Rev. Mexicana Astron. Astrof., 21, 213-217 (1990)

THE CENTRAL REGION OF A SAMPLE OF SEYFERT 2 GALAXIES

T. Storchi-Bergmann, E. Bica and M. G. Pastoriza

Instituto de Física, UFRGS, RS, Brasil

RESUMEN. Analizamos la población estelar en los 2-3 kpc interiores de nueve galaxias Seyfert 2 a partir de los anchos equivalentes de las líneas de absorción y de la forma del continuo. Derivamos los parámetros físicos y las abundancias químicas del gas a partir de los anchos e intensidades relativas de las líneas de emisión.

ABSTRACT. From the equivalent widths of the absorption lines and shape of the continuum, we analyze the stellar population in the inner 2-3 Kpc of 9 Seyfert 2 galaxies. From the widths and relative intensities of the emission lines we also derive physical parameters and chemical abundances for the gas.

Key words: ABUNDANCES — GALAXIES-STELLAR CONTENT — GALAXIES-SEYFERT

I. INTRODUCTION

The emphasis in spectral studies of Seyfert 2 galaxies has been mostly focused on the emission line spectra of the very nucleus, measured with apertures of about 2" (e.g. Koski, 1978; Phillips et al. 1983). The aim of this work is to study the relative importance of the various stellar components and the emitting gas seen globally through larger apertures in nearby galaxies. This kind of study is important in order to reproduce the observational conditions of more distant galaxies, for which the spatial resolution is small even for narrow apertures.

II. OBSERVATIONS

The observations made with the one meter telescope of Cerro Tololo Inter American Observatory using the Cassegrain Spectrograph and the 2D-FRUTTI two dimensional photon counting detector, in September 1986 and February 1987. The slit dimensions were 5"x11" or 8"x11", corresponding, at the distance of the galaxies, to the central 2-3 Kpc. All the spectra were flux calibrated, and cover the range 3600-7000 A, with a spectral resolution of 5 A. The galaxies observed are listed in table 1.

III. THE STELLAR POPULATION

After correction from the foreground reddening, we have measured the equivalent widths of the absorption lines. Based mainly on the emission-free features K(CaII), CN and G band, as well as on the continuum distribution, we searched for a similar template population in the library of synthetic spectra of Bica (1988). The internal reddening was estimated using its relation with the axial ratio b/a in the work Bica and Alloin (1986); minor extra reddening corrections were necessary in some cases for matching the template to the observed spectrum. We list in table 1 the final internal reddening for the stellar population E(B-V)i, as well as the selected template for each galaxy. According to Bica (1988), S2 is the most metallic, attaining $[Z/Z_0]=+0.3$, while the remaining ones have attained solar metallicity. S2 and S3 are red and dominated by the old population. In S4 to S6 the contribution of population younger than 10 yr increases from 9% to 22% in terms of flux fractions at λ5870 A. Figure 1 illustrates the two extreme types of population we found for our sample, together with the template subtractions to isolate the pure gas emission. Only in IC5135 we found an important blue component, giving evidence of star formation in the nucleus, which is confirmed by the strong Balmer absorption lines present in the spectrum. A spectrum taken 5" to the north of the nucleus shows a similar population, indicating that a very extended star formation event is taking place in the central region of IC5135.

Table 1
Basic Data, reddening and templates

Galaxy	Morphol.	M_B	Slit(Kpc)	VR(Km/s)	E(B-V)i	Temp.
1)N1667	Sc(r):IIpec	-22.54	4.8x3.5	4540	0.01	S4
2)N2992	Sa(tides)	-21.36	2.3x1.1	2390	0.35	S4
3)N3281	Sa	-22.11	3.8x1.7	3400	0.25	S2
4)N4388	Sab	-21.05	2.7x1.2	2520	0.38	S4
5)N4507	SBab(rs)I	-21.96	3.7x1.7	3390	0.10	S4
6)N4939	Sbc(rs)I	-22.77	3.3x1.5	3000	0.10	S2
7)N6890	Sab(s)II-III	-21.06	2.6x1.9	2490	0.03	S3
8)I5063	SO_3(3)pec/Sa	-20.95	3.6x2.6	3120	0.15	S2
9)I5135	Sa pec	-22.27	5.1x3.7	4800	0.00	S6

