Emission Lines in Active Galaxies: New Methods and Techniques
ASP Conference Series, Vol. 113, 1997
B.M. Peterson, F.-Z. Cheng, and A.S. Wilson (eds.)

A Correlation Analysis for Emission Lines in 52 AGN

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Abstract. We recently completed the first comparison of high- and low-ionization broad lines in a sample of 52 AGN. We summarize here the principal results of a correlation analysis for this sample. We then briefly outline a model for the broad-line structure in radio-quiet AGN that is suggested by the correlation analysis.

The advent of *HST* has enabled us to compare high (C IV λ1549) and low (Hβ λ4861) ionization broad lines in the *same* sample of 52 AGN. Comparison of HIL and LIL in the same source provides a way to remove part of the degeneracy between structural and kinematic information contained in the line profile. UV spectra were recovered from the *HST* FOS archive while optical data came from 1.5-m and 2.3m telescopes at Kitt Peak, ESO, Calar Alto, and San Pedro Martir. An overview of main results from this comparison and the detailed analysis can be found in Sulentic et al. (1995) and Marziani et al. (1996), respectively. We summarize here the main results of a correlation analysis described in the latter reference. Results must be viewed with caution because our data sample was quite heterogeneous (all spectra available in *HST* FOS archive) and biased towards radio-loud (31/52) sources. Correlations are ranked in rough order of decreasing value of Pearson's correlation coefficient where $c_p \geq 0.6$ was considered significant at $\sim$99% level.

1. C IV λ1549 vs. Hβ emission-line luminosity. The correlation was significantly stronger for radio-quiet AGN (c_p=0.97 vs. 0.75 for radio-loud objects). The radio-quiet result, in particular, suggests a surprising lack of internal obscuration within the broad-line region.
2. Numerous strong intercorrelations were observed between the profile centroid shift at different heights ($c(n/4)$ where n = 0–4) in both Hβ and C IV λ1549 (four and seven intercorrelations with $c_p \geq 0.7$ for radio-quiet

and radio-loud respectively; e.g., $c(3/4)$ vs. $c(1/2)$ in the same line). At the same time, little correlation was observed between line-profile shift and asymmetry. This suggests that *line shifts are real and distinct from profile asymmetries*, although the two can be confused in specific sources.

3. There is no evidence for any correlations *between* Hβ and C IV λ1549 shift or asymmetry parameters in radio-quiet sources. This result coupled with the systematic blueshift of C IV λ1549 relative to Hβ (and the rest frame) suggests that high- and low-ionization lines arise in different regions in radio-quiet AGN. Marginal evidence for such correlations exists in the radio-loud sample. That sample shows C IV λ1549 near the rest-frame velocity, while Hβ shows larger and predominantly (but not entirely) redshifts. The differences between radio-loud and radio-quiet correlations suggest that the broad-line region structure is significantly different in these two classes of AGN.

4. There are several correlations that involve only radio-quiet AGN: for example, the C IV equivalent width EW(C IV λ1549) decreases: (a) as the blueshift of C IV λ1549 relative to Hβ (and the rest frame) increases and (b) as the strength of the optical Fe II multiplets increases ($c_p \approx 0.6$–0.8).

The correlations and the systematic nature of the C IV λ1549 blueshift relative to Hβ in radio-quiet objects suggest a model where: (i) C IV λ1549 emitting clouds show a predominance of radial motion (outflow because we assume that the far side is obscured) in a bi-conical (and/or disk wind) structure with a wide ($\sim$45°) opening angle, (ii) Fe II optical emission arises in a flattened distribution (possibly an accretion disk), and (iii) Hβ arises in a different and less flattened distribution. In this model, C IV λ1549 shows minimum EW and maximum blueshift when we look down the bicone axis. Optical Fe II emission is strongest in this orientation because the flattened structure is viewed face-on. The blueshifted C IV λ1549 emitting structure may be either absent or disrupted in radio-loud sources.

Important observational tests will be related to the multifrequency properties of extra strong Fe II emitters, especially in the X-ray domain. One key point is to establish whether such objects are the high end of a continuous distribution in Fe II emission strength or the specimen of a rare and as yet unidentified class of AGN.

References

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https://doi.org/10.1017/S0252921100040264 Published online by Cambridge University Press