

## Kinematic differences between NLS1 and BLAGN sources

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It is well-known that the higher polycyclic aromatic hydrocarbon (PAH) abundance, lower black hole mass, higher accretion rate and lower luminosities are among the major characteristics of Narrow-Line Seyfert galaxies (NLS1), when they are compared to Broad line Seyfert galaxies (BLS1). NLS1s may be normal Seyfert galaxies at an early stage of evolution, their black holes may still be growing and/or they could be special for some other reason. In this work we discuss the findings that NLS1s have most of line and continuum luminosities correlated with  $\text{FWHM}(\text{H}\beta)$ , which may be the trace of their rapid black hole mass grow. BLS1 do not show such trends. Also, PAHs may be destroyed as the black hole grows and the starbursts are removed, for NLS1 objects.

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## 1. Introduction

Narrow-line Seyfert 1 (NLS1) galaxies show relatively narrow full width at half maximum ( $\text{FWHM} \leq 2000 \text{ km s}^{-1}$ , [1]) of permitted lines, narrower than in typical Seyfert 1 galaxies. NLS1s have certain specific characteristics with respect to the broad line active galactic nuclei (BLAGNs). NLS1 objects have more polycyclic aromatic hydrocarbons (PAHs) [2], more dust spirals and bars [3] and higher accretion rates [4] than BLAGNs, while BLAGNs have higher black hole (BH) masses ( $M_{\text{BH}}$ ) [5], and higher optical, X-ray and UV luminosities [6, 7]. NLS1s have lower optical variability [8], higher X-ray variability [9] and possibly a lower inclination [10], than the BLAGNs. NLS1s have strongest Fe II emission, strongest X-ray excess, and largest CIV blueshifts [11]. It is believed that NLS1s are AGNs in the early stage of evolution [5, 12] and that their black holes are growing [13].

The aim of this research was to explore if NLS1s show some characteristics different from BLAGNs, using some optical and mid-infrared (MIR) spectroscopic parameters, as this may suggest the nature of differences between these two groups of objects. Here, we present some correlations that are different for NLS1s and BLAGNs. We found that NLS1s show the dependence of most of line and continuum luminosities and PAH with  $\text{FWHM}(\text{H}\beta)$ , while BLAGNs do not show these trends.

## 2. The sample and method of analysis

In this work we adopted the criteria for NLS1s that  $\text{FWHM}(\text{H}\beta) \leq 2200 \text{ km s}^{-1}$  and that their flux ratio of total [O III]  $\lambda 5007$  to total  $\text{H}\beta$  is  $< 3$  [10]. The sample consists of 64 NLS1s and 99 BLAGNs, with redshifts  $< 0.7$ , that have optical (Sloan Digital Sky Survey – SDSS DR12) and MIR (InfraRed Spectrograph – IRS on Spitzer Space Telescope) spectral parameters, described and available in papers [14] and [6]. Spectral parameters are:

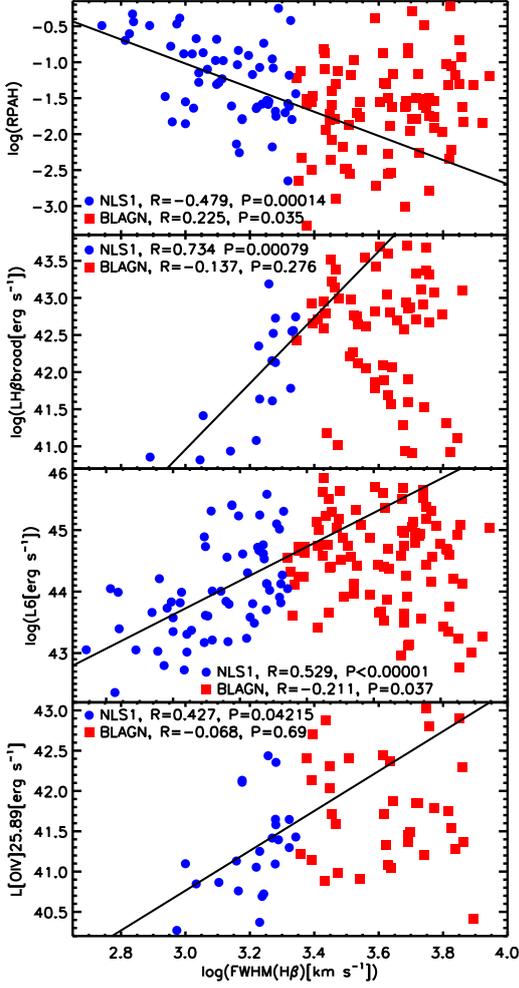
- Optical:  $\text{FWHM}(\text{H}\beta)$ , AGN continuum luminosity at  $5100 \text{ \AA}$ , ( $L_{5100}$ ), Luminosity of  $\text{H}\beta$  broad line<sup>1</sup> ( $L_{\text{H}\beta\text{b}}$ ) and  $M_{\text{BH}}$ .
- MIR: fractional contribution of PAH component to the integrated  $5\text{--}15 \mu\text{m}$  luminosity – RPAH, monochromatic luminosity of the source at  $6 \mu\text{m}$  – L6 and the luminosities of coronal MIR lines, [O IV] at  $25.89 \mu\text{m}$  and [Ne V] at  $14.32 \mu\text{m}$  –  $L[\text{O IV}]_{25.89}$  and  $L[\text{Ne V}]_{14.32}$ .