IV. EMISSION SPECTRUM

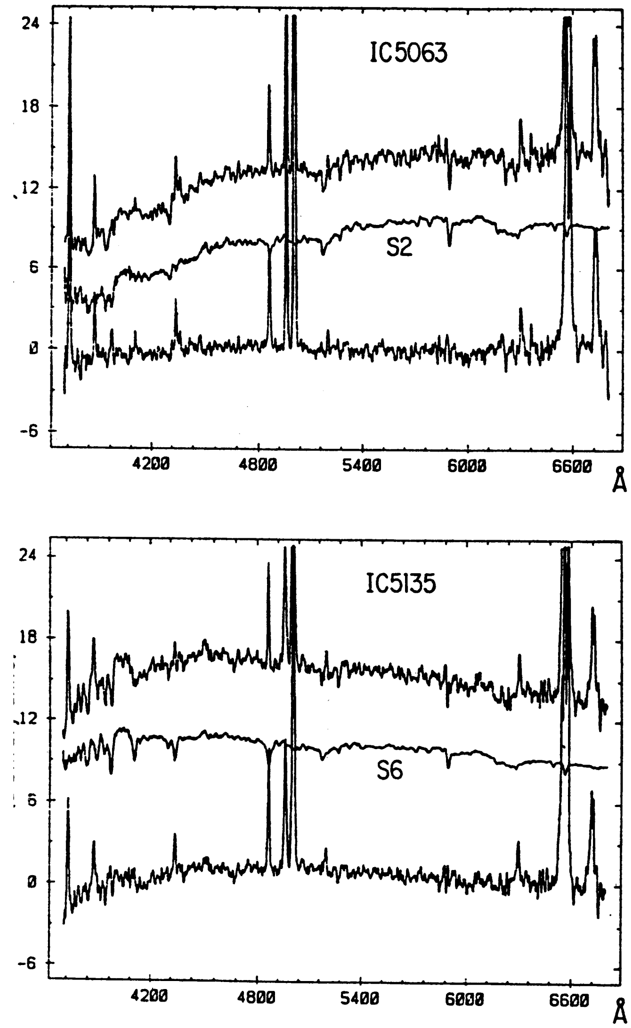
We have subtracted the stellar population and verified that the effect in the emission lines is small for Hα, but can be very important for Hβ, enhancing its intensity by a factor of 2 or more. This happens in the cases when the equivalent width of the emission line is comparable to that of the underlying absorption (4 A for a typical red population). We then measured the fluxes and full width at half maximum (FWHM) of the emission lines.

a) Broad components

In order to deblend Hα from [NII]λλ6548,84, we have adjusted gaussians to the profiles and verified that for the galaxies NGC2992, NGC4507, NGC6890, IC5063 and IC5135, a better adjustment is obtained if a broad H component (2000 km/s) is considered. Figure 2 shows the comparison between the fit with and without a broad component for IC5135. We have also detected broad components in [OIII]λλ4959,5007 for NGC4507, which are shifted 5A to the blue.

b) Line widths

Having verified that the FWHM of the emission lines are broader than the instrumental profile, we searched for correlations with the critical density for collisional de-excitation (de Robertis and Osterbrock, 1986). The line [OII]λλ3727 was used after a deblending correction. We have found evident correlation in NGC4507, NGC6890 and IC5135, and a marginal correlation for NGC1667, NGC2992 and IC5063.



igure 1.- Observed spectrum, ›elected template and the ›esidual showing two extreme ʼpes of stellar population.

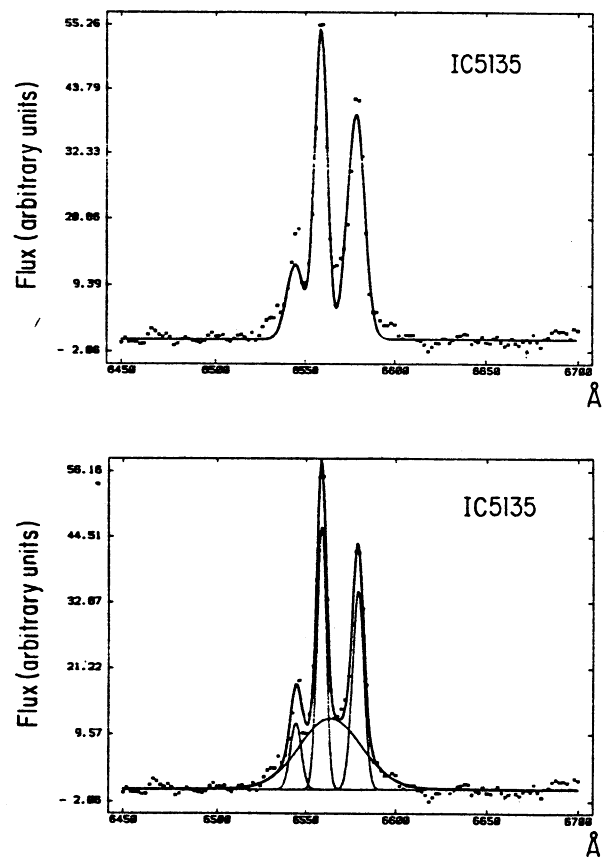


Figure 2.- Comparison between the gaussian fittings of the blend [NII]+Hα with and without a broad Hα component for IC5135.

