning the relation between the physical properties and the kinematics of the BLR clouds.

The Ly α +N V blend is generally fit well with the symmetric Ly α template, as found in Paper I, although in some objects, in particular 3C 232 and PG 1241+176 (Fig.4), the Ly α profile has significant asymmetry. We do not attempt to put quantitative constraints on the possible Ly α asymmetry in this study since the S/N available here is generally lower than in Paper I. As noted in Paper I and in earlier studies, in particular Wilkes & Carswell (1982), the high degree of symmetry of Ly α strongly constrains any significant radial motion of optically

thick clouds in the BLR, as suggested for example in the models of Emmering, Blandford & Shlosman (1992), and Kallman et al. (1993).

As found in Paper I, the C IV profile is generally similar to the symmetric Ly α profile (excluding the 1600 Å excess), which based on the predictions of Rees et al. (1989) for a virialized velocity field in the BLR, rules out U stratification steeper than $R^{-1/2}$. The C III] profiles shows some tendency for weaker wings and a stronger core, which is consistent with the implied density gradient in the BLR (the density must decrease with increasing R , unless $U \propto R^{-2}$, or steeper).

The Si IV+O IV] blend profile is reproduced quite well with our template method, and the deduced flux ratio is about 1, which is consistent with the result of Paper I, and with theoretically predicted ratios. Note that the multiplet components flux ratios in O IV] might significantly deviate from the ratios assumed here (§4.2.2), in particular if this multiplet is thermalized, and the Si IV/O IV] might therefore be somewhat different.

The Mg II profile deviates considerably from the template profile, however, as mentioned above, this might be mostly due to blending with the underlying Fe II emission.

5.5 *The Narrow Line Region*

As found in Paper I, the contribution of a narrow-[O III]-like component to the broad lines is generally very small ($\sim 1-4\%$), although in a few cases it can be as high as 15-25%. The expected amplitude of the narrow component in H β and in the UV lines can be estimated by assuming quasars have the narrow line spectrum of Seyfert 2 galaxies, and using the observed [O III] $\lambda 5007$ flux to normalize the expected flux. A Seyfert 2-like NLR in quasars might be predicted under some unified models of AGNs (e.g. Antonucci 1993). As shown above (Table 8), the upper limit (+ a detection in PG 1202+281) on the narrow H β /[O III] $\lambda 5007$ flux ratio is consistent with the Seyfert 2 NLR in quasars, however both the narrow C III]/[O III] $\lambda 5007$ and narrow Ly α /[O III] $\lambda 5007$ upper limits are generally smaller, by factors of up to 3-5, than the predicted values. This is consistent with the result of Wills et al. (1993), who found the upper limits on the narrow component of the UV lines to be significantly weaker than predicted. Note that Wills et al. based their prediction on the narrow H β component (which was well resolved for their objects), rather than the [O III] $\lambda 5007$ line, as was done here.

The above result indicates that the properties of the NLR of quasars are different from those of Seyfert 2 galaxies. A possible explanation for the weakness of the narrow component in the UV lines compared with the narrow optical [O III] $\lambda 5007$ line is that the NLR of quasars is characterized by a higher mean ionization parameter, which together with dust embedded in

the NLR clouds (Netzer & Laor 1993; Binette et al. 1993), will result in enhanced suppression of the UV lines. Note that in addition to the weakness of the narrow UV lines relative to [O III], the EW of [O III] itself tends to decrease with increasing continuum luminosity (Boroson & Green 1992). This could result from the combined effect of decreasing covering factor of the NLR gas, as its distance from the central source increases (see Wills et al. 1993), and enhanced suppression by dust.

5.6 *The EW vs. Luminosity Relation*

Almost all lines for which nine or more data points are available display an apparently significant drop in EW with increasing continuum luminosity (i.e. the Baldwin effect). This trend is also very clear when looking at the average emission spectrum as a function of continuum luminosity (Fig.2b). The only exception is the N V line which is consistent with having an EW independent of luminosity.

A detailed study of the Baldwin effect was recently made by Osmer, Porter, & Green (1994) using a sample of 182 quasars covering a wide range of luminosity and redshift. This study also indicates that the N V EW is at most weakly dependent on continuum luminosity, although it suggests this is also the case for the Si IV+O IV] blend, where we find a rather strong and steep correlation (using 13 objects). It is also interesting to note that the slope of the EW vs. luminosity relations found here for Ly α and C IV (-0.14 ± 0.07 , and -0.23 ± 0.08) are very similar to those found in the much larger sample of Osmer et al. (-0.13 , and -0.25), although the slopes for C III] are rather different (-0.17 ± 0.05 vs. -0.05 in Osmer et al.). For further discussion of the observational status of the Baldwin relation see Osmer et al. and references therein.

The Baldwin effect has been explained in a number of different ways:

1. A drop in the ionization parameter with increasing luminosity (Ferland & Mushotzky, 1984). This predicts the Baldwin effect to be particularly strong for the high ionization O VI, which is not the case in our data (see Fig.10).
2. A softening of the ionizing continuum shape with increasing luminosity (e.g. Zheng & Malkan 1993). This predicts the Baldwin effect to be particularly strong for He II recombination lines, which is not strongly supported by our data.
3. The continuum being emitted non-isotropically by a thin accretion disk, while the broad line emission being isotropic (Netzer, Laor & Gondhalekar 1992). This would generally produce a more uniform Baldwin effect for the different lines, as suggested by our data, however the gradual softening of the disk spectrum with increasing luminosity might imply a stronger effect

in He II, which is not strongly supported by our data.