RPAH and L6 were calculated using deblendIRS code [15]. The coronal MIR lines were fitted using the Gaussian function and the luminosities are obtained.

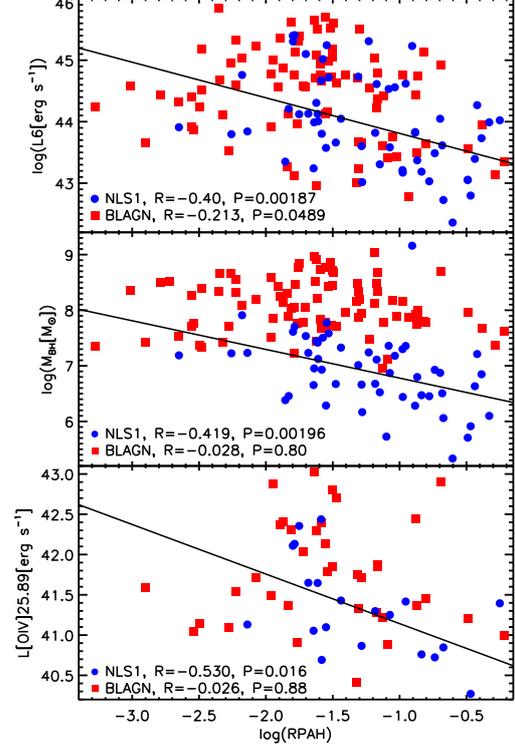
## 3. Results

In Fig. 1 we present the  $\text{FWHM}(\text{H}\beta)$  vs. several optical and MIR parameters: RPAH,  $L_{\text{H}\beta\text{b}}$ , L6 and  $L[\text{O IV}]_{25.89}$ . We noticed that NLS1s show the trends (relations with P-values  $< 0.05$  are adopted as significant), while BLAGNs do not show them.

<sup>1</sup>We fitted the broad spectral line  $\text{H}\beta$  with three Gaussians: narrow, intermediate and very broad. For  $\text{FWHM}(\text{H}\beta)$  and  $L_{\text{H}\beta\text{b}}$  we included both intermediate line region and very broad line region.



**Figure 1:** FWHM( $H\beta$ ) compared to other parameters: RPAH, LH $\beta$ b, L6 and L[O IV]25.89, for NLS1s and BLAGNs.



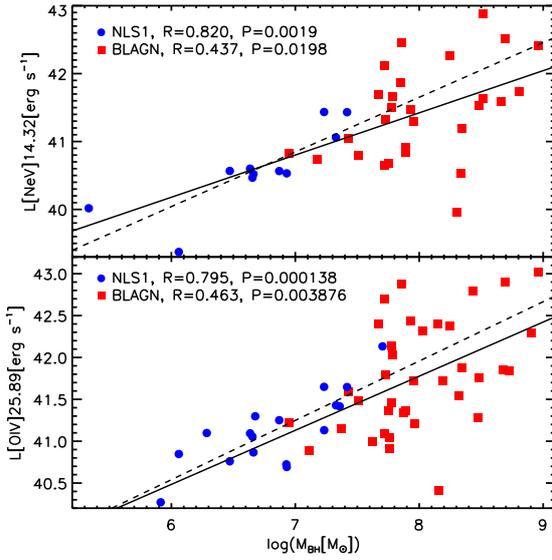
**Figure 2:** RPAH decreases with L6 (upper panel), with  $M_{BH}$  (middle panel) and with L[O IV]25.89 (bottom panel), for NLS1 objects. BLAGNs do not show any trends.

In Fig. 2 we present RPAH vs. parameters: L6,  $M_{BH}$  and L[O IV]25.89. RPAH decreases with L6 and L[O IV]25.89 and with  $M_{BH}$ s in NLS1 objects. BLAGNs do not show any obvious trends.

The correlation between L[Ne V]14.32 and L[O IV]25.89 with  $M_{BH}$  was found by [16], who claimed that this correlation is most likely the consequence of the NLR gas kinematics being determined by the potential of the bulge. Thus, these luminosities can be used to estimate  $M_{BH}$ . We tested this relation in Fig. 3. Significantly stronger trends were obtained for NLS1s than for BLAGNs, for both lines. That may imply that this relation may be more suitable for the estimation of  $M_{BH}$  for NLS1 objects than for BLAGNs.

