The continuum and emission line properties of low luminosity Type-1 AGN

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AGN – Open Questions

What is the dependence on $L_{Bol}$, $L/L_{Edd}$ & $M_{BH}$ of:
1. The continuum emission mechanism
2. The narrow and broad line-emitting gas properties

What is the dependence on broad line luminosity ($L_{bH\alpha}$) and width (FWHM) of:
1. The spectral energy distribution (SED)?
2. The broad and narrow emission line EW?
3. The BPT Position (narrow emission line ratios)?
Outline

A. The new Broad $H\alpha$ selected sample

B. What is the dependence on $L_{bH\alpha}$ and FWHM of the:
   1. spectral energy distribution (SED)?
   2. broad and narrow emission line EW?
   3. BPT Position (narrow emission line ratios)?
The Broad-Hα Selected Sample

SDSS DR7 (~1M objects): $z < 0.31$, S/N>10 → ~200K objects

1. $F_{\lambda}(10^{-17} \text{ erg cm}^{-2} \text{s}^{-1} \text{Å}^{-1})$

2. $F_{\lambda,\text{raw}}(10^{-17} \text{ erg cm}^{-2} \text{s}^{-1} \text{Å}^{-1})$

3. $L_{\lambda}(10^{10} \text{ erg s}^{-1} \text{Å}^{-1})$

4. 1,000<$FWHM<$30,000 km s$^{-1}$; minimum Broad Hα S/N

→ ~8K objects

→ Final sample: 3,824 objects
Similar Samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Data Release</th>
<th># of objects</th>
<th>Main Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Sample</td>
<td>DR7</td>
<td>3,824</td>
<td></td>
</tr>
<tr>
<td>Greene &amp; Ho 2007</td>
<td>DR4</td>
<td>8,495</td>
<td>Lower S/N threshold, No published NL fluxes, $\Delta \lambda = 300\text{Å}$ (look for low $M_{\text{BH}}$)</td>
</tr>
<tr>
<td>Vanden Berk et al. 2006</td>
<td>DR3</td>
<td>4,666</td>
<td>Lower S/N threshold, Require total FWHM (NL+BL) $&gt;1000$ km s$^{-1}$, $z &lt; 0.75$</td>
</tr>
<tr>
<td>Hao et al. 2005</td>
<td>DR2</td>
<td>1,317</td>
<td>Lower S/N threshold, Simpler NL / BL decomposition</td>
</tr>
</tbody>
</table>

**Our additions:**

1. $\Delta \lambda = 600\text{Å}$, very broad lines are detectable
2. Narrow line measurements
3. Additional photometry:  
   2MASS (detection fraction - 98%), GALEX (83%), ROSAT (42%)
Broad H\(\alpha\) Luminosity \((L_{bH\alpha})\) Distribution

New sample: BLR selected

SDSS Quasar Catalog (Schneider et al. 10): Optically selected

Ho et al. 97: Narrow slit (x3)
The diagram shows the correlation between the logarithm of the broad $H\alpha$ luminosity relative to the Eddington luminosity ($L_{bH\alpha}/L_{Edd}$) and the FWHM of the broad $H\alpha$ line. Low flux in wings and low Broad $H\alpha$ S/N are indicated by arrows on the graph. The selection criteria are marked by dotted lines, and the luminosity of the black hole ($M_{BH} = 10^9 M_\odot$) is shown by a dotted line. The parameters are defined as:

$m \equiv \log \frac{M_{BH}}{M_\odot}$; $l \equiv \log \frac{L}{L_{Edd}}$

The range for $m$ is from 8 to 14, and for $l$ from 3 to 14.
Eddington Ratio Distribution

New Sample

Point sources in the new sample

Kollmeier et al. 06

Bright quasar sample

all 3 selected to be point sources

\[ \text{tendency for } \log \frac{L}{L_{Edd}} \sim -0.5 \text{ seems like a selection effect} \]
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Mean Spectral Energy Distribution
Mean Spectral Energy Distribution

