

## THE DETECTION OF EXTREME LOW-LUMINOSITY AGNS

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### RESUMEN

Exploramos el diagrama de diagnóstico que utiliza la razón de líneas de emisión ( $[\text{NII}]\lambda 6584 \text{ \AA}/\text{H}\alpha$ ) frente al ancho equivalente de  $[\text{NII}]\lambda 6584 \text{ \AA}$ , propuesto por Coziol et al. (1998) a una muestra obtenida del SDSS DR5 para separar las galaxias dominadas por formación estelar y galaxias con núcleo activo (AGNs) de baja luminosidad. Este diagrama de diagnóstico no necesita las líneas clásicas de emisión como  $[\text{OIII}]\lambda 5007 \text{ \AA}$ , o  $\text{H}\beta$  para clasificar el tipo de actividad. Se demuestra empíricamente que esta combinación de líneas de emisión se puede utilizar para buscar en los llamados AGN de baja luminosidad.

### ABSTRACT

We explore the diagnostic diagram that uses the ratio of emission lines ( $[\text{NII}]\lambda 6584 \text{ \AA}/\text{H}\alpha$ ) versus equivalent width of  $[\text{NII}]\lambda 6584 \text{ \AA}$ , proposed by Coziol et al. (1998) to a sample obtained from Sloan Digital Sky Survey Data Release 5 to separate star-forming and active galaxies from low-luminosity AGNs. This diagnostic diagram does not need the classical emission lines like  $[\text{OIII}]\lambda 5007 \text{ \AA}$ , or  $\text{H}\beta$  to classify activity type. We show empirically that this combination of emission lines can be used to search the called Low-Luminosity AGN.

*Key Words:* galaxies: active — galaxies: evolution

### 1. INTRODUCTION

The most common activity diagnostic diagrams are those that compare the line ratio  $[\text{OIII}]\lambda 5007/\text{H}\beta$  with  $[\text{NII}]\lambda 6584/\text{H}\alpha$  (Baldwin, Phillips, & Terlevich 1981), with  $[\text{OI}]\lambda 6300/\text{H}\alpha$ , or with  $[\text{SII}]\lambda\lambda 6717, 6731/\text{H}\alpha$  (Veilleux & Osterbrock 1987). Applying different empirical separation sequences in these diagrams (Kewley et al. 2001; Kauffmann et al. 2003) allow to distinguish between two main ionization mechanisms: thermal photo-ionization by massive OB stars for Star Forming Galaxies (SFGs), and non thermal photo-ionization related to AGNs (Seyfert 2 or LINER). Although extremely useful, the standard diagnostic diagrams become unhelpful in cases where some emission lines are missing. Coziol et al. (1998) and Martínez et al. (2008, 2010) have found many examples of galaxies where the only clear emission transitions are the two nitrogen lines  $[\text{NII}]\lambda\lambda 6548, 6584$ . Coziol et al. (1998) have demonstrated that the ratio  $[\text{NII}]\lambda 6584/\text{H}\alpha$  in these galaxies is consistent with what is observed in typical AGNs. To compare these galaxies with those observed by Phillips et al. (1986), these authors have used a different “diagnostic diagram” which compares the equivalent width (EW) of  $[\text{NII}]\lambda 6584$  with the ratio of  $[\text{NII}]\lambda 6584/\text{H}\alpha$  (NII diagram). This diagram place such objects in a regime of Low-Luminosity AGNs (LLAGNs).

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### 2. SAMPLE DATA

The data used come from main catalog of the Sloan Digital Sky Survey Data Release 5 (Adelman-McCarthy et al. 2007). Using the Virtual Observatory service<sup>2</sup>, we have downloaded the spectra of 476931 objects spectroscopically classified as narrow line emission galaxies. The spectra were processed using the spectral synthesis code STARLIGHT (Cid Fernandes et al. 2005). One of the main advantages of using STARLIGHT is that it produces synthetic spectral models, which are built by summing simple stellar populations from a standard library, and from the residual spectrum we obtain a good measure of the emission line characteristics such as fluxes and EWs for the most important lines. In our original sample we have identified three different cases of missing emission lines: (1) either  $\text{H}\beta$  is missing, (2) or  $[\text{OIII}]\lambda 5007$  is missing, (3) or both lines are missing. We account for 68491 galaxies without  $\text{H}\beta$ , 27985 without  $[\text{OIII}]\lambda 5007$  and 10926 without both lines. In total, this represents 22% of the whole sample. If we consider only those galaxies that have emission lines with signal to noise ratios, S/N, greater or equal to 3 (S/N > 10 in the continuum), we are left with 224846 galaxies (47% from the original sample). From these, we account 34307 galaxies without  $\text{H}\beta$ , 12455 without  $[\text{OIII}]\lambda 5007$ , and 2840 without both lines. Again this represents 22% of the sample.

