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# Chemical abundance in the Polar Ring Galaxy NGC 4650A

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**Abstract.** We have carried out a detailed spectroscopic analysis of the Polar Ring Galaxy NGC 4650A. We studied the emission lines ratios in the brightest HII regions of NGC 4650A. We observed the presence of a young stellar population close to the galactic center and we measured the chemical abundance parameters. These results further support the hypothesis that the polar structure in NGC 4650A has the same properties of a spiral disk, rather than a ring: this is an important implication for the most reliable formation scenario of this system.

**Key words.** Galaxies: abundances – Galaxies: peculiar

## 1. Introduction

The Polar Ring Galaxies (PRGs) are made of a central spheroidal galaxy surrounded by a bright and well defined ring, made up of gas, stars and dust, which orbits nearly perpendicular to the plane of the central galaxy. The two velocity fields make PRGs (Sackett et al. 1994; Combes& Arnaboldi 1996; Iodice et al. 2003), a unique laboratory to derive the 3D shape of the dark matter halos around galaxies. NGC 4650A is one of the best investigated PRGs: even if the morphology of the HG resembles that of an early-type system (E7/S0), the main results obtained by an accurate surface photometry (Iodice et al. 2002; Gallagher et al. 2002) suggested that *i)* the HG is a disk galaxy characterized by colors and ages more similar to spiral galaxies rather than to early-type galaxy; *ii)* the polar structure is a disk, rather than a ring, whose stars and dust affects the HG light along the major axis till about 6 arcsec from the center. This last finding is consistent with the new high resolution 21-cm observations previously obtained with the Australia Telescope Compact Array (Arnaboldi et al. 1997): the main and unexpected result showed that the H I distribution (which is all associated to the polar structure) and kinematics is consistent with the one commonly observed for an edge-on spiral disk. In particular the H I disk is extended right into the center of the HG.

The calculation of chemical abundance in the polar structure can be an independent tool in order to study the stellar population and distribution. To this aim, we have analyzed the spectra along the polar structure of

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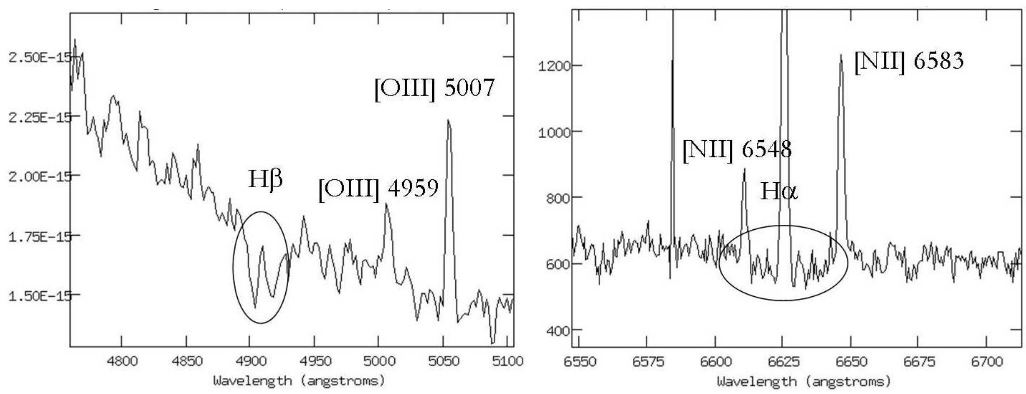


**Fig. 1.** Spectra relative to the regions where the slit intersects the central spheroidal component, where the $H\beta$ (left panel) and $H\alpha$ (right panel) lines are observed in absorption.

NGC 4650A in the optical wavelength range (3500 - 7000 Å).

## 2. Data and Results

Spectra were obtained in 1995 at the 2.3 m telescope of the Mt. Stromlo and Siding Spring Observatory, with the Double Beam Spectrograph (DBS). The angular resolution of the data is 0.5 arcsec/pixel and covers the wavelength range from 3500 to 7000 Å. The spectra were acquired at the position angle of the photometric major axis of the polar structure, P.A.=162 degrees (Iodice et al. 2002), with a total exposure time of 4.5 hours. The data reduction and calibration were performed using standard IRAF tasks.

In the regions where the slit intersects the central spheroidal component, the spectrum shows a continuum emission with some emission lines superimposed. At $\lambda$ = 6563 Å and $\lambda$ = 4861 Å we observe the $H\alpha$ and $H\beta$ Balmer lines in absorption, which are relative to the stellar component of the host galaxy (see Fig.1). At the same wavelengths, we also observe an emission line: this is reasonably due to a younger stellar population related to the polar structure. This result is consistent with a polar structure which reaches the galaxy center.

