The physical driver of Eigenvector 1 in Quasar Main Sequence

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References

We will check the $R_{\text{FeII}}$, $R_{\text{FeII}}$, $R_{\text{HII}}$, $R_{\text{HII}}$, $R_{\text{HII}}$, and $R_{\text{HII}}$ dependence for now in iteration. We intend to check the evolution of the $R_{\text{HII}}$, $R_{\text{HII}}$, and $R_{\text{HII}}$.

We need to find a correspondence between disk maximum temperature and the AGN model of $L_{\text{bol}}$, otherwise, we may be able to the $R_{\text{HII}}$, $R_{\text{HII}}$, $R_{\text{HII}}$, and $R_{\text{HII}}$ dependence for now in iteration.

We will test our theory for the model with lower (10^7 M\odot) mass black hole.

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Results & Discussions

How DO WE HAVE?

Figure 2: An example of the spectral energy distribution of the AGN broadband continuum and line emission produced by CLOUDY. $T_{\text{bol}}$ = 10^7 K. $N_{\text{H}}$ = 10^44 cm^{-2}, $L_{\text{bol}}$ = 5x10^44 erg s^{-1}, and $L_{\text{x}}$ = 10^45 erg s^{-1}. The two-component power law serves as the incident radiation.

Based on the hypothesis, the obtained relation between $T_{\text{bol}}$ is heavily affected by the change in the maximum temperature of the BBB component.

Future: What NEXT?

• We will check the $R_{\text{FeII}}$, $R_{\text{FeII}}$, $R_{\text{FeII}}$, and $R_{\text{FeII}}$ dependence for now in iteration. We intend to check the evolution of the $T_{\text{bol}}$ and $T_{\text{bol}}$.

• We need to find a correspondence between disk maximum temperature and the AGN model of $L_{\text{bol}}$.

• We will test our theory for the model with lower (10^7 M\odot) mass black hole.

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What do we have here?

- Quasars are rapidly accreting supermassive black holes at the centers of massive galaxies.
- Their dependence on a broad range of parameters, many of which are highly correlated, across all wavelengths reflects the diversity in the physical conditions of the regions in the vicinity of the central core.
- This problem is analogous to the problem of identifying what governs the stellar main sequence on the Hertzsprung-Russel diagram when the classification was based purely on spectral properties of the stellar atmospheres.
- Boroson & Green (1992) found a single parameter which was responsible for most of the dispersion in the observed properties of Type 1 AGNs - the Eigenvector 1 (EV1).
Enters - Quasar Main Sequence

- Observational progress with SDSS (Shen & Ho, 2014 and others) have made it possible to have a simplified definition of EV1, which sets the dominant trend controlling the AGN spectra wherein many properties (Eddington ratio, black hole mass, accretion rate and others) are found to be correlated.

**Figure 1:** The distribution of the FWHM(H β) for 20,000 quasars plotted against the EV1. The horizontal axis is the relative Fe II strength (R_{FeII}) and the vertical axis is the broad H β FWHM. The red contours show the distribution of selected quasar sample (quasar density increasing from outer to inner contours). The points are color-coded by the [OIII] (λ = 5007 Å) EW, averaged over all nearby objects in a smoothing box of ΔR_{FeII} = 0.2 and ΔFWHM_{Hβ} = 1,000 km s⁻¹.
We propose that the physical driver of EV1 is the **maximum of the accretion disk temperature**, reflected in the shape of the SED, which is also the basic parameter determining the broad band shape of the quasar continuum emission.

- The hypothesis seems natural because the spectral shape determines both broad band spectral indices as well as emission line ratios. We expect that this maximum temperature depends on the ratio of the Eddington ratio to the black hole mass (or, equivalently, on the ratio of the accretion rate to square of the black hole mass) so it also seems qualitatively consistent with the finding of Shen & Ho (2014).
In the case of a non-rotating black hole using the Shakura-Sunyaev model since in this case the maximum of the disk temperature is at $4.8 \ R_{Schw}$, the maximum temperature is:

$$T_{\text{max}} = \left[ \frac{3G\dot{M}}{8\pi\sigma r^3} \left( 1 - \sqrt{\frac{R_{in}}{r}} \right) \right]^{0.25} = 2.034 \times 10^{19} \left( \frac{\dot{M}}{M^2} \right)^{0.25}$$

which gives us:

$$\nu_{\text{max}} \sim \left[ \frac{L}{L_{\text{Edd}}} \right]^{0.25} \left( \frac{M}{\dot{M}} \right)^{0.25}$$

\[
\text{(where, } L_{\text{Edd}} = \frac{4\pi cGMm_H}{\sigma_T} \text{)}
\]
To model the AGN full continuum, the SED of a quasar is parametrized by:

