X-RAY PROPERTIES OF DOUBLE-PEAKED BALMER-LINE ACTIVE GALAXIES

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ABSTRACT

We study the X-ray properties of 39 AGN (24 radio-quiet [RQ] and 15 radio-loud [RL]) with double-peaked Balmer emission lines. 28 of them are Sloan Digital Sky Survey (SDSS) AGN serendipitously observed with *ROSAT*, *XMM-Newton*, or *Chandra*; an additional 11 previously studied double-peaked RL AGN are considered for comparison purposes. Double-peaked Balmer lines originate in the accretion disk and are an important diagnostic of the accretion flow. We find that the ratio of UV-to-X-ray emission, $\alpha_{\rm ox}$, of RQ double-peaked AGN are similar to those of normal RQ AGN with comparable UV luminosities. Most RL double-peaked AGN are more X-ray luminous than normal RQ AGN, as expected for RL objects. For both RL and RQ double-peaked AGN a few notable exceptions appear X-ray underluminous for their UV luminosity. The spectral shapes of double-peaked AGN are also consistent with those of other objects with similar radio properties.

Key words: active galaxies; X-ray and UV emission; disk-emission AGN.

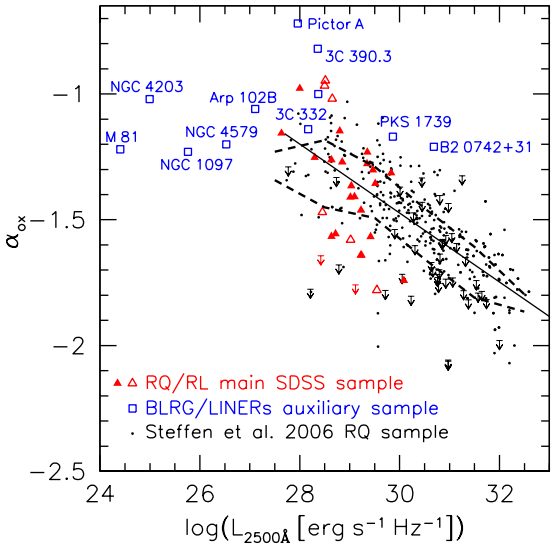

Figure 1. α_{ox} *vs.* $L_{2500\,Å}$ *for disk-emission AGN in comparison with normal AGN from [St06]. The solid line is the best-fit bisector and the dashed lines connect the 25th- and 75th-percentiles estimated for each magnitude bin by [St06].*

1. INTRODUCTION

A small fraction of active galaxies ($\sim$3% of optically selected AGN and up to $\sim$20% of broad line radio galaxies [BLRGs]) have double-peaked Balmer-line shapes indicative of accretion-disk line emission. The class of disk-emission AGN is rather heterogeneous – it includes BLRGs, LINERs (low-ionization nuclear emission-line region galaxies), and luminous Seyferts, spanning a range of radio-loudness, luminosity, black-hole mass, and accretion rate. It is clear that the association of Balmer line disk-emission in AGN with a subsample of radiatively inefficient accretion-flow AGN is not sufficient to explain all double-peaked AGN. Since most of the double-peaked AGN have strong Balmer-line emission, which could not have been produced by the release of gravitational energy locally without invoking unrealistic radiative efficiency, X-ray illumination from the inner thick disk is deemed necessary to produce the observed signatures. In search of clues to the nature of the luminous double-peaked AGN, we embarked on a detailed study of the 0.5–10 keV X-ray properties of this class.

2. SAMPLE

We selected a new sample of double-peaked AGN from SDSS areas with overlapping *ROSAT* PSPC, *Chandra*, or *XMM-Newton* archival exposures. Our main sample consists of 28 double-peaked Hα-line AGN, 80% of which lie in pointings with effective exposure times of > 2 ks. Using a variety of statistical tests (on the redshift, luminosity, radio-loudness, Hα-line width, and centroid distributions) we confirmed that this sample is representative of the sample of disk-emission AGN presented in Strateva et al. (2003) [hereafter the S03 sample]. We also con-

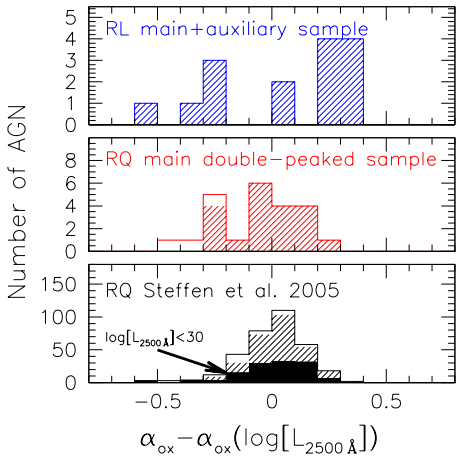

Figure 2. α_{ox} residual distributions, after subtraction of the best-fit α_{ox}–$\log[L_{2500\,\text{Å}}]$ relation from St06.

