Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310009130

A New Look at Optical and X-ray Emission in SDSS/XMM-Newton Quasars

Monica C. B. Young[1,2]

[1]Harvard-Smithsonian Center for Astrophysics, 60 Garden St., Cambridge, MA 02138, USA
email: `myoung@head.cfa.harvard.edu`

[2]Department of Astronomy, Boston University, 725 Commonwealth Ave. Boston, MA 02215, USA

Abstract. We develop a new approach to the well-studied anti-correlation between the optical-to-X-ray spectral index, α_{ox}, and the monochromatic optical luminosity, l_{opt}. By cross-correlating the SDSS DR5 quasar catalog with the XMM-Newton archive, we create a sample of 327 quasars with both optical and X-ray spectra, allowing α_{ox} to be defined at arbitrary frequencies, rather than the standard 2500 Å and 2 keV. We find that while the choice of optical wavelength does not strongly influence the $\alpha_{ox} - l_{opt}$ relation, the slope of the relation flattens significantly with X-ray energy. This result suggests a change in the efficiency of X-ray photon production, where the efficiency of low energy X-ray production depends more strongly on the seed (optical/UV) photon supply. We discuss implications for line-driven wind models.

Keywords. quasars: general, galaxies: active, accretion, accretion disks

1. Introduction

A quasar's optical to X-ray continuum ionizes the characteristic broad lines and is responsible for any line-driven outflows from the accretion disk (Proga *et al.* 2000). Yet much of this continuum is never visible due to absorption in our own galaxy, so it must be parameterized by an imaginary power-law, traditionally defined by endpoints at 2500 Angstroms and 2 keV.This power-law has been observed to steepen with optical luminosity (e.g., Avni & Tananbaum 1982; Steffen *et al.* 2006). At face value, this relation suggests that efficiency of X-ray production decreases with luminosity, but theory cannot explain why this should be the case. We characterize the dependence of α_{ox} on luminosity by defining the relation at different frequencies than those traditionally used. The results have important implications for line-driven disk winds.

2. Measuring α_{ox} in the SDSS/XMM-Newton Quasar Survey

We have cross-correlated the DR5 Sloan Digital Sky Survey (SDSS) with *XMM-Newton* archival observations to obtain 792 X-ray observations of SDSS quasars. This gives the largest sample of optically selected quasars with both optical and X-ray spectra (473 with X-ray S/N > 6). We exclude broad absorption line and radio-loud quasars, as well as spectra with significant absorption or bad fits, and then we calculate α_{ox} with the standard formula: $\alpha_{ox} = \frac{log(f_x/f_o)}{log(\nu_x/\nu_o)}$ where f_x is the monochromatic flux at 1, 1.5, 2, 4, 7, or 10 keV and f_o is the monochromatic flux at 1500, 2500, or 5000 Å.

For each source with X-ray S/N > 6, we measure the monochromatic flux at 1, 1.5, 2, 4, 7 and 10 keV after fitting an unabsorbed power-law. We then interpolate a power-law through the SDSS photometry to get the luminosity at 1500, 2500, and 5000 Å.

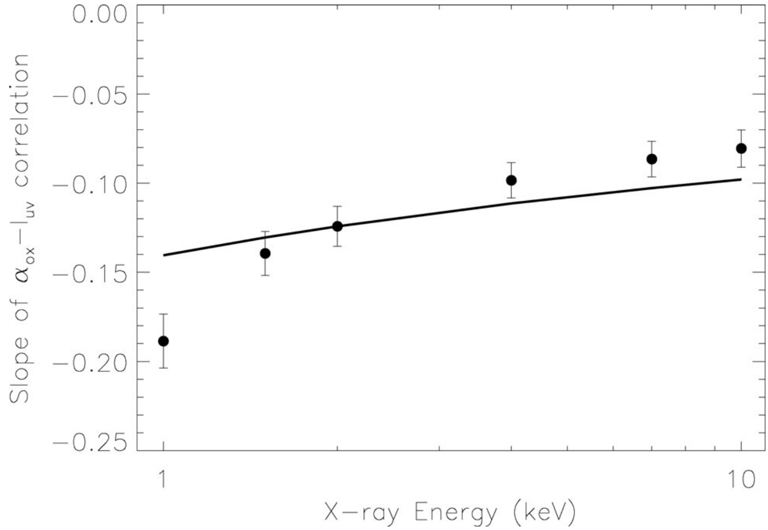

Figure 1. The slope of the $\alpha_{ox} - l_{opt}$ relation with respect to the X-ray energy. The optical wavelength is held constant at 2500 Å. The filled circles show the measured values, and the solid line shows the values predicted by the baseline effect.

3. Results

The slope of the $\alpha_{ox} - l_{opt}$ relation flattens and the dispersion tightens as the X-ray energy used to define α_{ox} increases. The effect of changing X-ray energy is much stronger than that of changing optical wavelength.

The definition of α_{ox} depends on the baseline over which it is defined, so stretching the baseline (for example, moving from 1 to 10 keV) can artificially flatten the $\alpha_{ox} - l_{opt}$ slope. However, Figure 1 shows that while changing the X-ray baseline clearly has an influence, the slope for 1 keV is significantly steeper than it would be if the intrinsic correlation were constant. The slopes at 4, 7 and 10 keV are also flatter than predicted by the baseline effect at the 1σ level. Since the baseline effect is arbitrarily normalized to the slope at 2 keV, the main result of subtracting the baseline effect is not to assess the significance of the slope at a given energy, but rather to show that the *intrinsic* slope of the $\alpha_{ox} - l_{opt}$ relation is flattening as X-ray energy increases.

4. Significance for Line-Driven Winds

The preliminary results of a population study suggest that selection effects cannot reproduce these results, so the $\alpha_{ox} - l_{opt}$ relation is likely intrinsic to quasars. This has important implications for line-driven disk winds (Murray & Chiang 1995; Proga *et al.* 2000), where UV disk photons drive a wind via radiation pressure on spectral lines. Line-driven winds depend on UV luminosity, which determines column density, and on X-ray luminosity, which determines ionization state. The traditional $\alpha_{ox} - l_{opt}$ relation predicts that at high optical luminosities, more driving radiation (high l_{opt}) and less ionizing radiation (steep α_{ox}) should encourage a strong, dense wind. The results of this study suggest that this effect is stronger than previously realized due to the significantly steeper $\alpha_{ox} - l_{opt}$ relation at 1 keV. Wind models should take this dependence into account when modeling the balance between driving radiation and overionization.

References

Avni Y. & Tananbaum H. 1982, ApJ, 262, L17

Murray N., Chiang J., Grossman S. A., & Voit G. M. 1995, ApJ 451, 498

Proga D., Stone J. M., & Kallman T. R. 2000, ApJ, 543, 686

Steffen A., Strateva I., Brandt W., Alexander D., Koekemoer A., Lehmer B., Schneider D., & Vignali C. 2006, AJ, 131, 2826

https://doi.org/10.1017/S1743921310009130 Published online by Cambridge University Press