Proceedings of the XII Serbian-Bulgarian Astronomical Conference
(XII SBAC) Sokobanja, Serbia, September 25-29, 2020
Editors: L. Č. Popović, V. A. Srećković, M. S. Dimitrijević and A. Kovačević
Publ. Astron. Soc. "Rudjer Bošković" No 20, 2020, 33-38

THE SPECTRAL PROPERTIES OF THE AGN TYPE 2 SAMPLE: THE SEARCH FOR THE SIGMA* SURROGATE

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Abstract. M_{BH} - σ* relation is the most commonly used method for the M_{BH} (mass of the super-massive black hole) estimation in the AGNs (Active Galactic Nuclei) Type 2. Since σ* (stellar velocity dispersion) is in some cases diluted by the noise in AGN Type 2 spectra, it is of interest to find appropriate surrogate for σ* in some prominent AGN Type 2 spectral characteristics. Here we used the large sample of the AGN Type 2 spectra from SDSS and try to find under what circumstances the width of the [O III]5007 Å emission lines can be used as σ* surrogate. We find that only in the case of objects with no asymmetry in the narrow emission lines profiles, the width of the [O III] core can be used appropriately as σ* surrogate, since outflow kinematics do not affect significantly the [O III] profile.

1. INTRODUCTION

According the Standard Unified model (Antonucci 1993, Urry & Padovani 1995S), in the center of an Active Galactic Nuclei there is a super-massive black hole ($M_{BH}>10^6$ Msun) surrounded by the accretion disc and high velocity gas of the Broad Line Region (BLR), where broad emission lines arise. Around BLR there is a torus of the dust, and out of the dusty torus, there is the Narrow Line Region (NLR), where the narrow emission lines arise. The AGNs Type 2 are observed through dusty torus (edge-on), which covers the broad emission lines from BLR, so only the narrow emission lines can be seen in their spectra. On the other hand, in the spectra of the AGNs Type 1, which are observed under higher inclination angle, both the narrow and the broad emission lines can be observed.

The estimation of the M_{BH} is of the great importance for investigation of the AGNs, their structure and evolution, as well as co-evolution with the host galaxy.

The commonly used method for M_{BH} estimation is M_{BH} - σ* relation (see e.g. Tremaine et al. 2002), where σ* is the velocity dispersion of the stars located in the bulge of the host galaxy, which are strongly gravitationally bounded to the M_{BH}. σ* is measured using the width of the stellar absorption lines in AGN spectra. The problem is that σ* is not always well measurable in Type 1 AGNs spectra due to strong luminosity of the AGN continuum, while in Type 2, it could be diluted by the noise. Taking into account that M_{BH} - σ* relation is the only method for the estimation of the M_{BH} for the Type 2 AGNs, it would be very useful to find some prominent spectral property that can be used as the surrogate for the σ*.

There were numerous attempts to find the surrogate for the σ* in Type 1 AGNs, using the width of the narrow emission lines (see Nelson 2000, Shields et al. 2003, Grupe & Mathur 2004, Greene & Ho 2005, Bonning et al. 2005, Salviander & Shields 2013). However, setback for larger application of this method is the large scatter between σ* and width of the narrow emission lines of Type 1 AGNs.

Nelson & Whittle (1996) noticed that there is lower correlation between σ* and the [O III] 5007 Å wings, than with the [O III] 5007 core. Recently, several analysis of the complex NLR kinematical structure are done, using the large samples of the AGNs (Woo et al. 2016, Eun et al. 2017). They showed that the narrow emission lines can be decomposed to the two components: one is the core component of the line, which arises from gravitationally bounded gas, and the other is the non-gravitational, wing component of the line, which arises in the gas outflow. It is of the great importance to correctly separate the gravitational from non-gravitational narrow line component, in order to find the good surrogate for the σ*.

In this work we analyze the sample of the AGNs Type 2, in order to find the subsample in which the width of the narrow lines can be used as appropriate surrogate for the σ*.

2. THE SAMPLE AND ANALYSIS

For this research, we obtained the sample of the 525 AGNs Type 2, taken from the SDSS, DR14, with high signal-to-noise ratio, S/N>20. After reddening and redshift correction, we performed spectral principal component analysis in order to subtract host galaxy contribution (see procedure in Lakićević et al. 2017).