#### 4. Discussion

Regarding the FWHM( $H\beta$ )–RPAH trend for NLS1s (Fig. 1), it was already noticed in [14]



**Figure 3:** Upper panel: correlation  $L[\text{Ne V}]14.32-M_{\text{BH}}$ ; lower panel: correlation  $L[\text{O IV}]25.89 - M_{\text{BH}}$ .

and references within, but for the whole BLAGN and NLS1 sample.  $\text{FWHM}(\text{H}\beta)\text{--LH}\beta\text{b}$  trend (Fig. 1) is found by [9] and [1]. [1] found it both for NLS1s and BLAGNs.  $\text{FWHM}(\text{H}\beta)$  and  $\text{LH}\beta\text{b}$  origin from broad line region (BLR), which is gravitationally bound to the BH. Thus,  $\text{FWHM}(\text{H}\beta)$  is used to measure the dispersion velocity of that region, while  $\text{LH}\beta$  most likely also grows with  $M_{\text{BH}}$ . This may be connected with the findings of [17] that the objects with more starbursts show certain correlations that other Seyferts 1 do not have (such as the correlation  $\text{FWHM}(\text{H}\beta)\text{--L}5100$ ). Finally, the correlations of  $\text{FWHM}(\text{H}\beta)$  with  $L6$  and  $L[\text{O IV}]25.89$ , for NLS1s (Fig. 1) could also be explained with BH growth, since 1)  $\text{FWHM}$  increases with  $M_{\text{BH}}$  (see above), and 2) luminosities depend on BH size [2]. These trends may be the trace of the evolution of NLS1 objects, as  $\text{FWHM}(\text{H}\beta)$ , luminosities and  $M_{\text{BH}}$  grow.

Anticorrelations of RPAH with luminosities and  $M_{\text{BH}}$  (Fig. 2) could be understood as the PAH destruction and starburst removal, with BH growth, in NLS1 objects, but also as the natural transition from the type NLS1 to BLAGN type of objects. PAHs may be more actively destroyed in NLS1s than in BLAGNs, as  $M_{\text{BH}}$  and MIR luminosities grow.

Trends  $M_{\text{BH}}\text{--Luminosities}$  of coronal lines (Fig. 3), are found to be considerably higher for NLS1s than for BLAGNs. Perhaps the reason for that is that the MIR narrow line region lines can not well estimate the BLR parameters of BLAGN objects. The future research should examine these trends for the larger samples of objects.

## 5. Conclusion

NLS1s could be the objects with BHs that grow faster than the ones in BLAGNs, as it is proposed in various literature. They have higher accretion rates, more starbursts, but lower line and continuum luminosities at optical and MIR wavelengths and lower  $M_{\text{BH}}$  than BLAGNs [6]. Here we used optical and MIR spectral parameters to explore the correlations that are different

between NLS1 and BLAGN objects. These differences are important to understand the nature of these objects.

The results of our investigations led us to following conclusions:

- The correlations between FWHM( $H\beta$ ) and luminosities of MIR and optical lines and continuum, for NLS1s, are probably the consequence of the  $M_{\text{BH}}$  growth which increases both FWHMs and luminosities. Higher mass increase the luminosities and velocities.
- We found that RPAH decreases with  $M_{\text{BH}}$  and luminosities of coronal lines and continuum, only for NLS1s.
- The trends  $M_{\text{BH}}$ –Luminosities of coronal lines are higher for NLS1s than for BLAGNs.

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### References

- [1] Véron-Cetty, M. P., Véron, P., & Gonçalves, A. C., 2001, *A&A*, 372, 730
- [2] Sani, E., Lutz, D., Risaliti, G., et al. 2010, *MNRAS*, 403, 1246
- [3] Deo, R. P., Crenshaw, D. M., & Kraemer, S. B. 2006, *AJ*, 132, 346
- [4] Bian, W.-H. & Zhao, Y.-H. 2003, *PASJ*, 55, 599
- [5] Mathur, S. 2000, *New Astron. Rev.*, 44, 469
- [6] Lakićević, M., Popović, L. Č., Kovačević-Dojčinović, J. 2018, *MNRAS*, 478, 4068
- [7] Grupe, D., Komossa, S., Leighly, K. M. & Page, K. L. 2010, *ApJS*, 187, 64
- [8] Rakshit, S., & Stalin, C. S. 2017, *ApJ*, 842, 96
- [9] Zhou, H., Wang, T., Yuan, W., Lu, H., Dong, X., Wang, J., & Lu, Y. 2006, *ApJS*, 166, 128
- [10] Rakshit, S., Stalin, C. S., Chand, H. & Zhang, X.-G. 2017, *ApJS*, 229, 39R
- [11] Shapovalova, A. I., Popović, L. Č., Burenkov, A. N., et al. 2012, *APJS*, 202, 10
- [12] Mathur, S., Kuraszkiewicz, J., & Czerny, B. 2001, *New A*, 6, 321
- [13] Jin, C., Ward, M., & Done, C. 2012, *MNRAS*, 422, 3268
- [14] Lakićević, M., Kovačević-Dojčinović, J., Popović, L. Č. 2017, *MNRAS*, 472, 334
- [15] Hernán-Caballero, A., Alonso-Herrero, A., Hatziminaoglou, E. et al. 2015, *ApJ*, 803, 109
- [16] Dasyra, K. M., Ho, L. C. & Armus, L. 2008, *ApJ*, 674, L9
- [17] Popović, L. Č. & Kovačević, J. 2011, *ApJ*, 738, 68P