<sup>2</sup>Available at <http://www.starlight.ufsc.br>.

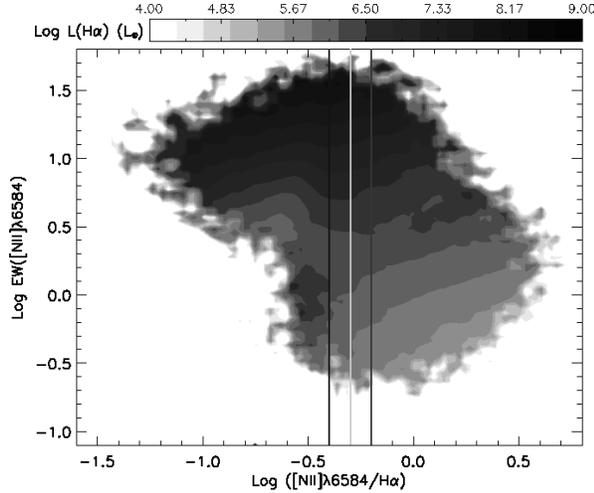


Fig. 1. Contour of luminosity of  $H\alpha$ , the solid line at  $-0.3$  separate SFGs from TO, and  $-0.4$  and  $-0.1$  define de buffer zone where find the TO's.

### 3. LUMINOSITY

A very high fraction (62.3%) of the galaxies without [OIII] fall on the AGN side of the NII diagram (to the right of continuous line at  $-0.3$  in  $[NII]/H\alpha$ ). The galaxies without  $H\beta$  fall mostly (93%) on the AGN side. The distribution of the galaxies without both lines seems similar to that of the galaxies without  $H\beta$ : 91% are on the AGN side. Most of the galaxies with some emission lines missing fall below  $\log(EW[NII]) = 0.6$ : 77% without [OIII], 94% without  $H\beta$  and 98% without both lines. Their median luminosity on this region in  $H\alpha$  is  $5.6 \times 10^{39} \text{ erg s}^{-1}$ , which justify the LLAGNs classification. In Figure 1 we can see this decrease in luminosity.

### 4. FWHM OF $H\alpha$

These galaxies show broad FWHM typical of AGNs plus extra nuclear excitation compared to SFGs. Another characteristics of AGNs is their relatively broad line profiles compared to SFGs. Typical FWHM in AGNs range between 170 and 700  $\text{km s}^{-1}$ . Such broad lines cannot be explained by thermal motion. It suggests the gas producing the emission is moving at high speed. The values were quadratically corrected for the resolution of the telescope (follow Greene & Ho 2006). One can see how the FWHM increases from the SFGs to the TOs to the AGNs. In Figure 2 we can see the histogram of FWHM of  $H\alpha$ .

### 5. DISCUSSION

Based on a large sample of emission line galaxies from SDSS, we have shown that the galaxies

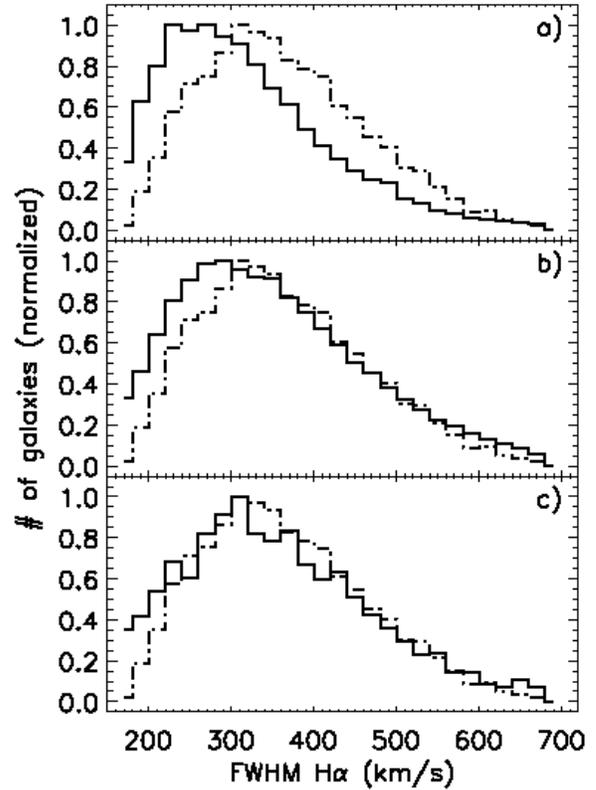


Fig. 2. Distributions of the FWHM of  $H\alpha$ : (a) galaxies without [OIII]; (b) galaxies without  $H\beta$ ; (c) galaxies with both lines missing. The point dashed line corresponds to the standard AGNs.

that cannot be classified because some important emission lines are missing are in majority LLAGNs. Therefore this characteristics seems to be the signature of LLAGNs in the nearby universe (Coziol et al. 1998).

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