The study of the energy distribution along the slit gives the typical HII regions spectra (see Fig.2 left panels): we detected a discreet emission in the Balmer series lines ($H\alpha$ 6563 Å, $H\beta$ 4861 Å, $H\gamma$ 4340 Å) and other lines from more complex chemical elements, like oxygen ([OII] $\lambda$ = 3727 Å, [OIII] $\lambda$ = 4959 Å and $\lambda$ = 5007 Å ), nitrogen ([NII] $\lambda$ = 6548 Å and $\lambda$ = 6583 Å) and sulphur ([SII] $\lambda$ = 6717 Å and $\lambda$ = 6731 Å) .

From the flux ratio of emission lines we obtained 1) chemical abundance parameters and 2) their variation with polar radius. In order to have the right flux value, we made corrections from the intrinsic reddening by dust. From intrinsic flux ratio, we obtained the oxygen abundance parameter R23, the nitrogen abundance indicator [NII]/[OII] and the oxygen ionization level [OIII]/[OII] (see Fig.2 right panels). These parameters were compared with those of luminous spiral disks like NGC 1313, NGC 1365 and M 101 in order to derive the metallicity of HII regions analyzed in the polar structure of NGC 4650A. The observed values and their variation with the polar radius are in agreement with those for spiral disks.

### 2.1. Conclusions

We have carried out a detailed spectroscopic analysis of the Polar Ring Galaxy NGC 4650A by measuring the chemical abundance of its polar structure in the optical wavelength range. This is the first measurement of the chemical abundance for the Polar Ring Galaxy NGC

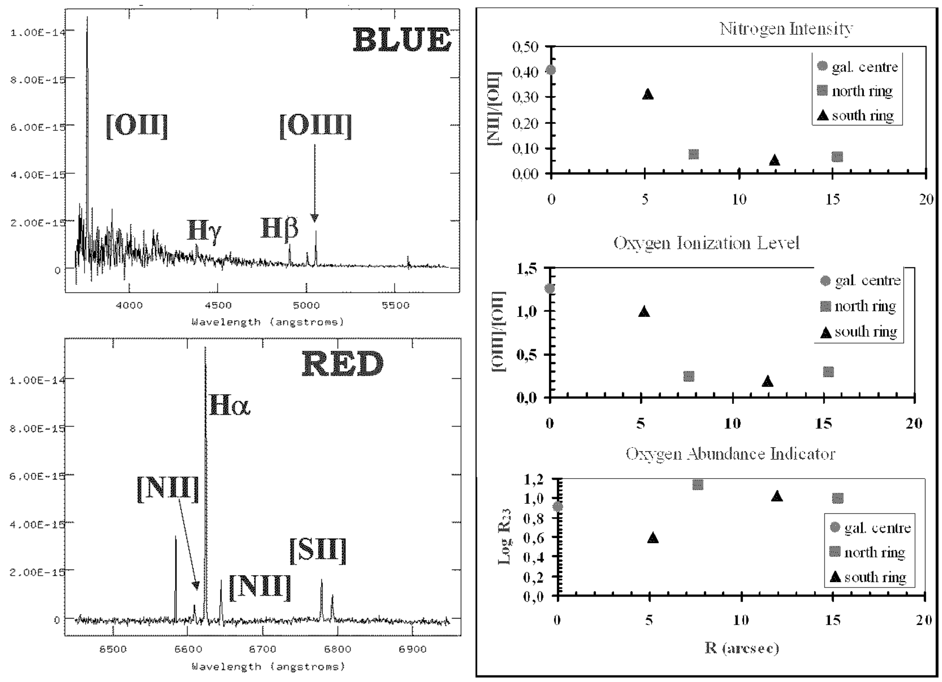


**Fig. 2.** Left panels - Spectra observed in the north edge of the polar ring. Right panels - Intensity of nebular lines for the polar structure in NGC 4650A.

4650A. The main results show that: 1) a young stellar population is present in the galactic center; 2) the chemical abundance parameters of the polar structure are similar to the typical values for spiral disks 3) metallicity is decreasing with radius. These let us independently confirm that the polar structure is very similar to a spiral disk, not only for its morphology but also for its stellar population. Furthermore, this component in NGC 4650A is extended to the galaxy center, as already suggested in the previous works on this galaxy (Arnaboldi et al. 1997; Iodice et al. 2002). This observational evidence can be reconciled better with the results of the disk-disk merging to form PRGs (see Bekki (1998); Bournaud & Combes (2003)).

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