The extreme values of eigenvector one – the spectral properties

Marzena Śniegowska[1·2·3] and Bożena Czerny[2]

1. Warsaw University Observatory, Al. Ujazdowskie 4, 00-478 Warsaw, Poland
2. Center for Theoretical Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland
3. Nicolaus Copernicus Astronomical Center (PAN), ul. Bartycka 18, 00-716 Warsaw, Poland

The SDSS catalogs contain almost 300 000 well studied quasars with good optical spectroscopy. Eigenvector 1 ($R_{\rm Fe}$) is a formal parameter which is the ratio of the equivalent widths of $\rm Fe_{II}$ to Hβ. We analyze the most extreme examples of quasars with the highest possible values of the corresponding $R_{\rm Fe}$ (larger than 1.3) from the Shen et al. (2011) catalog. We focus on the most extreme $R_{\rm Fe}$ values from our modelling and discuss in detail the physical properties of these 6 extreme objects.

1 Introduction

Active Galactic Nuclei (AGN) are astrophysical sources powered by an accreting central black hole which have a range of emission line properties. We focus on the radio-quiet type 1 sources. Nowadays, observed properties of AGNs seem to be dependent on inclination and luminosity, according to the Unified Model of AGN (Urry & Padovani, 1995). The Principal Component Analysis (PCA) showed that there is a single hidden parameter, contribution of other parameters (e.g. black hole mass, Eddington ratio and black hole spin) which corresponds to a meaningful part of the measured parameter dispersion (Boroson & Green, 1992). Eigenvector 1 is an observational parameter which is the ratio of the equivalent widths of $\rm Fe_{II}$ to Hβ.

2 Method

We select 27 AGNs with the values of eigenvector 1 above 1.3 from the Shen et al. (2011, hereafter S11) catalog and take into consideration only objects with the $R_{\rm Fe}$ and Hβ measured with the error below 20%. We correct the spectra for Galactic reddening using the Cardelli et al. (1989) extinction curve. Continuum emission of the AGN is modelled taking into account the contribution from the accretion disk and from the host galaxy starlight. We model the $\rm Fe_{II}$ pseudo-continuum with the theoretical templates of Bruhweiler & Verner (2008) and subtract the $\rm Fe_{II}$ and Balmer Continuum (BC) pseudo-continua on the basis of the preliminary fits. Starlight contribution is modelled using the code STARLIGHT (Cid Fernandes et al., 2005). This STARLIGHT version is based on 45 stellar templates of Bruzual & Charlot (2003), which coresspond to different stellar ages (15 options) and metallicities (3 options). We model in detail the wavelength region 4400–5100 Å, taking into account the previously determined starlight shape, $\rm Fe_{II}$, Hγ, Hβ and the [OIII] doublet which are calculated in details. Black hole mass is measured in a standard way from the monochromatic luminosity at 5100Å (L_{5100} luminosity) and the FWHM of the broad Hβ line as in Bentz et al. (2013).

name	RA	Dec	R_{Fe}	χ^2	EW(FE)	EW(Hβ)	R_{Fe}	FWHM	$\log M_{\mathrm{BH}}$
			from				this		
	[°]	[°]	S11		[Å]	[Å]	work	[km s^{-1}]	[$M_{\odot}$]
1052	163.142	23.651	2.25	4.44	136.0	87.2	1.6	5392	8.79
1100	165.152	6.689	2.58	1.48	34.3	18.3	1.9	1502	7.42
1111	167.849	50.859	2.10	2.83	220.2	171.5	1.3	4502	8.73
1207	181.751	-2.324	1.37	2.30	50.1	26.8	1.9	2099	7.73
1502	225.689	40.910	2.12	1.02	51.0	17.2	3.0	1445	7.28
1652	253.219	26.834	2.57	4.36	220.1	142.3	1.5	8099	8.99

Tab. 1: Extreme EV1 objects.