Physical parameters and chemical abundances

We have compared the observed emission line ratios with those :edicted by the photoionization code CLOUDY (Ferland and Netzer, 1983), ıd by an integrated model (Viegas-Aldrovandi and Gruenwald, 1988) which ›nsiders the contribution of clouds of different densities. Both models 'e described in Storchi-Bergmann and Pastoriza (1989). In figures 3a-3c, we ıow diagrams involving the strongest emission lines where we have plotted the ıta points and the model values which best reproduce them. We have also ›mpared our values with those from previous observations obtained with ›ertures 3-6 times smaller (Durret and Bergeron, 1988; Veron-Cetty and :ron, 1986; Phillips, Charles and Baldwin, 1983). In figures 3a-3c, we ıdicate with an arrow the displacement from our values of the points ›rresponding to the smaller apertures.

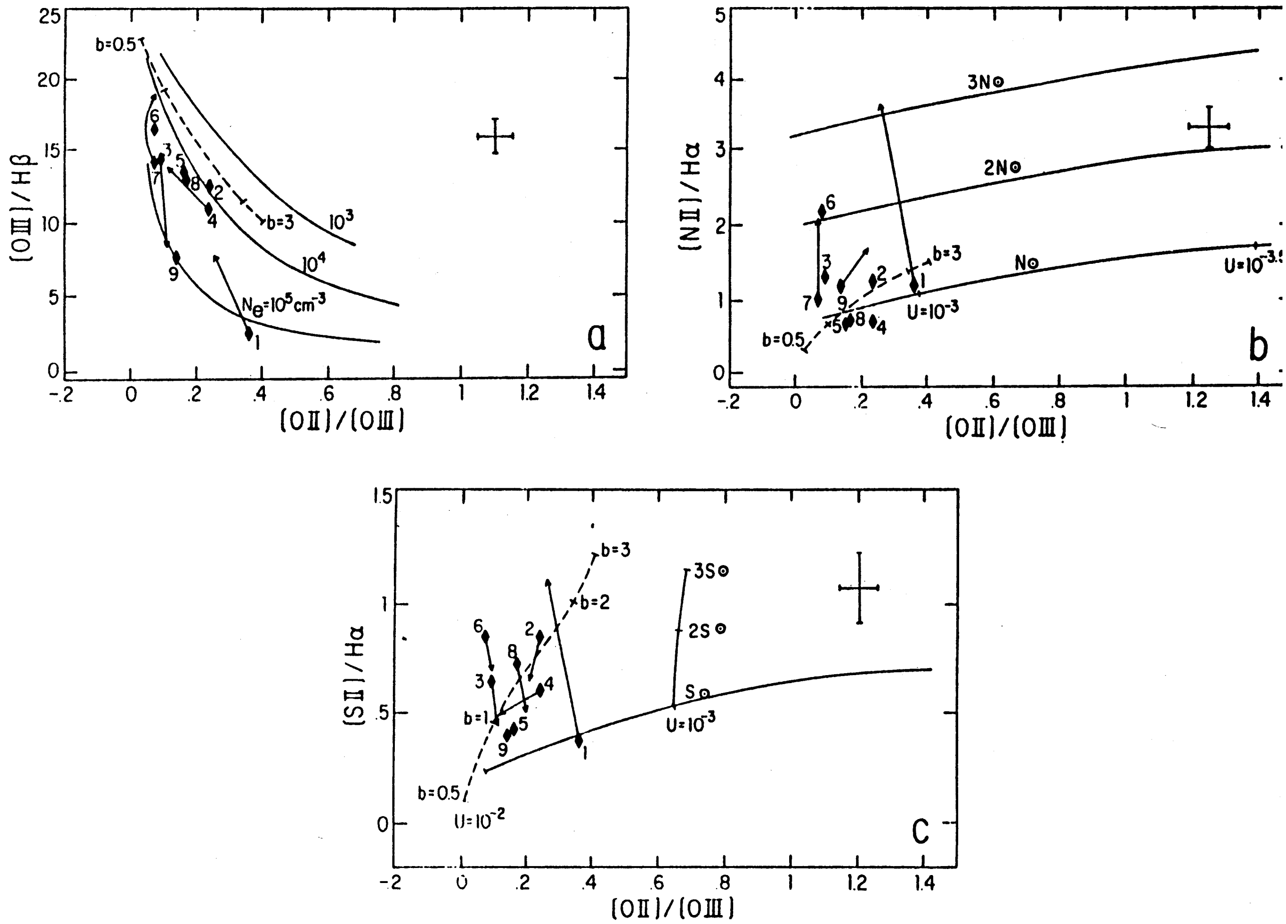


Figure 3.- Observed emission-line ratios (numbers 1-9, Table 1), CLOUDY (continuous lines) and integrated models (broken lines) from the high density limit (left) to the low density limit (right). Arrows show the gradient when a slit area 3-6 times smaller is used.

From figures 3a-3c we conclude that the data can be reproduced by models with a power-law ionizing source with spectrum $F_\nu \propto \nu^{-1.5}$ densities in the range $10^2 < Ne < 10^6$ cm^{-3}, and photoionization parameter $10^{-3.5} < U < 10^{-2}$. The abundance of most elements is solar (plotted models) but we have verified that it could reach two times solar and still reproduce the data. Nevertheless, in order to reproduce the high [NII]/Hα ratio presented by NGC4939 and the nucleus of NGC6890 and NGC1667 we had to enhance the nitrogen abundance, two times in the first and three times in the other two relative to the other heavy elements. Also sulfur presents an indication of overabundance: the vertical dispersion in the [SII]/Hα values can be reproduced by varying the sulfur abundance relative to the other elements from solar to three times solar. However, the dispersion can be equally well reproduced by varying the contribution of high density gas in the clouds emitting [SII]. More discussion about these points can be found in Storchi-Bergmann and Pastoriza (1989).

