The flux ratio of the [N II] λλ6548, 6583 Å lines in AGNs Type 2

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ABSTRACT

In spectra of the Active Galactic Nuclei (AGNs), the [N II]λλ 6548, 6583 Å lines are commonly fitted using the fixed intensity ratio of the components. However, the used values for fixed intensity ratio are slightly different through literature and there is significant lack of the references for their theoretical calculation or experimental measurements from spectra. The obtained theoretical values for [N II] 6583.45 Å/6548.05 Å line intensity ratio found in literature are between 2.93-3.07. Here we present the measurements of the flux ratio of the [N II] 6548, 6583 Å emission lines for a sample of 250 AGNs Type 2 spectra taken form Sloan Digital Sky Survey (SDSS) data base. The spectra are chosen to have high signal-to-noise ratio and to [N II] and Hα lines do not overlap. The obtained flux ratio from measurements is 3.03 ± 0.06. We compared it with the theoretical calculations.

1 INTRODUCTION

The forbidden emission lines [N II] λ6548.05 Å ($2s^22p^2\ ^1D_2$ - $2s^22p^2\ ^3P_1$) and [N II] λ6583.45 Å ($2s^22p^2\ ^1D_2$ - $2s^22p^2\ ^3P_2$) are among the most prominent emission lines in spectra of the photoionized gas in AGNs, starburst galaxies and planetary nebulae. Since these two lines have the same upper level of the transition, it is expected that their flux ratio is fixed in spectra. The [N II] lines are commonly used for diagnostics of kinematical and physical properties of the astrophysical objects. However, [NII] and Hα lines are often blended in spectra of AGNs, which sometimes makes difficult using of the [N II] lines in diagnostics purposes. To reduce the number of fitting parameters in decomposition of the complex [N II]+Hα wavelength band it is necessary to fix the flux ratio of [N II] λ6583 and [N II] λ6549 lines. The used values for fixed intensity ratio are slightly different through literature and there is significant lack of the references for their theoretical calculation or experimental measurements from spectra.

The obtained theoretical values for [N II] 6583.45 Å/6548.05 Å line intensity ratio are between 2.93-3.07 (see Table 1). Acker et al. (1989) measured the flux ratio of the [N II] lines for 267 planetary nebulae of our Galaxy. They found line ratio of 2.92 ±0.32. However, there is lack of the systematic experimental measurements of [N II] lines from AGN spectra. These measurements are done only for several particular objects (see Nazarova et al. 1996, Dietrich et al., 2005). The aim of this work is to do systematic measurements of [N II] lines ratio in large sample of AGNs Type 2 spectra and to compare the obtained value with theoretical values.

	Transition probability [N II]λ6583 (s^{-1})	Transition probability [N II]λ6548 (s^{-1})	Transition probability ratio [N II]λ6583/ [N II]λ6548	Ref.
1.			3	Stevenson, 1932
2.	$2.4\cdot10^{-3}$	$0.81\cdot10^{-3}$	2.96	Condon, 1934
3.	$2.2\cdot10^{-3}$	$0.75\cdot10^{-3}$	2.93	Pasternack, 1940
4.	$2.99\cdot10^{-3}$	$1.01\cdot10^{-3}$	2.96	Mendoza, 1983
5.	$3.005\cdot10^{-3}$	$1.016\cdot10^{-3}$	2.96	Galavis et al., 1997
6.	$3.015\cdot10^{-3}$	$0.9819\cdot10^{-3}$	3.07	Storey & Zeippen, 2000
7.	$2.91\cdot10^{-3}$	$0.984\cdot10^{-3}$	2.96	NIST Database 2021 (Kramida et al. 2020, Tachiev & Fischer 2001)

Table 1. Theoretical results of transition probabilities of [N II] lines.