1. a low-energy slope of the Big Bump continuum ($\alpha_{uv}$);
2. slope of the X-ray component ($\alpha_{x}$);
3. their corresponding exponential cutoffs;
4. the relative luminosities of these two components (determined by setting the spectral index $\alpha_{ox}$, that describes the continuum between optical-UV bump and the X-ray peak);
5. incorporating a total bolometric luminosity ($= 10^{45} \text{ ergs}^{-1}$) of the quasar cloud;
6. the broad line region (BLR) from the core of the nuclei;
7. the mean hydrogen density of the cloud (deduced from the ratios of emission lines); and
8. a limiting column density ($N_{H}$) to define the outer edge of the cloud.
Results and Discussions

Figure 2: An example of the spectral energy distribution of the AGN transmitted continuum and line emission produced by CLOUDY:

$T_{\text{eff}} = 3.45 \times 10^4 \text{ K}$,  
$\alpha_{\text{ox}} = -1.6$, $\alpha_{\text{uv}} = -0.36$,  
$\alpha_{\lambda} = -0.9$,  
$n_H = 10^{11} \text{ cm}^{-3}$,  
$N_H = 10^{24} \text{ cm}^{-2}$ and  
$log (R_{\text{BLR}}) = 17.208$. The two-component power law serves as the incident radiation.
As a first test we check the dependence of the change in the \( T_{\text{eff}} \) to \( R_{\text{FeII}} \) at constant values of \( L_{\text{bol}} \), \( \alpha_{\text{ox}} \), \( \alpha_{\text{ox}} \), \( n_{\text{H}} \) and \( N_{\text{H}} \). We fix the distance to the clouds using the clean model relation by Bentz et. al (2013).

\[
\left( \frac{R_{\text{BLR}}}{1 \text{ lt-day}} \right) = 10^{1.555 + 0.542 \log \left( \frac{\lambda L_{\lambda}}{10^{44} \text{ erg s}^{-1}} \right)}
\]  

\[ \text{(3)} \]

The range of Eddington ratio \( \left( \frac{L}{L_{\text{Edd}}} \right) \) for this branch of solutions between \( 3.45 \times 10^4 \) K and \( 5 \times 10^5 \) K is [0.01244, 2.61247].

Based on the hypothesis, the obtained relation between \( R_{\text{FeII}} \) is heavily affected by the change in the maximum temperature of the BBB-component.
Figure 3: Inter-dependence of the parameters with simple n-degree Bézier curves: (a) composite Fe\textsc{II} line luminosity - H\textsc{\beta} line luminosity; (b) R\textsubscript{FeII} - T\textsubscript{BBB}; (c) R\textsubscript{BLR} - T\textsubscript{BBB}; (d) R\textsubscript{FeII} - R\textsubscript{BLR}
WHAT NEXT?

• We will check the $R_{\text{Fe}^\text{II}}$ dependence on other parameters which are used ($L_{\text{bol}}, \alpha_{\text{ox}}, \alpha_{\text{uv}}, n_H$ and $N_H$). We intend to incorporate the microturbulence to whose variation the emission flux is sensitive as suggested in Bruhweiler and Verner (2008).

• The $R_{\text{Fe}^\text{II}}$ - $T_{\text{BBB}}$ dependence for now is monotonic. We intend to check the mechanism of the formation of $\text{Fe}^\text{II}$ and $\text{H}^\beta$.

• We need to find a correspondence between disk maximum temperature and the AGN model of a disk + corona with full GR and more complex geometry, and we have to do statistical studies based on samples with known black hole masses.

• We will test our theory for the sources with known SED peak position.

• “The CLOUDY issue”
Thank You!
Trying to model the intrinsic FeII spectrum using

- **CLOUDY**
  - initial values: $\Phi(H) = 18.5$, $hden = 10$, $c.d = 22$
  - test 1: $\Phi(H) = 20.5$, $hden = 11$, $c.d = 22$, $v_{turb} = 20$
    (371 levels-68,635 transitions-upto 11.6 eV ; 1527 transitions within 4434-4684Å)
  - test 2: $\Phi(H) = 20.5$, $hden = 11$, $c.d = 24^*$, $v_{turb} = 20$
    (371 levels-68,635 transitions-upto 11.6 eV ; 1563 transitions within 4434-4684Å)

Comparing the results with Verner FeII Emission template for I Zw1
(831 levels-344,035 transitions-upto 14.06 eV ; 644 transitions in the template $\Rightarrow$ only 29 transitions within 4434-4684Å)

(* - as per Bruhweiler & Verner, 2008)