We interpret the changes observed in the line ratios as due to the presence of extended less excited ionized gas surrounding the nucleus, which were included in our slit. For most galaxies the more central [SII]/H values are lower probably due to the contribution of higher density clouds near the nucleus which lowers the [SII] intensity due to collisional de-excitation, except for NGC1667. For this galaxy, which presents a high [SII]/Hα in the nucleus, we favour the interpretation of sulfur overabundance 3 times solar in the nuclear gas, as is observed for nitrogen.

7. CONCLUSIONS

This study has led to the following conclusions relative to the inner 2-3 Kpc of the observed galaxies:

1) The typical stellar population is old with a metallicity from solar to two times solar. It does not differ much from that of normal galaxies of the same morphological type, except for IC5135, in which about 20% of the flux at λ5870 A is due to star forming events in the last 10^8 years;

2) The effect of the subtraction of the stellar population is very important for Hβ;

3) Broad Hα components were found for NGC2992, NGC4507, NGC6890, IC5063 and IC5135;

4) NGC4507, NGC6890 and IC5135 present a correlation between the FWHM of the forbidden lines and critical densities, indicating density stratification;

5) Using photoionization models, we conclude that the nuclear gas is photoionized by a power-law continuum, has abundances for most heavy elements between solar and two times solar but presents a nitrogen overabundance in NGC4939 and NGC6890, and of nitrogen and sulfur in NGC1667;

6) Comparison of our intensity ratios with smaller apperture ones shows that in several cases we have measured not only the active nucleus, but also surrounding gas, which may occur when one observes more distant galaxies, even with small apertures. We have shown that this might lead to wrong conclusions about the nuclear physical parameters and chemical abundance.

REFERENCES

Bica, E. 1988, Astron. & Astrophys. 195, 76.
Bica, E. and Alloin, D. 1986, Astron. and Astrophys. 162, 21.
De Robertis, M. M. and Osterbrock, D. E. 1986, Ap. J. 301, 727.
Durret, F. and Bergeron, J. 1988, Astron. & Astrophys. Suppl. 75, 273.
Ferland, G. J. and Netzer, H. 1983, Ap. J. 264, 105.
Koski, A. T. 1978, Ap. J. 233, 56.
Phillips, M. M., Charles, P. A. and Baldwin, J. A. 1983, Ap. J. 266,485.
Storchi-Bergmann, T. and Pastoriza, M. G. 1989 Ap. J., in press.
Veron-Cetty, M.-P. and Veron, P. 1986, Astr. & Astrophys. Suppl. 66,335.
Viegas-Aldrovandi, S. M. and Gruenwald, R. B. 1988, Ap. J. 324, 683.

Eduardo Biça, Miriani G. Pastoriza,and Thaisa Storchi-Bergmann: Instituto de Fisica, UFRGS, Campus do Vale, C.P. 15051, 91500 Porto Alegre, RS, Brazil