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Comparison of the rich optical Fe II line spectra of selected NLSy1 objects from two epochs

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Abstract- This paper presents the analysis of medium resolution optical spectra of NLSy1 objects obtained with the 1.9 m telescope at SAAO (Sutherland). Six bright objects were observed during at least two epochs in the two year period from January 2016 to November 2017: ESO 12-G21, Fairall 265, Mkn 1044, H 0707-495, IRAS 03450+0055 and Ton S180. Multiple spectra for each epoch were co-added to achieve exceptionally high signal-to-noise, allowing the resolution and characterization of weak individual Fe II and other lines. Parameters determined from line profiles include relative strength, width and asymmetry. The combined spectra from each epoch were then compared to establish the existence and possible nature and extent of spectral changes in each object. As opposed to many other types of AGN, no dramatic spectral changes were detected between the epochs, and our spectra also do not differ much from decade-old discovery spectra of these objects. Where changes were detected, we detail these and attempt to interpret these in terms of established physical models of NLSy1 galaxies.

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1. Introduction

I Zw 1 objects are galaxies with extremely strong Fe II emission and weak forbidden lines [1-2]. This paper describes a study of the variations that may occur in the spectra of objects over time [3]. The work presented here aims to study the physical conditions in the Fe II emission zone of Narrow-Line Seyfert 1 galaxies (NLSy1), and in particular the I Zw 1 sub-class. By exploring the nature of medium-term spectral evolution this study seeks to explore their peculiarities and test the applicability of the standard model of Active Galactic Nuclei in describing the spectral evolution.

Moreover, examining the spectral features may contribute to the existing body of knowledge by also attending some of the questions that have been posed about the sufficient and necessary conditions for the onset of NLS1 activity, the source of AGN variability, the dynamics responsible for the comparatively narrow Balmer lines, the location of the Fe II emission line region and many correlations between Fe II emission and other AGN properties which need a physical explanation.

2. Observations and spectral calibration

The targets chosen for our study include most of the brightest known sources with NLSy1 spectra accessible from Sutherland. For the spectra presented here, the observations were carried out for the period from December 2016 to November 2017. In this paper we compare the spectra of six objects for which we had by the end of 2017 been able to secure sets of spectra at two different epochs.

The observations were carried out with the 1.9 m telescope at Sutherland Observatory, which was equipped with the SAAO Optical Spectrograph (SpUpNIC). Grating 6 with a grating angle 12.5° was used to get medium resolution spectra covering a range of wavelength from 3500-6300Å. The slit width was 0.9 arcsec and used a Cu-Ar Lamp to produce the arc spectrum for calibration purposes. To secure the flux calibration we observed well-established spectrophotometric standard stars.

The raw images from the 1.9 m telescope were reduced with standard IRAF packages, and included the wavelength and flux calibration. Each of the spectra displayed below were obtained by adding 5-10 spectra, each of 20 minute integration, in order to achieve a high signal-to-noise ratio. The spectra have undergone heliocentric Doppler corrections with the continuum flux subtracted. For this subtraction the task `continuum` from the `onedspec` package in IRAF was used to fit a function with rejection of the high and low points using sigma clipping. To make the [OIII] 5007Å line exactly the same strength in both epochs, all points on one spectrum were multiplied by a constant factor which also enabled to correct for light losses caused by cloud or bad seeing during the observations.

3. Results

All the spectra above show almost same strength in both epochs. The variations in line strength between the epochs appear to be small compared to other Seyfert 1′s. The spectra here appear to be slightly fainter for epoch 2 except Fairall 265, for which the spectrum seems to be brighter.

We note here that the spectrum of Fairall 265, which is of a better quality than other spectra previously published [4], shows that this AGN is not a I Zw 1 object. Its Hβ emission line is too