4. A drop in the covering factor of the BLR clouds with increasing luminosity. This predicts an effect of exactly the same amplitude for all emission lines. Our results suggest somewhat different amplitudes for different lines, but the associated errors are relatively large, and this explanation cannot be ruled out by our data.

A detailed study of high S/N spectra of a larger sample of AGNs is required for a more accurate determination of the slope and strength of the Baldwin relation for different lines, in particular for O VI and He II which provide critical tests for some of the explanations mentioned above. Such a study might allow a reliable determination of the origin of this effect.

The absence of a Baldwin effect for N V is consistent with the claim of Hamann & Ferland (1992, 1993) that the N V/C IV and N V/He II ratios increase with redshift (which is correlated with luminosity in our sample). They interpret this result as due to enhanced N abundance and overall high metallicity in high-redshift quasars.

6 SUMMARY

We have analyzed the UV emission-line properties of a heterogeneous sample of 13 quasars using HST and ground based spectra, together with optical $H\beta$ + [O III] $\lambda\lambda 4959, 5007$ spectra for all the low redshift quasars. We use an objective algorithmic procedure to obtain a smooth model fit for the observed line profiles which allows an accurate determination of the basic line blend parameters. We then use these models to generate template profiles which are used to examine the similarity of the different line profiles, with the multiplet nature of the lines taken into account, and for deblending the individual line parameters. The major results are the following:

1. The O VI profile is generally very similar to the $Ly\alpha$ profile. This rules out a significant line emission from a VBLR characterized by a high ionization parameter ($U \sim 1$) and high velocity ($FWHM \sim 10,000 \text{ km s}^{-1}$), which was suggested to exist inside the BLR in studies of other AGNs.
2. We find that the $H\beta$ line is in most cases either significantly broader or narrower than $Ly\alpha$ and C IV, which suggests it is not produced by the same distribution of clouds in the BLR as those clouds producing the bulk of the UV lines.
3. We find the following new emission features: a. $\lambda \sim 832 \text{ \AA}$, most likely due to O II $\lambda 833$ +O III $\lambda\lambda 833$ emission. b. $\lambda \sim 1070 \text{ \AA}$, most likely an Fe II multiplet. c. $\lambda \sim 1175 \text{ \AA}$, probably due to C III*. Some possible implications of these features are briefly mentioned in §5.3.

4. The narrow components in both $\text{Ly}\alpha$ and $\text{C III}]$ are generally significantly weaker than expected based on the narrow UV to $[\text{O III}] \lambda 5007$ line ratios in Seyfert 2 galaxies and the observed $[\text{O III}] \lambda 5007$ fluxes in our sample. This implies that the NLR in quasars are different from those in Seyfert 2 galaxies (possibly because of a higher U and thus enhanced dust suppression of UV lines in the NLR of quasars).
5. All lines, excluding N V , appear to follow the Baldwin relation. The slope of the EW vs. luminosity relation for the different lines does not support explanations which invoke either a decrease in U , or softening of the ionizing continuum, with increasing luminosity, as a single physical mechanism producing the Baldwin relation. This result is based on a relatively small sample, and a detailed study of a significantly larger sample with high S/N spectra is required to establish this result.
6. We find a small average blueshift for the peaks of $\text{Ly}\alpha$, C IV , and $\text{C III}]$, while the lower ionization lines, Mg II , O I , C II and $\text{H}\beta$ have an average velocity shift closer to zero, or are slightly redshifted with respect to $[\text{O III}] \lambda 5007$. The suggestion that the velocity shifts increase with the ionization level is inconsistent with the small average redshift of O VI .
7. We verify the presence of the $\text{C III } \lambda 977 + \text{Ly}\gamma$ and the $\text{N III } \lambda 991$ emission lines, measured in Paper I, in our sample as well. However, the $\text{S VI } \lambda\lambda 933, 944$ doublet is not reliably detected in our sample.
8. We find an average $\text{Ly}\gamma/\text{Ly}\beta/\text{Ly}\alpha$ decrement of 0.03:0.06:1.0, using four detections of $\text{Ly}\gamma$ and nine detections of $\text{Ly}\beta$ in the combined sample. This decrement is similar to the one obtained in Paper I using a smaller sample.

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FIGURE CAPTIONS

Figure 1. The overall spectral shape of the 13 quasars. Each panel shows the observed flux density vs. rest wavelength. The data were corrected for Galactic reddening and smoothed with a Gaussian with the width of the spectral resolution. The thin line in each panel is the composite quasar spectrum of Francis et al. (1991) vertically shifted to overlap with the HST data at 2000 Å. This composite was obtained from ground-based observations of a few hundred quasars at $z \sim 1 - 2$. Note the overall similarity between each spectrum and the composite.

Figure 2. Upper panel: The HST and Francis et al. composite. The HST composite is based on the continuum shape of 18 quasars observed with HST (the 13 reported here + five from Paper I), while the Francis et al. composite was obtained from ground-based observations. Note the remarkable similarity of both composites, despite the differences in sample size and redshift range. The large difference shortward of Ly α is due to unresolved Ly α forest at high z . Lower panel: The luminosity dependence of the emission line properties. The total sample of 18 objects was divided to three equal parts according to νL_ν at 1350 Å. Note the clear drop in EW with increasing luminosity for practically all emission features (the Baldwin effect). The drop is particularly strong for He II $\lambda 1640$. This effect is further demonstrated in Fig.5.