We fit the [O III]λλ 4959, 5007 Å narrow lines with two component model: one Gaussian for the core, and another for the wing (see Fig 1). We found that in 26% of objects from the sample there is no any asymmetry in the [O III] line profiles, i.e. [O III] emission lines can be fitted with only one, core Gaussian component (see Fig 1, left). In the rest of the sample (~74%), the asymmetry is present in the [O III] profiles, so these emission lines are fitted with two Gaussians (core + wing component, see Fig 1, right).

Therefore, the initial sample of the 525 AGNs Type 2 is divided into two subsamples according to the strength of the outflow which is reflected in the strength (width and shift) of the wing components of the narrow emission lines. The first subsample consists of the 135 Type 2 AGN spectra, in which there are no wing components in narrow emission lines, and the other subsample consists of 391 AGN spectra, in which the wing (outflow) components are present in [O III] lines.

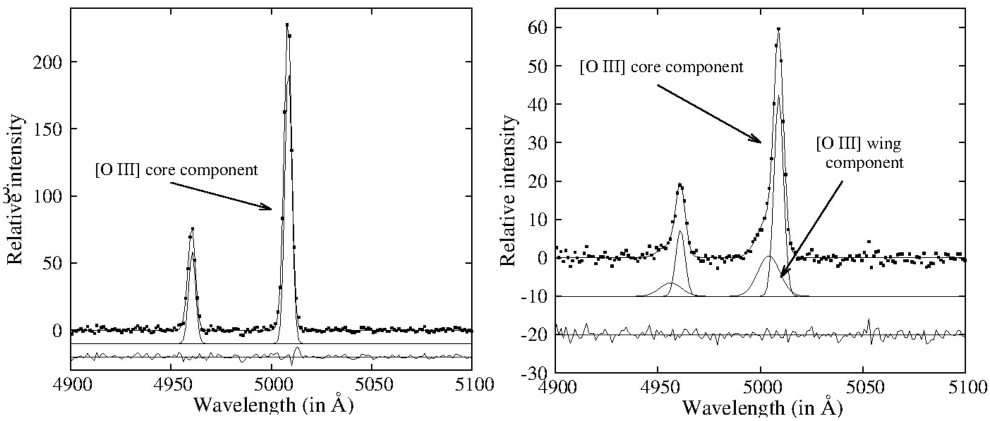

Figure 1: The example of the fit of object with no asymmetry in [O III] line profile (left), and with present asymmetry in [O III] line profile (right).

3. RESULTS AND CONCLUSIONS

The recent investigations of the NLR kinematics (Woo et al. 2016, Eun et al. 2017) suggest that, in order to avoid the outflow influence to the line width, wing component should be subtracted from the [O III] profile, and only the core component should be used as surrogate for the σ*. Here we investigate if there is some influence of the outflow kinematics, not only in the wings, but also in the core components as well. We compared the widths of the [O III] core components with the σ*, for both subsamles. We found that correlation between widths of [O III] core components and σ* is significantly stronger for subsample with absent wing components (r = 0.70, P = 0), than for the subsample with strong wing components (r = 0.29, P = 1.7E-6). The correlations are shown in Fig 2a, b. Also, we compared the [O III] luminosity with the width of the [O III] core component for the both subsamples, and we colored the symbols with diverse colors for different M_{BH}(σ*) bin intervals (M_{BH} is estimated using M_{BH} - σ* relation given in Woo et al. 2015). In the subsample with absent wing components, correlation between these two parameters is stronger (r = 0.53, P = 4.4E-11), and it could be seen that L [O III] and width of the [O III] core component are both indicators of the M_{BH}(σ*) (see Fig 3a). For subsample with present wing components, there is only weak trend between these two parameters, and they are not correlated with $M_{BH}(\sigma^*)$ (see Fig 3b).

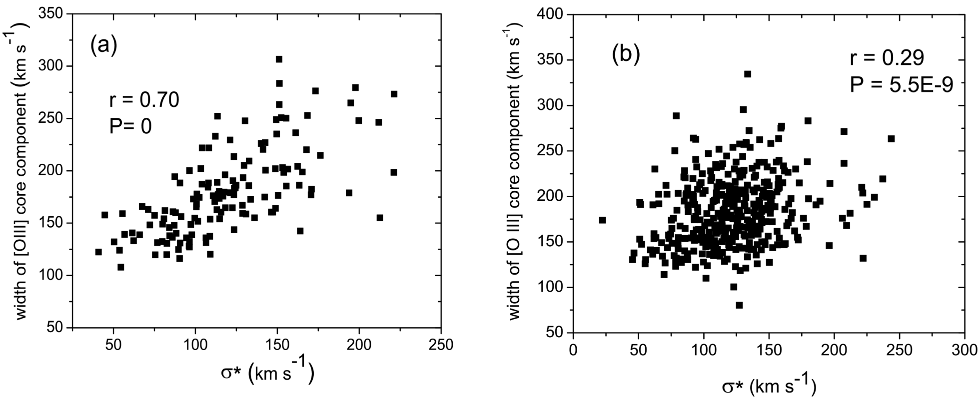

Figure 2: The correlation between σ * and width of [O III] line core component for the subsample with no asymmetry in [O III] line profile (a), and for subsample with present asymmetry in [O III] line profile (b).