1.2 μm (J)

Hosts are more massive

Residuals

Matched Galaxies

3940Å

Residuals

Hosts are bluer

Matched Galaxies

2Mass SDSS Galex

Total

Residual = Total - Scaled AGN

Redshift Matched Non-Active Galaxies

Matched Galaxies

Residuals

$L_{\text{H}\alpha}$ (erg s$^{-1}$)

42.0

log $v$ (Hz)
Mean Spectral Energy Distribution

$\lambda = 1.2 \mu m (J)$

Hosts are more massive

Residuals

$\lambda = 3940 \AA$

Hosts are bluer

Residuals

Matched Galaxies

For $L_{bH\alpha} > 10^{41.5}$ erg s$^{-1}$, the mean SED remains constant with luminosity and scales with $L_{bH\alpha}$. 
SED by $L_{bH\alpha}$ & Slope

Substantial absorption by dust

No absorption by dust

X-ray less affected

2MASS  SDSS  GALEX ROSAT
(+1 dec)
**SED by**

$L_{\text{bH}}$ & Slope

**Total**

No absorption by dust

Substantial absorption by dust

X-ray less affected

Substantial host contamination

Slight host contamination

No absorption by dust

Substantial host contamination

Slight host contamination

Substantial absorption by dust

2MASS  SDSS  GALEX ROSAT

$(+1 \text{ dec})$
SED by $L_{bH\alpha}$ & Slope

![Graph showing SED by $L_{bH\alpha}$ & Slope]
Main changes to optical slope are due to mechanisms external to the accretion disk.
Spectrum by FWHM – Highest $L_{bH\alpha} \text{ bin}$

FeII Multiplets (Phillips 78)

NLS1s

Very broad lines
SED by $L_{bH\alpha}$ and FWHM

Mass increase with FWHM

Widest H$\alpha$

Narrowest H$\alpha$ (NLS1s)

Zoom on absorption features:
flux increases with FWHM
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Most low luminosity Type 1 Seyferts are 1.5-1.9
Are all partially obscured, or is it the NLR covering factor?
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BPT Position of BLR selected AGN

Type-2 AGN: Kewley et al. 06, Kauffmann et al. 03  (Background)
BPT Position of BLR selected AGN

Luminosity Dependence

low $L_{bH\alpha}$ . . high $L_{bH\alpha}$

![Graph showing the BPT diagram for AGN, Seyfert, and LINER types with low and high luminosity.](image-url)
BPT Position of BLR selected AGN

Broad Hα FWHM Dependence

NLS1s . . Very broad lines
BPT Position of BLR selected AGN

\[
\frac{L}{L_{\text{Edd}}} \text{ Ratio Dependence}
\]

low \(\frac{L}{L_{\text{Edd}}}\) \ldots high \(\frac{L}{L_{\text{Edd}}}\)
Main Results and Possible Implications

A new sample of low luminosity Type-1 AGN (publicly available soon).

1. AGN with $10^{44}$ erg s$^{-1} < L_{\text{Bol}} < 10^{46.5}$ erg s$^{-1}$ have:
   I. A fixed mean-SED shape, scales with $L_{b\text{H}\alpha}$.
      *An optically thick accretion disk and constant BLR covering factor?*
   II. Mean host galaxies similar to mean inactive galaxies.

2. EW (NLR) increases with decreasing luminosity.
   *Most Seyferts 1.5-1.9 probably differ from Sey’ 1.0 in NLR covering factor*

3. BPT classification of T1-AGN:
   9% Composites, 1% SF, 3% LINERs
   I. Change in mean position with $L$. *Change in ionization parameter?*
   II. AGN at $\log L/L_{\text{Edd}} \approx -2.5$ are LINERs.
      *Change in ionizing continuum?*
   III. NLS1s have low [OIII]/narrow H$\beta$ and low [NII],[SII],[OI]/narrow H$\alpha$. *Change in ?*