The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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Hβ spectra of high-redshift QSOs: Eigenvector 1 at high luminosities†

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Abstract. We present VLT–ISAAC spectra of unprecedented S/N and resolution for the Hβ region in a sample of $n = 17$ quasars in the range $z = 0.8$–2.5. The data represent our first attempt to test source occupation and line properties for the Eigenvector 1 parameter space that was defined using a sample of sources with $z < 0.8$. We find no strong luminosity/redshift dependent effects with the possible exception of an increase in the minimum broad line profile width from 1000 to 3000 km s^{-1} between $M_B \approx -20$ and -28.

We have obtained high S/N spectra of the Hβ region of a sample of 17 HE quasars with intermediate redshift ($0.85 \leqslant z \leqslant 2.5$) and high luminosity ($-26 \geqslant M_B \geqslant -30$). For the first time we have a sample of NIR spectra with resolution and S/N comparable to those obtained for 200+ lower-redshift Type 1 AGN (Marziani et al. 2003 (M03)). Spectra (Fig. 1) were obtained between 2001 November and 2002 February using ESO/VLT1+ISAAC providing a resolution of ~ 300 km s^{-1} in all bands (Z, sZ, J, H). The observations represent our first attempt to test the robustness of the Eigenvector 1 (E1) parameter space previously defined using lower redshift sources (Boroson & Green 1992; Sulentic et al. 2000). Our goals include testing: 1) domain space occupation in the optical E1 plane and 2) the apparent luminosity independence of all E1 properties.

The VLT spectra enable us to measure both E1 optical parameters: FWHM(Hβ) and the broad-line equivalent width ratio W(FeII$_{\rm opt}$)/W(Hβ) = R$_{\rm Fe}$, where W(FeII$_{\rm opt}$) measures the λ4570 blend. Broad Hβ, and the narrow [OIII]$\lambda\lambda$5007,4959, were isolated by subtracting appropriately scaled FeII emission from the spectra using a template based on IZw1. FeII emission properties show no differences from our lower-redshift sample (M03) and the FeII template works equally well at these high redshifts.

We find no significant differences in source occupation for the optical plane of E1 as defined previously (Fig. 2a). There may be a slight tendency for higher redshift source to displace towards the upper right but this requires verification with a much larger sample. The results are consistent with our previous suggestion that E1 occupation is driven neither by source luminosity nor BH mass but rather by the Eddington ratio convolved with source orientation to the line of sight.

Figure 2b shows possible evidence for a systematic increase in minimum observed FWHM(Hβ) with source luminosity. A general increase in FWHM(Hβ) with luminosity is not certain because radio-loud sources are over-represented in the higher luminosity

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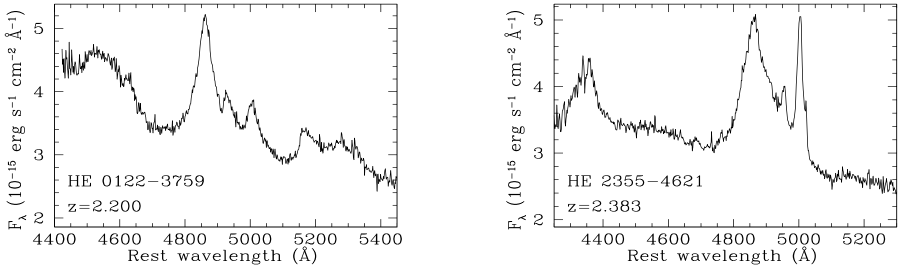

Figure 1. Two examples of the 17 spectra of HE QSOs obtained at the ESO/VLT

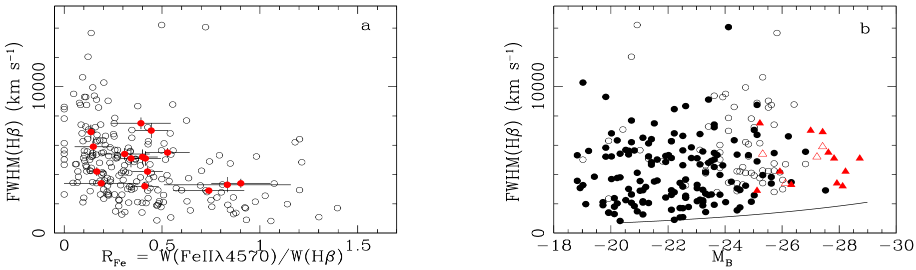

Figure 2. Left: the main E1 diagram, which shows the relation between broad Hβ line width and relative FeII intensity. The HE QSOs are represented by the filled circles with error bars. There is no evidence that their distribution is different from that of the open circles (sources from M03), despite the different luminosity distribution. Right: the broad Hβ line width vs. luminosity. Triangles represent HE QSOs, circles are AGN from M03. Symbols are filled for radio-quiet sources, empty for radio-loud. The curve is the estimated lower limit to the FWHM as a function of luminosity.

part of our sample and they are known to show systematically larger FWHM(Hβ). The increase in minimum FWHM with L might be expected if we:

- assume virialized motions in the Broad Line Region (BLR)
- use the $R_{BLR} \propto L^{\alpha}$ relation found by Kaspi et al. (2000), with $\alpha = 0.7$
- assume that low-redshift NLS1 have an Eddington ratio close to 1

By combining these relations, we obtain the lower boundary to the broad-line widths shown in Fig. 2b.

Using L(5100Å) (rest wavelength) and the FWHM(Hβ) as described by Vestergaard (2002), we can estimate the mass of the central black hole, assuming that the BLR-size vs. luminosity relation found by Kaspi et al. (2000) can be extrapolated to high luminosities and redshifts. We used the formula derived by McLure & Jarvis (2002). The mass estimates yield large values, close to or reaching $10^{10}\,M_{\odot}$, for the most luminous sources. Estimates of the Eddington ratios indicate that most QSOs are radiating near $\sim 0.3\,L_{Edd}$.

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