As it can be seen from these correlations, the width of the [O III] core component is better surrogate for σ* in the subsample with absent outflows, and consequently better M_{BH} indicator.

This implies that in the case when outflow kinematics is strong in spectra (strong wing components in narrow emission lines), there is probably some influence of the outflow in the narrow core component as well. These results are in accordance with the results obtained from spatial spectroscopy of the several AGNs Type 2 by Karouzos et al. 2016. They found that outflows contribute, not only to the wing, but also to the [O III] core component.

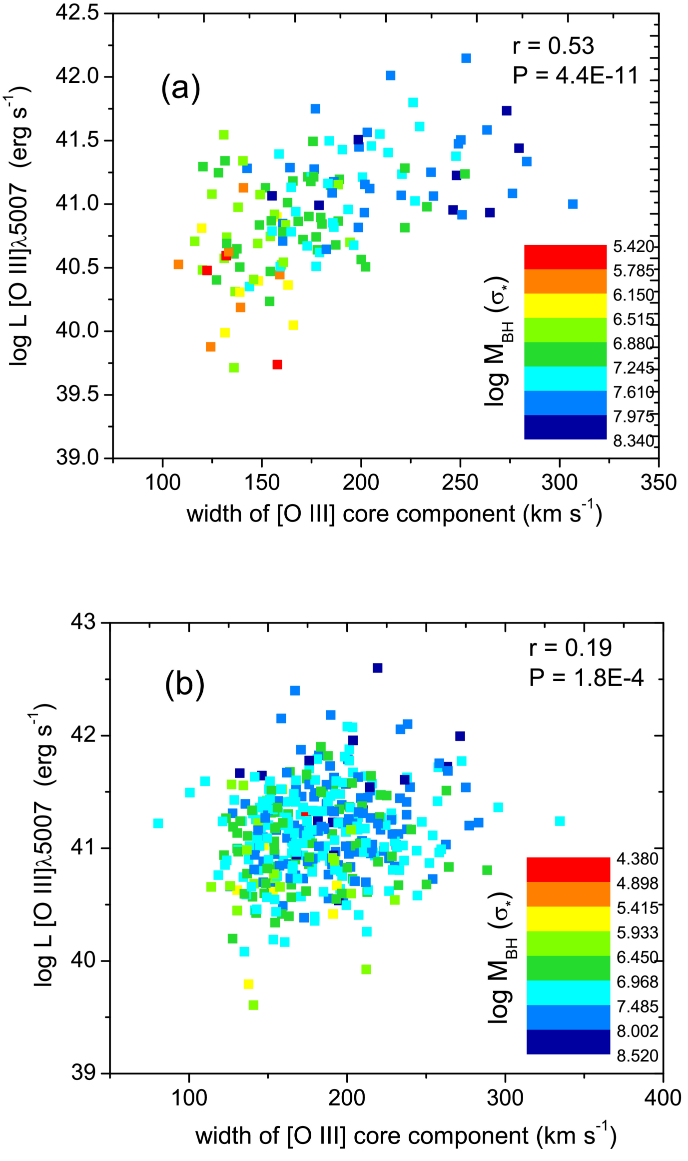

Figure 3: The correlation between L[O III] and width of [O III] line core component for the subsample with no asymmetry in [OIII] line profile (a), and for subsample with present asymmetry in [O III] line profile (b).

Our results point out that M_{BH} estimation using the width of the [O III] core as surrogate for the σ* can be applied for the AGNs Type 2 with absent wing components (with no asymmetry in emission line profiles), in order to get accurate M_{BH} estimation. In the case of the AGNs Type 2 with significant emission line asymmetry, this method should be taken with the caution because of the large scatter caused by the outflow influence.

Our future investigation will be directed to the analysis of the other emission lines in AGN type 2 spectra, in order to check if there are some emission lines which are less affected with outflow kinematics than [O III] lines, and therefore better σ* surrogate.

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