Figure 3. Template fit to the O VI blend. The blend is fit with a sum of “symmetric Ly α ” profiles (see text). The dashed line histogram is the observed blend profile, the thick line is the best fit model. The χ^2 of the fit, and the number of degrees of freedom are indicated in each panel. In two objects, HS 0624+6907 and S4 1435+63, neither Ly α or C IV $\lambda 1549$ were available, and templates of other objects were used (see text). Note the generally very good match for O IV. The excess flux at $\lambda \gtrsim 1050$ Å appears to be a distinct component, rather than a broad wing of O IV. The excess flux at $\lambda < 1000$ Å is fit well by N III $\lambda 991$ and C III $\lambda 977$ +Ly γ .

Figure 4. Template fit to the Ly α blend. Note the generally good match to red wing of the blend. A Si II $\lambda 1263$ component is required in some cases. A weak component at $\lambda \sim 1175$ Å, possibly C III* $\lambda 1176$ is also required in some cases (see Table 5).

Figure 5. Template fit to the Si IV+O IV] blend. The Si IV/O IV] flux ratio (typically 1) and velocity shifts (typically zero) are also indicated in each panel.

Figure 6. Template fit to the C IV blend. Note the excess flux at $\lambda \sim 1600$ Å apparent in

some of the objects. A similar excess was noted in Paper I. A weak N IV] $\lambda 1486$ component was also included in some cases. A small contribution of the Si II $\lambda\lambda 1527, 1533$ doublet might also be present in some cases, but it was not included in the fit. In some objects the C IV profile is clearly asymmetric, and both blue and red excesses are apparent.

Figure 7. Template fit to the C III] blend. In most cases C III] appears to have a weaker broad wing, and a stronger core, compared with the template. An Al III $\lambda 1857$ component is apparent in all cases (might be blended, or possibly dominated, by Fe II emission). A weaker Si III] $\lambda 1893$ component is apparent in most objects.

Figure 8. Template fit to the Mg II blend. The model includes only the two components of the Mg II doublet. Significant contribution from the underlying Fe II blends is apparent at ~ 2750 Å, and is also likely to affect the Mg II profile at other wavelengths.

Figure 9. A comparison of the H β and the template profiles. The contribution of Fe II has been subtracted using the method of Boroson & Green. Excluding 4C 73.18, the template (Ly α or C IV) and H β have very different profiles.

Figure 10. The luminosity dependence of the equivalent width of 10 of the emission lines measured for the total sample of 18 quasars. A least square fit for $\log EW = A(\nu L_\nu)^\alpha$ is plotted in each panel. A significant Baldwin effect is suggested for all lines, excluding N V.

Figure 1a

Figure 1b

Figure 1c

Figure 1d

Figure 1e

Figure 2

O VI

Figure 3

Ly α

Figure 4

Si IV + O IV]

Figure 5

Si IV + O IV]

Figure 5 (continued)

C IV

Figure 6

C IV

Figure 6 (continued)

C III]

Figure 7

C III]

Figure 7 (continued)

Mg II

Figure 8

H β

Figure 9

Figure 10

TABLE 1

The Sample

Object	α (J2000)	δ (J2000)	z	V	M_V	E(B-V)	Reference
NAB 0024+22	00 27 15.4	+22 41 58	1.1083 ^a	16.57	-27.6	0.078	1
HS 0624+6907	06 30 02.5	+69 05 04	0.3707 ^b	14.20	-27.7	0.146	2
3C 232	09 58 21.0	+32 24 02	0.5301 ^b	15.78	-26.7	0.034	3
PG 1116+215	11 19 08.7	+21 19 18	0.1764 ^b	15.04	-25.2	0.030	4
PG 1202+281	12 04 42.2	+27 54 12	0.1654 ^b	15.60	-24.4	0.036	4
PG 1216+069	12 19 20.9	+06 38 38	0.3318 ^b	15.75	-25.9	0.033	4
PG 1241+176	12 44 10.8	+17 21 04	1.2807 ^a	15.90	-28.6	0.038	1
PG 1302-102	13 05 33.0	-10 33 20	0.2783 ^b	15.23	-26.1	0.070	4
S4 1435+63	14 36 45.8	+63 36 38	2.0617 ^c	16.10	-29.9	0.035	1
PG 1444+407	14 46 45.9	+40 35 06	0.2670 ^d	15.66	-25.5	0.026	4
PG 1538+477	15 39 34.8	+47 35 31	0.7706 ^a	16.02	-27.5	0.034	1
PG 1634+706	16 34 28.9	+70 31 33	1.3346 ^a	14.85	-30.1	0.120	1
4C 73.18	19 27 48.5	+73 58 02	0.3025 ^b	15.50	-25.9	0.163	5

^a Determined using Ly α .^b Determined using [O III] λ 5007.^c Determined using C III] λ 1909.^d Determined using H β .

References for optical spectrum.- (1) Steidel & Sargent (1991); (2) Groote, Heber, & Jordan (1989); (3) B. Wills (private communication); (4) Boroson & Green (1992); (5) C. Lawrence (private communication).