2. THE SAMPLE AND MEASUREMENTS

The spectra used in this research are chosen from SDSS DR14 using SQL query with following requests: to be classified as AGNs Type 2 in SDSS spectral classification, median signal-to-noise ratio to be > 20, and [N II] and Hα EWs to be larger than 5 Å. In this way, we obtained 588 spectra. The spectra were corrected for the Galactic reddening, cosmological redshift and weak continuum is subtracted using the continuum windows given in Kuraszkiewicz et al. (2002). Afterwards, the spectra were fitted using nonlinear least-squares (NLLS) Marquardt-Levenberg algorithm with single or double Gaussian model (one Gaussian fits the core of the line, and one fits the wings of the line). The Hα line is fitted with all free parameters, while widths and shifts of Gaussians which fit [N II] lines are put to be the same, since we assume that these two lines arise in the same emission region. Their intensities are left to be the free parameters. In order to chose the subsample in which we can perform the most precise measurements of the [N II] lines intensities, we excluded from the sample all objects where [N II] and Hα lines are blended (Figure 1a). Also we excluded all spectra where [N II] and Hα lines cannot be fitted well with single Gaussian model, i.e. including of an additional wing component Gaussian is needed in order to fit well their line shapes (Figure 1b). Finally, our sample contains 250 spectra of AGNs Type 2, where [N II] and Hα lines do not overlap, and can be fitted well with single Gaussian function for each line (Figure 1c).

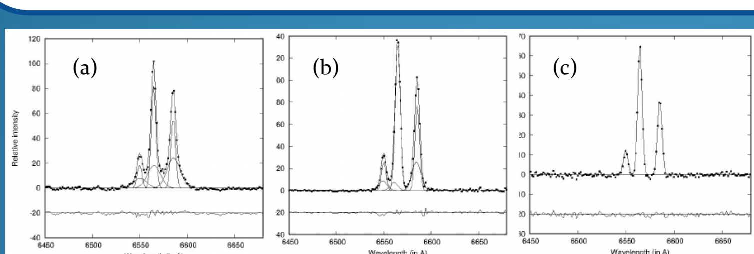

Figure 1. The examples of [N II] + Hα wavelength band in AGNs Type 2. (a) blended Hα and [N II] lines, (b) unblended Hα and [NII] lines, but fitted with double Gaussian model, (c) Hα and [NII] lines do not overlap and they are fitted well with single Gaussian model. The spectra as in cases (a) and (b) are rejected from the sample.

3. RESULTS

After we obtained the intensities of the [N II] lines from the best fit, we calculated their intensity ratio for each object. The results are shown in Figure 2. We found that the uncertainty of the continuum subtraction has the largest influence to the error of the [N II] flux ratio measurements. Since the uncertainty of the continuum subtraction grows with larger noise in continuum, we calculated amplitude-to-noise ratio (A/N) for the smaller [N II] line ([N II] 6548.05 Å) for all objects. The noise is calculated in 6510-6530 Å range. We found that for majority of the objects for the sample, A/N ratio of the [N II] 6548.05 Å line is larger than 20. To estimate the error of the continuum subtraction, we chose the spectrum with the smallest A/N ratio of the [N II] 6548.05 Å line (A/N = 8.5) in our sample. Then we applied the continuum subtraction for that spectrum 5 times, and fitted the [N II] lines in each continuum subtracted spectrum. We found that relative error of [N II] flux ratio in this the most extreme case is 2%, which is taken to be the error of the measurements for total sample. Finally, the mean value of the flux ratio of [N II] lines obtained from our measurements for total sample is 3.03 ± 0.06. This result is in accordance with obtained theoretical result which include relativistic corrections to the magnetic dipole operator, given in Storey & Zeippen, 2000, while theoretical results which do not include relativistic corrections are slightly smaller than our result, even within errorbars (see Table 1).

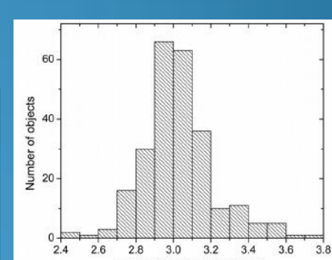

Figure 2. The flux ratio of the [N II] lines measured in sample of 250 AGNs Type 2.