Incorporating the Narrow-Line Region into a Coherent View of the Central Engine & Host Galaxy


Willsfest ~ September 2014
What do the narrow lines know about the central engine?

disappearing NLR

Netzer+04

mid-IR NLR “Baldwin Effect”

Hoenig+08; Keremedjiev+09

eigenvector 1 correlations

Boroson & Green 92; Wills+99
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What does a typical SDSS quasar look like in mid-IR spectra?

mid-IR continuum from warm dust (1-10 pc) + narrow line region emission lines (10-10^3 pc) + PAH emission from host galaxy (kpc)
Typical *Spitzer* spectra of SDSS quasars

- $z=0.040$
- $z=1.90$
- $z=2.08$
Mid-IR composite of 184 Type 1 quasars

$\log(L_{5.6\mu m}) = 41.0 - 46.1$ [erg/s]
Mid-IR composite of 184 Type 1 quasars

\[ \log(L_{5.6 \mu m}) = 41.0 - 46.1 \text{ [erg/s]} \]
PAHfit results of luminosity composites

\[
\log(L_{5.6\mu m}) = 44.8-46.1 \text{ [ergs/s]}
\]

\[
\log(L_{5.6\mu m}) = 43.6-44.7 \text{ [ergs/s]}
\]

\[
\log(L_{5.6\mu m}) = 41.0-43.6 \text{ [ergs/s]}
\]
Narrow line luminosities

\[ [\text{O IV}] \ (55 \text{ eV}) \]

\[ [\text{Ne V}] \ (97 \text{ eV}) \]
Number of ionizing photons vs. line luminosity
Number of ionizing photons vs. line luminosity

predicted + observed slopes for [Ne V] match well
Two points from mid-IR NLR spectral analysis

→ The EW is not a meaningful metric for high ionization lines in the mid-IR (a mid-IR Baldwin Effect isn’t meaningful).

→ In composite spectra, the NLR is getting stronger with increasing continuum luminosity (with non-linear scaling) as expected.
What do the narrow lines know about the central engine?

→ eigenvector 1 correlations

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Optical narrow lines with high S/N (composites)
Isolate narrow lines from central engine

\[ 4 L_{5100} \times 3 \text{ HB FWHM} \times 7z = 84 \text{ bins} \]

\[ L_{5100} \]

\[ \text{H\beta FWHM} \]

Shen+11 sample

empirical proxies for \( M_{\text{BH}} \) and \( L/L_{\text{Edd}} \)
Optical narrow lines with high S/N (composites)
Evolution of quasar NLR: [NeV] vs. redshift
Evolution of host galaxy: \([\text{OII}]\) vs. redshift
Compare \([\text{OII}] \) & \([\text{NeV}]\)

**increasing with z**

interpretation: reflects SF in host galaxy
Conclusions

→ don’t forget your quasar lives in a galaxy

→ high ionization narrow lines are powerful probes of the NLR