TABLE 2

Journal of Observations

Object	Date	Detector/Grating	Exp. time (s)
NAB 0024+22	204.1992	RD/G190H	8200
	204.1992	RD/G270H	1880
HS 0624+6907	035.1993	BL/G130H	9000
3C 232	360.1992	RD/G190H	4400
	360.1992	RD/G270H	1800
PG 1116+215	050.1993	BL/G130H	9200
	050.1993	RD/G190H	2000
	050.1993	RD/G270H	800
PG 1202+281	349.1992	RD/G190H	3600
	349.1992	RD/G270H	1400
PG 1216+069	075.1993	BL/G130H	17802
	074.1993	RD/G190H	4000
	074.1993	RD/G270H	1400
PG 1241+176	343.1992	RD/G270H	2600
PG 1302-102	199.1992	RD/G190H	2600
	199.1992	RD/G270H	1000
S4 1435+63	306.1991	RD/G270H	3600
PG 1444+407	249.1992	RD/G190H	3600
	249.1992	RD/G270H	1400
PG 1538+477	269.1992	RD/G190H	7800
	103.1993	RD/G270H	2000
PG 1634+706	307.1991	RD/G270H	3200
4C 73.18	286.1992	RD/G190H	4400
	286.1991	RD/G270H	1640

Note.- All gratings used the $0''.25 \times 2''.0$ slit.

TABLE 3

Continuum Emission Parameters

Object	νL_ν	λ_1	λ_2	$\alpha_{\lambda_1-\lambda_2}$	λ_1	λ_2	$\alpha_{\lambda_1-\lambda_2}$	λ_1	λ_2	$\alpha_{\lambda_1-\lambda_2}$
NAB 0024+22	46.89	800	1350	-1.81	1350	2200	-0.65	2200	3000	-1.53
HS 0624+6907	46.57 ^a	...	...	...	...	...	...	...	...	...
3C 232	46.19	...	...	...	1350	2200	-1.09	2200	3000	-0.76
PG 1116+215	46.00	1000	1350	0.14	1350	2200	-0.43	2200	2650	-1.23
PG 1202+281	44.64 ^b	...	...	...	1450	2200	-1.33	2200	2650	-1.73
PG 1216+069	46.05	920	1350	-1.52	1350	2200	-0.64	...	...	...
PG 1241+176	47.35	1000	1350	-1.62	1350	2200	-0.87	2200	3000	-0.63
PG 1302-102	46.32	...	...	...	1350	2200	-0.65	...	...	...
S4 1435+63	47.76 ^c	...	...	...	1700	2200	0.01	2200	2650	-0.84
PG 1444+407	45.99	...	...	...	1350	2200	-0.65	...	...	...
PG 1538+477	46.90	950	1350	-2.97	1350	2200	-0.46	2200	3000	-0.45
PG 1634+706	48.15	1000	1350	-0.19	1350	2200	-0.04	2200	3000	-0.58
4C 73.18	46.10	...	...	...	1350	2200	-0.45	...	...	...
PKS 0405-123	47.10	800	1350	-1.20	1350	2080	-0.60	...	...	...
H 1821+643	46.71	950	1350	-1.84	1350	2200	-0.78	...	...	...
PG 0953+414	45.91	950	1350	-1.06	1350	2200	-0.31	2200	2650	-1.57
3C 273	46.73	1000	1350	-0.38	1350	2200	-0.58	2200	2650	-1.00
Mrk 205	45.06 ^c	...	...	...	1500	2200	-0.39	2200	3000	-1.29

Note.- νL_ν is measured at 1350Å (for $H_0 = 50 \text{ km s}^{-1}$, $q_0 = 0$), unless otherwise noted.

^a Measured at 1100Å.

^b Measured at 1450Å.

^c Measured at 1700Å.

