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Physical parameters and chemical abundances in bipolar PNe

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Bipolar nebulae constitute a large subset of the planetary nebulae population. In this work we report the first results of a program aimed to derive physical parameters and chemical abundances for a sample of Galactic bipolar planetary nebulae seen from the southern hemisphere. Observational data were gathered at the 1.60-m telescope of the Pico dos Dias Observatory in Brazil, and the observational technique consisted in performing long-slit optical spectroscopy along the axis of symmetry of each nebula, and then in other parallel axes, deriving this way the observational parameters for a set of points throughout the nebula. Electron density was derived using the [S II] 671.6/673.1 nm line ratio and electron temperature was derived through the [O III] 500.7/436.3 nm and [N II] 658.4/575.4 nm line ratios. Helium abundances were derived using the recombination theory with the appropriate correction for collisional effects. Oxygen, nitrogen, sulfur and argon abundances were derived from the ionic abundances, adopting ionization correction factors to take into account unobserved ions.

Results derived this way are suitable for 3D modeling, and we show here the models adjusted for each object derived with the Cloudy photoionization code, using its pseudo-3D output, which allows to clearly see the non-homogeneity of the objects as well as to derive intrinsic parameters such as their dimensions and characteristics of the central sources. We also investigate the applicability of the ICFs to describe the different regions of such objects, as well as the influence of heating by shock of winds, and the local influence of dust in the reddening and observed line fluxes.

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PHYSICAL PARAMETERS AND CHEMICAL ABUNDANCES IN BIPOLAR PLANETARY NEBULAE

THE CASE OF NGC5844

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Abstract

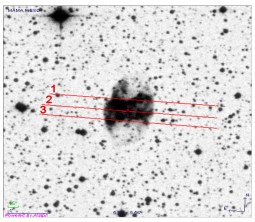
Bipolar nebulae constitute a large subset of the planetary nebulae population. In this work we report the first results of a program aimed to derive physical parameters and chemical abundances for a sample of galactic bipolar planetary nebulae seen from the southern hemisphere. Observational data were gathered at the 1.60m telescope of the Pico dos Dias Observatory in Brazil, and the observational technique consisted in performing long slit optical spectroscopy along the axis of symmetry of each nebula, and then in other parallel axes, deriving this way the observational parameters for a set of points throughout the nebula. Electron density was derived using the [SII]671.6/673.1 nm line ratio and electron temperature was derived through the [OIII] 500.7/436.3 nm and [NII] 658.4/575.4 nm line ratios. Helium abundances were derived using the recombination theory with the appropriate correction for collisional effects. Oxygen, nitrogen, sulfur and argon abundances were derived from the ionic abundances, adopting ionization correction factors to take into account unobserved ions.

Results derived this way are suitable for 3D modeling, and we show here the models adjusted for each object derived with the Cloudy photoionization code, using its pseudo-3D output, which allows to clearly see the non-homogeneity of the objects as well as to derive intrinsic parameters such as their dimensions and characteristics of the central sources. We also investigate the applicability of the ICF's to describe the different regions of such objects, as well as the influence of heating by shock of winds, and the local influence of dust in the reddening and observed line fluxes. In this work we describe the case of NGC 5844.

Observational Data

The observational data were gathered at the 1.60m telescope of the Pico dos Dias Observatory in Brazil with the Cassegrain spectrograph.

The methodology consisted in long slit spectroscopy along the axis of symmetry of the object and in axes parallel to that. This way it was possible to obtain the required data to derive physical parameters and chemical abundances for distinct points of each nebula. In the present work we report the results for NGC 5844 and its modelling.



Positioning of the slits at observation

Results and discussion

Physical parameters and chemical abundances were derived ins steps of **8.4"** along the slits. The aim was to detect variations and structures in the nebula.

Electron density were derived from the [SII] lines 6716/6731Å line ratio.

Electron temperatures were based on the line ratios:

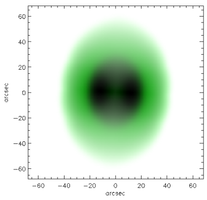
T [OIII] = (4959Å +5007 Å) / 4363Å

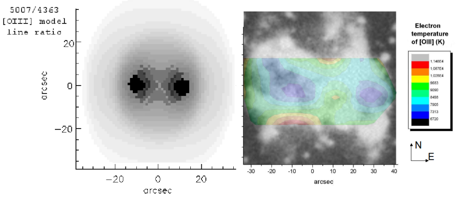
T [NII] = (6548Å +6583 Å) / 5755Å

He abundance was derived from the recombination theory, with collisional corrections excitation. **N**, **O**, **S**, **Ar**, **Ne** abundances were calculated adopting ionization correction factors.

Modelling

We show here a symmetrical model derived with the ***Cloudy*** [1] photoionization code, version *c08.00*, using its pseudo-3D output, *Cloudy_3D [2]*. Densities and chemical abundances were taken from the observations. The results show the non-homogeneity throughout the object, and also allowed the derivation of intrinsic parameters such as dimensions and characteristics of the central source. The best model for the nebula and its parameters are shown at right.





The [OIII]temperature distribution

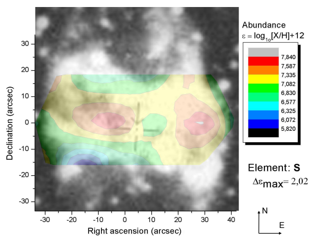
The figure above shows a comparison between the observed temperature map interpolated along the slits (at right) and the model output (at left).

PARAMETER	VALUE
Lcs (Lsun)	630
Tc (K)	110000
He/H	0,140
log(N/H)+12	8,81
log(O/H)+12	8,82
log(Ne/H)+12	7,24
log(S/H)+12	6,77
log(Ar/H)+12	8,54
<n1> (cm-3) (equatorial)	250
<n2> (cm-3) (polar)	150
d(kpc)	1,4
r2 to l.o.s. (deg)	85
Geometry	elips
r2/r1 (polar to equatorial)	1,66
r1 (cm)	1e16

The ICF's
Ionization correction factors

ICF's were adopted to take into account unobserved ions. However, their values depends of conditions assumed to the nebula.

In the figure below, we present the results using the a unique ICF [3] to the entire nebula. Another pattern the ICF's should be used to investigate elemental inhomogeneities in the nebula.



Distribution of the sulphur abundance in NGC5844

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Conclusions and perspectives

The model can provide a good description of the object. Moreover, it can be used to investigate assumptions like ICF's, or to derive intrinsic features such as dimensions or central star properties.

The next step will be the extension of this analysis to other objects, comparing the model outputs with observational data derived using IFU spectrographs.

References

[1] G.J. Ferland et al., "CLOUDY 90: Numerical Simulation of Plasmas and Their Spectra", 1998, PASP, 110, 761.

[2] C. Morisset, "Cloudy_3D, a new pseudo-3D photoionization code", 2006, IAUS, 234, 467.

[3] A.V. Escudero et al., "New abundances of planetary nebulae in the Galactic Bulge", 2004, A&A, 414, 211.