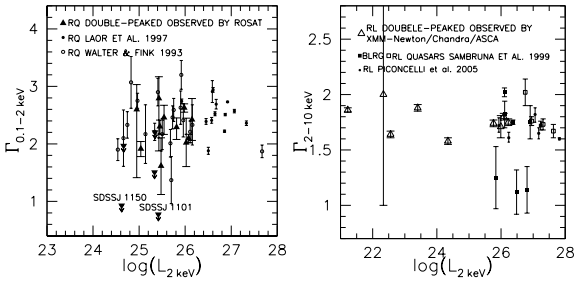

Figure 3. Power-law photon indices for simple absorbed power-law fits of the RQ double-peaked AGN in the 0.1–2 keV band (left) and the RL double-peaked AGN in the 2.0–10.0 keV band in comparison with appropriate normal AGN samples.

sider 11 previously studied double-peaked BLRGs and LINERs with high-quality UV and X-ray data (the auxiliary sample), which are at lower luminosity and redshift than the S03 sample and are all RL. The full sample consists of 39 double-peaked AGN, 24 radio quiet (RQ) and 15 RL. Since RL AGN are known to differ in their X-ray properties from RQ AGN (with flatter power-law photon indices, Γ, and higher X-ray fluxes), we study the X-ray properties of RL and RQ double-peaked AGN separately.

3. X-RAY PROPERTIES OF DISK-EMISSION AGN

Figure 1 presents the ratio of UV-to-X-ray luminosity densities, $\alpha_{\rm ox} \equiv -0.384\log[L_{2500\,\text{Å}}/L_{2\,\text{keV}}]$, as a function of the UV monochromatic luminosity, $L_{2500\,\text{Å}}$. A strong correlation exists between $\alpha_{\rm ox}$ and $L_{2500\,\text{Å}}$ in optically selected RQ AGN samples (e.g., Steffen et al., 2006, hereafter St06), and RQ disk-emission AGN also follow this correlation. The apparent lack of high-luminosity objects with double-peaked lines in Figure 1 is probably a result of the selection procedure, which is volume limited to SDSS AGN with $z < 0.33$. The distribution of $\alpha_{\rm ox}$ residuals for RQ disk-emission AGN (obtained by subtracting the best fit relation from St06, $\alpha_{\rm ox} = -0.137\log[L_{2500\,\text{Å}}] + 2.637$) is presented in Figure 2. It is statistically consistent with the distributions of the full St06 sample and a luminosity matched St06 subsample (e.g., a Kuiper test returns $D = 0.27$, with a 49% probability that the two distributions are indistinguishable). The Kaplan-Meier estimated mean of the RQ subsample residuals for the disk-emission AGN is $\langle\alpha_{\rm ox} - \alpha_{\rm ox}(L_{2500\,\text{Å}})\rangle = -0.07 \pm 0.06$, consistent within the errors with that of the St06 luminosity matched subsample, $\langle\alpha_{\rm ox} - \alpha_{\rm ox}(L_{2500\,\text{Å}})\rangle = -0.01 \pm 0.02$. The RL disk-emission AGN have $\alpha_{\rm ox}$ residuals[1] which are statistically different from those of both RQ disk-emission AGN and normal AGN. As expected for RL AGN, the majority of RL disk-emission AGN are more X-ray luminous relative to their UV emission. Despite the agreement of the overall RQ distributions of $\alpha_{\rm ox}$ residuals for double-peaked and normal AGN, a few RQ and RL disk-emission AGN are clearly X-ray weak relative to their UV emission. Figure 3 shows the power-law photon indices, Γ, for the RQ disk-emission AGN measured in the 0.1–2.0 keV band and the RL disk-emission AGN measured in the 2.0–10.0 keV in comparison with carefully matched normal AGN samples. The Γ's of the RQ disk-emission AGN, all but two of which were observed in the soft band only, were estimated using the standard *ROSAT* hardness ratio, HR1, assuming no intrinsic absorption above Galactic. The Γ's of the RL disk-emission AGN were obtained using direct 2.0–10.0 keV spectral fits. With the exception of the two SDSS RQ disk-emission AGN whose very flat Γ's suggest the presence of absorption above Galactic, the Γ's of both RL and RQ AGN agree well with those of normal AGN.

We conclude that the soft X-ray emission of double-peaked AGN as a class does not differ substantially from that of other AGN with comparable radio and UV emission and is thus unlikely provide a simple explanation for the incidence of disk-emission in AGN.

[1]Note in Figure 1 that the $\alpha_{\rm ox}(L_{2500\,\text{Å}})$ relation is not well defined for $\log(L_{2500\,\text{Å}}) < 27.5$, rendering the $\alpha_{\rm ox}$ residuals of the lowest luminosity RL disk-emission AGN very uncertain.

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