TABLE 4
Parameters for the Emission Blends

Object	O VI ^a		Ly α ^b		Si IV/O IV]		C IV ^c		C III] ^d		Mg II ^e	
	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2
	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}
	α	S/N	α	S/N	α	S/N	α	S/N	α	S/N	α	S/N
	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ
	EW	Δ	EW	Δ	EW	Δ	EW	Δ	EW	Δ	EW	Δ
	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ
	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ
NAB 0024+22	950	1130	1130	1320	1360	1448	1450	1710	1800	1980	2690	2930
	2.71	2.55	2.55	2.42	2.20	2.02	2.04	1.53	1.50	1.35	1.12	1.04
	-1.65	23.9	-1.66	27.3	-0.60	27.6	-0.26	...	-0.92	...	-1.14	...
	22.8	± 5.70	48.4	± 3.70	3.13	± 1.16	20.3	...	7.66	...	6.97	...
	41.1	± 12.0	92.3	± 10.6	7.0	± 2.9	52.8	...	25.8	...	30.6	...
	-130	± 34	0	± 21	620	± 7	-620	...	-53	...	230	...
	7344	± 498	5081	± 103	6801	± 1592	5811	...	5718	...	7394	...
HS 0624+6907	955	1100	...	...	...	...	...	...	...	...	...	...
	36.03	29.63	...	...	...	...	...	...	...	...	...	...
	-0.62	18.9	...	...	...	...	...	...	...	...	...	...
	139	± 32.0	...	...	...	...	...	...	...	...	...	...
	31.3	± 9.0	...	...	...	...	...	...	...	...	...	...
	-1463	± 885	...	...	...	...	...	...	...	...	...	...
	5513	± 243	...	...	...	...	...	...	...	...	...	...
3C 232	...	...	1150	1280	1370	1470	1480	1740	1800	1980	2690	2910
	...	...	3.43	3.37	3.52	3.17	3.21	3.13	3.09	2.63	1.92	1.73
	...	...	-1.82	21.7	-0.50	37.3	-1.84	37.5	-0.31	37.7	-0.69	10.0
	...	...	43.30	± 3.35	5.73	± 1.34	16.8	± 2.75	12.70	± 2.80	15.60	...
	...	...	83.4	± 10.4	11.0	± 2.9	34.4	± 6.5	29.6	± 7.5	56.0	...
	...	...	-267	± 1	-202	± 116	-18	± 257	-288	± 26	35	...
	...	...	2187	± 24	5573	± 525	5526	± 505	10270	± 2479	4980	...
PG 1116+215	1000	1110	1155	1290	1350	1450	1475	1690	1833	1960	...	...
	74.62	55.55	50.08	44.29	39.28	35.71	36.07	31.51	30.23	28.32	...	...
	0.83	25.6	-0.89	40.3	-0.66	43.2	-1.01	50.7	-1.03	72.1	...	...
	126	± 27.0	624	± 19.5	59.1	± 10.3	240	± 19.5	83.7	± 5.85	...	...
	15.7	± 4.5	112	± 6.3	13.4	± 2.6	59.3	± 6.0	24.5	± 2.1	...	...
	-714	± 338	-354	± 15	297	± 36	-497	± 1	-57	± 64	...	...
	6374	± 1446	4220	± 31	5470	± 179	4495	± 67	4847	± 70	...	...
PG 1202+281	...	...	...	...	...	...	1452	1690	1830	1980	...	...
	...	...	...	...	...	...	1.87	1.86	2.18	1.76	...	...
	...	...	...	...	...	...	-1.96	13.4	0.71	22.2	...	...
	...	...	...	...	...	...	88.4	± 3.90	19.6	± 1.40	...	...
	...	...	...	...	...	...	407	± 52.7	86.7	± 10.3	...	...
	...	...	...	...	...	...	-585	± 145	-895	± 274	...	...
	...	...	...	...	...	...	2941	± 86	3147	± 45	...	...

TABLE 4 - *continued*
Parameters for the Emission Blends

Object	O VI ^a		Ly α ^b		Si IV/O IV]		C IV ^c		C III] ^d		Mg II ^e	
	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2
	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}
	α	S/N	α	S/N	α	S/N	α	S/N	α	S/N	α	S/N
	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ
	EW	Δ	EW	Δ	EW	Δ	EW	Δ	EW	Δ	EW	Δ
	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ
	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ
PG 1216+069	955	1070	1150	1290	1360	1450	1450	1700	1830	1980	...	...
	15.38	13.19	12.39	11.28	10.67	8.57	8.57	8.08	7.43	6.29	...	...
	-0.65	25.5	-1.19	31.1	0.42	42.1	-1.63	52.3	0.11	43.7	...	...
	34.9	± 3.65	187	± 6.50	13.9	± 3.84	130	± 3.00	15.7	± 34.9	...	...
	19.0	± 2.3	118	± 7.9	10.8	± 3.2	117	± 5.0	17.3	± 3.1	...	...
	-464	± 9	112	± 2	734	± 47	307	± 23	-85	± 11	...	...
	4359	± 153	2506	± 50	5493	± 340	3039	± 8	3177	± 162	...	...
PG 1241+176	1012	1060	1165	1320	1360	1450	1500	1700	1827	1980	2690	2930
	3.95	3.96	3.88	3.84	3.79	3.53	3.40	3.07	2.88	2.42	1.84	1.59
	-2.09	40.7	-1.93	52.2	-0.87	32.3	-1.19	...	0.16	...	-0.30	...
	12.7	± 1.40	60.1	± 2.70	3.32	± 2.56	18.3	...	5.44	...	5.37	...
	14.1	± 1.9	68.2	± 4.4	4.0	± 3.3	24.2	...	9.1	...	13.7	...
	-310	± 7	0	± 1	436	± 420	-150	...	363	...	58	...
	3292	± 135	2506	± 48	6599	± 2789	2262	...	3723	...	6567	...
PG 1302 $\pm$ 102	...	...	...	...	1360	1450	1480	1700	1825	1980	...	...
	...	...	...	...	27.04	24.67	23.96	24.21	21.26	19.22	...	...
	...	...	...	...	-0.57	40.7	-2.07	56.1	-0.76	53.8	...	...
	...	...	...	...	33.6	± 7.60	94.3	± 13.0	55.5	± 8.00	...	...
	...	...	...	...	10.1	± 2.4	30.7	± 4.8	21.6	± 3.5	...	...
	...	...	...	...	-175	± 120	-310	± 1	-17	± 216	...	...
	...	...	...	...	7315	± 1063	3634	± 212	6764	± 308	...	...
S4 1435+63	960	1065	...	...	...	...	...	...	1825	1970	2700	2910
	1.86	1.96	...	...	...	...	...	...	1.33	1.12	.68	.60
	-2.51	40.2	...	...	...	...	...	...	0.25	...	-0.36	...
	7.43	± 1.53	...	...	...	...	...	...	3.72	...	4.32	...
	12.6	± 2.9	...	...	...	...	...	...	10.1	...	22.0	...
	813	± 104	...	...	...	...	...	...	0	...	-99	...
	5154	± 241	...	...	...	...	...	...	4284	...	5494	...
PG 1444+407	...	...	...	...	1350	1450	1490	1690	1830	1980	...	...
	...	...	...	...	14.19	12.80	12.60	12.14	10.86	9.59	...	...
	...	...	...	...	-0.56	38.6	-1.71	55.6	-0.42	51.4	...	...
	...	...	...	...	23.7	± 4.55	46.2	± 5.25	30.4	± 3.75	...	...
	...	...	...	...	13.9	± 3.0	29.3	± 4.0	23.6	± 3.4	...	...
	...	...	...	...	-357	± 99	-516	± 10	232	± 17	...	...
	...	...	...	...	5810	± 252	4226	± 180	5483	± 107	...	...