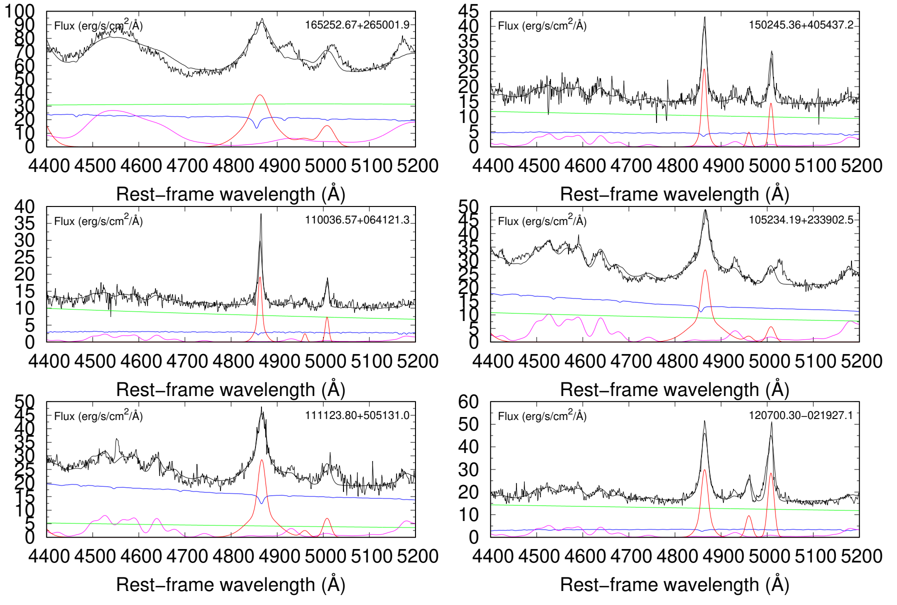

Fig. 1: The region of the Hβ line for sources with extreme R_{Fe} values, black line shows the data and the best fit. The fit components are given in the following colors: emission lines (red), Fe II (magenta), disk power law including extinction (green) and starlight (blue).

3 Results

The analysis of extreme eigenvector 1 sources shows that the detailed modelling of the spectra modifies parameters of the sources. In this work we focus on extreme sources from our modelled sample of 27 extreme objects from S11 catalog. R_{Fe} value for modelled objects is smaller than values from the S11 catalog. The results of our fitting for extreme objects are given in Tab. 1. The objects with $R_{\mathrm{Fe}} > 1.3$ from our modelling seem to be relatively rare (only six objects) and do not seem to form a homogeneous sample (see Fig. 1). Three of them are narrow- and three are broad-line AGNs. The most extreme object is shown in Fig. 2. In Shen & Ho (2014) the trend of the decrease of the EW([OIII]) line with R_{Fe} is illustrated. For each of them

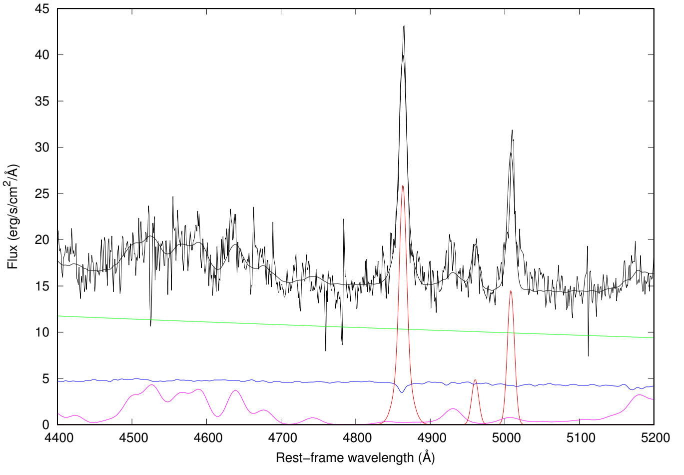

Fig. 2: The region of the Hβ line for the most extreme source from our sample (SDSS150245.36+405437.2).

the Hβ line is better represented by Gaussian lines. In our work the [OIII] emission seems to be strong in all the six extreme objects, with EW([OIII]) from 22 to 45 Å, much higher than expected from the Shen & Ho (2014) diagram for strong R_{Fe} emitters. Boroson & Green (1992) saw a strong correlation between R_{Fe} and the peak of [OIII]5007, and our objects show significant dispersion in [OIII]5007 ratio. This, and the unexpected strenght of OIII line need deeper exploration. Because of two strong $\mathrm{Fe_{II}}$ (at 4930.70 Å and 5031.87 Å) transitions the decomposition is tricky. In our fits the normalizations of these lines come from the template fitting and might not be correct (Kovacevic et al., 2010). The issue of the spectral fitting in the automatic mode was already raised in Sulentic & Marziani (2015) and this work shows it as well.

4 Conclusions

This analysis confirmed the existence of the extreme EV1 sources, but they seem to be rare. The nature of anticorrelation between R_{Fe} and the peak of [OIII5007] (Boroson & Green, 1992) still needs a deeper explanation. Our analysis takes into account the $\mathrm{Fe_{II}}$ contamination more carefully than the automatic analysis by S11. Anyway, we do not achieve fully self-consistent fits for the objects.

Acknowledgements. The project was partially supported by Polish National Science Center grant No. 2015/17/B/ST9/03436/.

References

Bentz, M. C., et al., *ApJ* **767**, 149 (2013)

Boroson, T. A., Green, R. F., *ApJS* **80**, 109 (1992)

Bruhweiler, F., Verner, E., *ApJ* **675**, 83-95 (2008)

Bruzual, G., Charlot, S., *MNRAS* **344**, 1000 (2003)

Cardelli, J. A., Clayton, G. C., Mathis, J. S., *ApJ* **345**, 245 (1989)

Cid Fernandes, R., et al., *MNRAS* **358**, 363 (2005)

Kovacevic, J., Popovic, L. C., Dimitrijevic, M. S., *VizieR Online Data Catalog* **218** (2010)

Shen, Y., Ho, L. C., *Nature* **513**, 210 (2014)

Shen, Y., et al., *ApJS* **194**, 45 (2011)

Sulentic, J., Marziani, P., *Frontiers in Astronomy and Space Sciences* **2**, 6 (2015)

Urry, C. M., Padovani, P., *Publications of the Astronomical Society of the Pacific* **107**, 803 (1995)