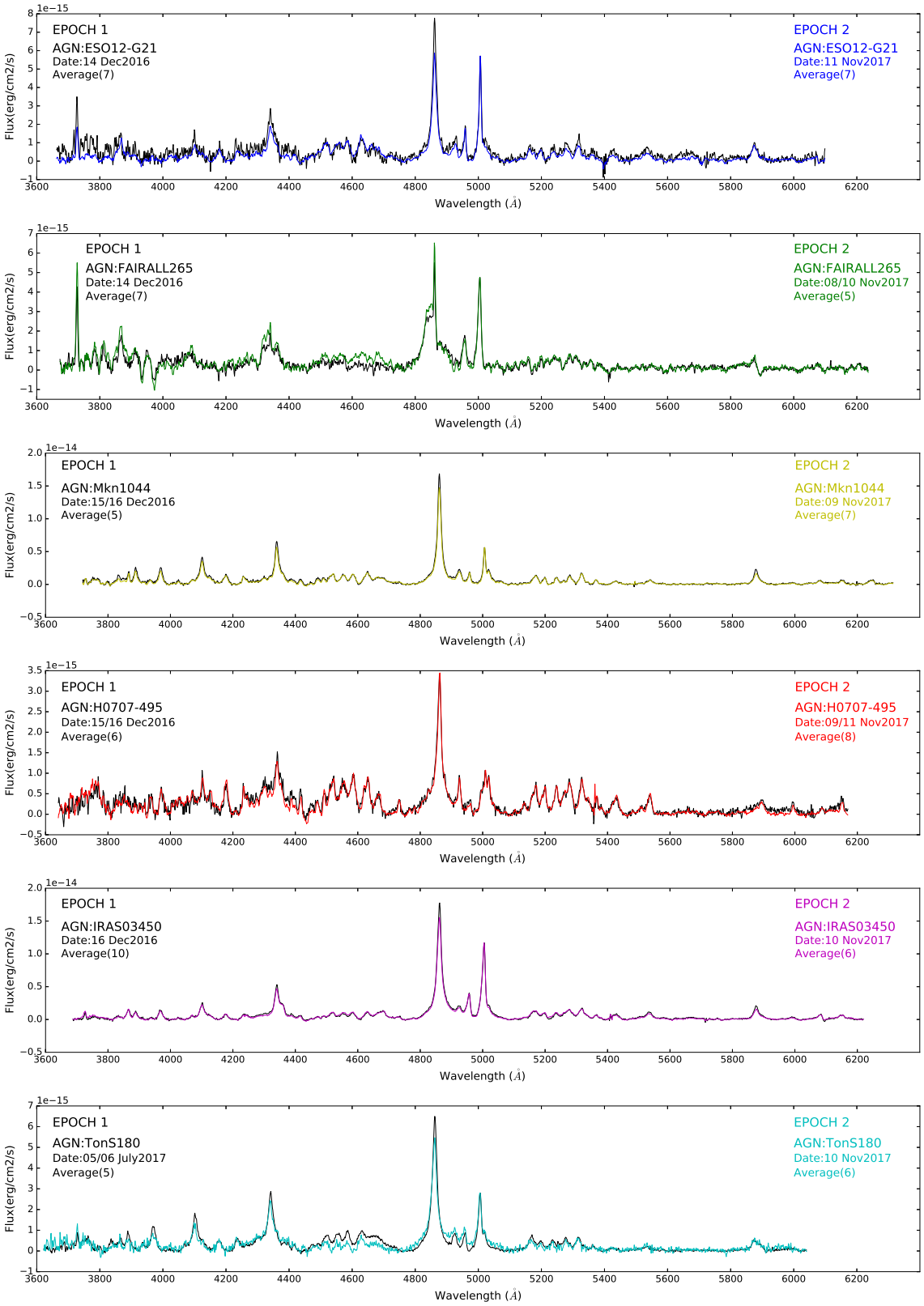

Figure 1: Comparing spectra of the two epochs for six objects.

broad for that class, and furthermore displays two bumps on either side of the main peak. The lines of Fairall 265 appear to be stronger in strength while the Balmer lines for this object grew more than Fe II in particular, showing that they are probably generated closer to the black hole.

While the flux of Balmer and helium lines has decreased slightly in most I Zw 1 spectra over time, the He I(5876Å) line for Ton S180 has slightly grown in strength in epoch 2.

For ESO 12-G21, Mkn 1044, H 0707-495, IRAS 03450+0055 and Ton S180, the Fe II bands on either side of the Hβ line and the central band around Hβ appear to be decreased in strength, but only very marginally. This supports an observation made in a previous paper [5] that the spectra of I Zw 1 objects appear to be significantly more stable than those of other AGN.

4. Discussion

These initial results, covering just two epochs, highlight the importance of further observations of the I Zw 1 object sample studied in this paper. A better characterization of the suspected lag of the Fe II bands relative to the Balmer and helium lines would further constrain the location of this particular nuclear component.

Despite the rapid and sometimes dramatic variations reported at high energy wavebands, the optical spectra of I Zw 1 class objects are remarkably stable over very long periods.

5. Conclusion

No dramatic differences have been noted in the optical spectra of a sample of bright I Zw 1 object observed at two epochs spaced about a year apart. This supports previous suggestions that this is an inherent property of this AGN subclass. Where small changes are evident, our data suggest that the Fe II variations seem to lag the Balmer lines (and possibly the He I lines).

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