TABLE 4 - *continued*
Parameters for the Emission Blends

Object	O VI ^a		Ly α ^b		Si IV/O IV]		C IV ^c		C III] ^d		Mg II ^e	
	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2
	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}	f_{λ_1}	f_{λ_2}
	α	S/N	α	S/N	α	S/N	α	S/N	α	S/N	α	S/N
	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ	Flux	Δ
	EW	Δ	EW	Δ	EW	Δ	EW	Δ	EW	Δ	EW	Δ
	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ	Velocity	Δ
	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ	FWHM	Δ
PG 1538+477	958	1080	1140	1290	1350	1450	1450	1690	1825	1965	2690	2910
	5.46	5.36	5.61	5.99	6.41	5.60	5.60	4.48	4.41	3.45	2.22	2.05
	-1.85	35.9	-2.54	62.1	-0.11	48.8	-0.54	50.9	1.31	30.2	-1.00	...
	29.50	± 3.75	145.00	± 2.00	9.88	± 2.39	59.60	± 3.20	10.30	± 5.46	12.40	...
	30.9	± 4.7	140.6	± 4.3	9.3	± 2.5	66.2	± 4.9	15.3	± 9.4	33.0	...
	21	± 4	0	± 33	-101	± 42	-2	± 21	-722	± 130	235	...
	6261	± 176	5875	± 194	6771	± 531	6195	± 120	4936	± 404	5194	...
PG 1634+706	1000	1100	1150	1290	1360	1440	1460	1700	1830	1980	2660	2910
	36.51	28.88	29.59	22.74	21.66	19.18	17.69	12.63	12.19	9.99	6.31	5.36
	0.46	101.3	0.29	114.8	0.13	60.2	0.21	...	0.53	...	-0.18	...
	84.50	± 7.15	380.00	± 7.00	21.00	...	106.00	...	39.40	...	39.70	...
	10.8	± 1.0	62.6	± 1.7	4.4	...	29.4	...	15.4	...	29.6	...
	-1030	± 93	0	± 17	-463	...	-169	...	75	...	375	...
	6392	± 264	3738	± 14	3803	...	4924	...	4184	...	3484	...
4C 73.18	...	...	...	...	1360	1450	1470	1700	1810	1980	...	...
	...	...	...	...	15.08	11.22	11.11	9.17	8.46	7.49	...	...
	...	...	...	...	2.62	26.9	-0.68	32.6	-0.65	31.5	...	...
	...	...	...	...	23.10	± 6.85	172.00	± 9.00	44.50	± 6.25	...	...
	...	...	...	...	13.5	± 4.5	127.7	± 10.8	43.4	± 7.5	...	...
	...	...	...	...	137	± 73	132	± 3	42	± 6	...	...
	...	...	...	...	4958	± 298	3685	± 39	4212	± 153	...	...

Notes.- λ_1, λ_2 - end points used to define the local continuum ($\text{\AA}$). $f_{\lambda_1}, f_{\lambda_2}$ - observed flux density at end points ($10^{-18} \text{ erg s}^{-1} \text{ cm}^{-2} \text{ \AA}^{-1}$). α - spectral index defined as $-2 - \ln(f_{\lambda_1}/f_{\lambda_2})/\ln(\lambda_1/\lambda_2)$. S/N- average signal to noise ratio per resolution element at $\lambda_1 - \lambda_2$ (specified only for HST spectra). Flux- line flux ($10^{-14} \text{ erg s}^{-1} \text{ cm}^{-2}$). EW- rest frame equivalent width. Velocity- velocity shift of best fit model line peak (rest frame redshift defined in Table 1). A systematic error of $\sim 60 \text{ km s}^{-1}$ is possible. Δ - approximate error (estimated for HST spectra by repeated fittings with continuum level displaced by $\pm 1\sigma$).

^a Blend includes: Ly γ , C III $\lambda 977$, N III $\lambda 991$, Ly β , O VI $\lambda 1034$ (depending on λ_1).

^b Blend includes: Ly α , N V $\lambda 1240$, and possibly Si II $\lambda 1263$ and C III* $\lambda 1175\text{\AA}$.

^c Blend includes: C IV $\lambda 1549$, He II $\lambda 1640$, O III] $\lambda 1664$, and possibly N IV] $\lambda 1486$.

^d Blend includes: C III] $\lambda 1909$, Si III] $\lambda 1892$, and Al III $\lambda 1857$.

^e Blend includes unresolved Fe II multiplets.

TABLE 5
Weak Emission Line Parameters

Object	O I λ 1303		C II λ 1335		N III λ 1750		Si II λ 1814	
	Flux $\pm\Delta$		Flux $\pm\Delta$		Flux $\pm\Delta$		Flux $\pm\Delta$	
	EW $\pm\Delta$		EW $\pm\Delta$		EW $\pm\Delta$		EW $\pm\Delta$	
	Velocity $\pm\Delta$		Velocity $\pm\Delta$		Velocity $\pm\Delta$		Velocity $\pm\Delta$	
	FWHM $\pm\Delta$		FWHM $\pm\Delta$		FWHM $\pm\Delta$		FWHM $\pm\Delta$	
3C 232	2.02	0.94	1.34	0.44	...	...	...	...
	3.8	1.8	2.5	0.8	...	...	...	...
	1265 ^a	0	0 ^a	0	...	...	...	...
	5247	958	3246	641	...	...	...	...
PG 1116+215	15.60	2.30	10.10	5.55	...	...	...	...
	3.1	.5	2.2	1.3	...	...	...	...
	427	174	-11	21	...	...	...	...
	3243	543	2128	292	...	...	...	...
PG 1202+281	...	...	...	...	0.21	+0.44 -0.15	0.38	+0.44 -0.23
	...	...	...	...	0.8	+1.9 -0.6	1.5	+1.9 -0.9
	...	...	...	...	-60	-348 +26	-1191	+240 -368
	...	...	...	...	1636	+1830 -923	2309	1502
PG 1216+069	2.42	+2.12 -1.17	...	...	...	...	0.59	+1.33 -0.41
	1.6	+1.5 -0.8	...	...	...	...	0.6	+1.3 -0.4
	-352	+939 +735	...	...	...	...	219	-19 +206
	4146	1151	...	...	...	...	2139	+576 -1834
PG 1241+176	0.72	+0.68 -0.64	0.57	+0.79 -0.48	...	...	...	...
	0.8	+0.8 -0.7	0.7	+0.9 -0.6	...	...	...	...
	-600	-70 -1445	-48	+8 -531	...	...	...	...
	4292	+1804 -3866	4585	+2149 -3083	...	...	...	...
PG 1302-102	3.42	+4.61 -1.66	3.21	+3.34 -2.41	...	...	...	...
	0.9	+1.3 -0.5	0.9	+1.0 -0.7	...	...	...	...
	-353	+279 -35	-304	+417 +41	...	...	...	...
	1779	+1834 -216	4492	+549 -3103	...	...	...	...
PG 1444+407	2.30	+1.97 -1.00	1.48	+1.42 -1.15	0.68	0.41	...	...
	1.2	+1.2 -0.5	0.8	+0.8 -0.6	0.5	0.3	...	...
	114	+498 +172	80	-484 -369	-521	90	...	...
	697	+1680 +300	1193	+2287 -810	1763	377	...	...
PG 1538+477	2.50	0.90	...	...	...	...	...	...
	2.3	0.9	...	...	...	...	...	...
	724	6	...	...	...	...	...	...
	743	53	...	...	...	...	...	...
PG 1634+706	7.33	1.58	3.16	1.02	...	...	...	...
	1.4	0.3	0.6	0.2	...	...	...	...
	1194	126	445	57	...	...	...	...
	2342	79	2631	432	...	...	...	...

^a Value fixed a priori.

TABLE 6
Template Deblended Emission Line Parameters

Object	Ly γ 972.54	C III 977.02	N III 990.98	Ly β 1025.72	O VI 1033.82	C III* 1175.70	Ly α 1215.67	N V 1240.15	Si II 1263.31	Si IV 1396.75	O IV 1402.46	N IV 1486.50	C IV 1549.05	He II 1640.46	O III 1664.15	Al III 1857.40	Si III 1892.03	C III 1908.73
NAB 0024+22	2.22 0	...	2.69 0	5.33 0	9.36 541	...	44.3 0	5.1 525	...	1.92 500	1.92 500	...	18.3 -13	1.46 588 ^a	0.63 0	...	0.89 0	7.59 -148
HS 0624+6907	12.1 0	8.76 0	12.2 -1077	39.9 0	54.2 42	...	...	...	...	...	...	...	...	...	...	...	...	...
3C 232	...	...	...	...	...	...	39.0 -267	2.80 ^a 1734 ^a	0.55 398	3.33 0	3.33 0	...	10.53 -523	1.54 -309	1.18 903	2.02 0	4.09 0	7.06 0
PG 1116+215	...	...	...	26.4 -354	97.5 0	10.3 20	497 -354	96.6 526	13.5 60	35.8 0	35.8 0	...	222 -625	11.3 -2088 ^a	8.74 -403	12.2 0	4.51 0	81.6 -604
PG 1202+281	...	...	...	...	...	...	...	...	...	...	...	0.95 0	81.9 -709	3.34 -722	3.05 -512	...	2.00 ^a 0 ^a	20.1 -848
PG 1216+069	2.43 113	1.35 0	3.28 0	6.70 113	22.8 199	...	166 113	6.94 535	5.92 -1136	6.59 500	6.59 500	...	87.5 307	10.2 ^a 1529 ^a	7.02 307	1.56 0	0.78 0	13.4 -102
PG 1241+176	...	...	...	0 0	13.0 -45	1.09 -286	36.8 0	15.2 -111	...	2.04 500	2.04 500	...	14.7 25	2.52 -622	0.89 307	0.71 0	0.55 0	3.58 366
PG 1302-102	...	...	...	...	...	...	...	...	...	19.1 0	9.55 0	...	64.2 -310	13.4 -327	11.8 147	11.3 -446	15.1 318	28.6 310
S4 1435+63	...	0.66 0	0.70 0	0.31 0	6.41 548	...	...	...	...	...	...	...	...	...	...	...	...	3.90 0
PG 1444+407	...	...	...	...	...	...	...	...	...	14.9 0	7.45 0	...	30.0 -516	7.22 0 ^a	2.57 0 ^a	4.63 543	10.4 0	15.2 232
PG 1538+477	...	2.19 0	4.09 0	1.26 0	23.7 -154	...	137 0	6.88 1122	...	5.59 0	5.59 0	...	54.6 -110	4.72 0	3.13 0	...	...	13.6 ^a -730 ^a
PG 1634+706	...	...	2.24 0	22.5 0	53.2 -52	16.2 0	311 0	53.8 211	4.90 237	19.6 0	9.80 0	...	86.3 -145	7.16 -306	5.07 942	1.48 ^a 0 ^a	2.72 0	35.4 100
4C 73.18	...	...	...	...	...	...	...	...	...	8.21 0	16.4 0	2.23 76	140 132	14.4 0	8.88 86	4.01 0	7.19 0	32.7 -27

Note- Upper line for each object is the line flux (10^{-14} erg s $^{-1}$ cm $^{-2}$), lower line is the line center velocity (km s $^{-1}$).
^a Template provides a bad fit.

TABLE 7
Average Velocity Shifts

Lines			Paper I			This paper			Combined sample		
O VI	-	[O III]	0	± 0	(3)	80	± 100	(3)	40	± 80	(6)
O VI	-	Ly α	230	± 60	(3)	130	± 270	(6)	160	± 220	(9)
Ly α	-	[O III]	-220	± 40	(4)	-170	± 250	(3)	-200	± 150	(7)
C IV	-	[O III]	-140	± 170	(5)	-320	± 390	(7)	-240	± 320	(12)
C IV	-	Ly α	40	± 50	(4)	-80	± 160	(7)	-35	± 140	(11)
C III]	-	[O III]	-70	± 160	(5)	-150	± 430	(7)	-115	± 330	(12)
C III]	-	Ly α	95	± 110	(4)	30	± 270	(6)	55	± 210	(10)
Mg II	-	[O III]	100	± 160	(3)	35		(1)	85	± 130	(4)
Mg II	-	Ly α	260	± 90	(2)	230	± 130	(5)	250	± 110	(7)
O I	-	[O III]	420	± 220	(4)	-40	± 380	(4)	190	± 380	(8)
O I	-	Ly α	650	± 250	(4)	340	± 820	(5)	470	± 620	(9)
C II	-	[O III]	120	± 850	(3)	-80	± 200	(3)	20	± 560	(6)
C II	-	Ly α	350	± 880	(3)	230	± 250	(3)	310	± 590	(6)
He II	-	[O III]	-580	± 240	(5)	-340	± 300	(4)	-470	± 280	(9)
He II	-	Ly α	-400	± 210	(4)	-70	± 440	(5)	-210	± 380	(9)
H β	-	[O III]	110	± 100	(5)	50	± 110	(7)	75	± 110	(12)
H β	-	Ly α	370	± 80	(4)	130	± 270	(3)	270	± 210	(7)

Note.- All velocities are in km s^{-1} . Number of objects for each average is given in paranthesis. A systematic error of $\sim 60 \text{ km s}^{-1}$ between optical and UV velocity measurements is possible.

TABLE 8
Upper Limits on a Narrow [O III]-Like Component

Object	Ly α Fraction EW Ratio	C III] Fraction EW Ratio	H β Fraction EW Ratio	[O III] λ 5007 FWHM EW Flux
3C 232	0.152 11.4 1.7	0.060 1.0 0.12	0.245 3.4 0.072	1180 43 5.3
PG 1116+215	0.032 2.8 3.9	0.043 1.0 0.87	0.049 8.6 0.61	1033 13.3 4.74
PG 1202+281		0.017 1.4 0.094	0.030 3.3 0.096	542 31.1 4.0
PG 1216+069	0.032 3.4 1.83	0.020 0.3 0.090	0.012 1.3 0.14	434 9.2 3.92
PG 1302-102		0.029 0.3 0.71	0.021 0.8 0.087	680 10.3 1.51
PG 1444+407		0.042 0.5 1.00	0.141 10.9 1.97	1155 6.2 0.81
4C 73.18		0.039 1.2 0.33	0.032 3.3 0.17	891 ^a 18.1 5.01
Seyfert 2 Ratio ^b	5.1	0.51	0.093	...

Note.- Fraction is the narrow to total line flux ratio. EW is in units of Å.
FWHM is in units of km s⁻¹. Flux is in units of 10⁻¹⁴ erg s⁻¹ cm⁻²,
Ratio is narrow component upper limit to measured [O III] λ 5007 flux ratio.

^a Unresolved

^b Based on the composite Seyfert 2 spectrum of Ferland & Osterbrock (1986).