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# A 3D MORPHO-KINEMATIC STUDY OF NGC 3132

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RESUMEN

Presentamos una nueva herramienta, basada en cálculos de fotoionización en 3D, para modelar Nebulosas Planetarias (PNe). De dos modelos para PNe mostramos que el incremento en intensidad observado en varios de estos objetos no es necesariamente debido a un gradiente de densidad, como es interpretado usualmente. Estudiamos las propiedades morfo-cinemáticas de la PN NGC 3132 y mostramos que la forma bipolar de diábolo reproduce adecuadamente las principales tendencias observadas en imágenes de alta resolución.

ABSTRACT

We present a new modeling tool for planetary nebulae (PNe), based on 3D photoionization calculations. From models for two theoretical PNe, we show that the intensity enhancement in the equatorial zone, observed in several of these objects, is not necessarily due to a density gradient as usually interpreted. We study the morpho- kinematic properties of the PN NGC 3132 and show that a bipolar Diabolo shape successfully reproduces the main trends in the observed high resolution images.

*Key Words:* **METHODS: NUMERICAL – PLANETARY NEBULAE: INDIVIDUAL (NGC 3132)**

## 1. INTRODUCTION

Planetary nebulae show a wide range of observed morphologies, but since the Interacting Winds Model (Kwok, Purton, & Fitzgerald 1978), it is possible to relate the observed features to two basic geometries: elliptical and bipolar (also known as butterfly). The study of PNe geometries linked to evolutive characteristics of the central star (mass, luminosity, etc.) can set important constraints on stellar evolution theories (e.g., Stanghellini, Corradi, & Schwarz 1993; Corradi & Schwarz 1995). A new modeling tool for the study of morphologies and kinematic properties of PNe, based on a 3D photoionization code, is presented. As a real application, two models for NGC 3132 are discussed. The first model, which considers the PN as a ellipsoidal shell, neither reproduces the density variation along the nebula nor the velocity profiles observed in [O III]5007 by Sahu & Desai (1986). A second model, considering a Diabolo shape for the PN geometry, is successful in reproducing both the density variation and velocity profiles.

## 2. 3D MODELS FOR NGC 3132

The 3D photoionization code (Gruenwald, Viegas, & Broguière 1997), as well as the new IDL tools for viewing the results (Morisset, Gruenwald, & Viegas 2000), were applied to NGC 3132. The properties of the central star and the gas are the same as those used by Bässgen, Diesch, & Grewing (1990). Two models were calculated, differing only in the spatial distribution of the gas: one assuming an ellipsoidal shell and the other a Diabolo shape as shown in Figure 1. The results show that the ellipsoidal shell successfully reproduces the low resolution images observed, as well as the global spectroscopy. However, this geometry fails to reproduce the density decrease towards the central region of the PN, derived from the line ratio [S II]6718/6732 (Juguet

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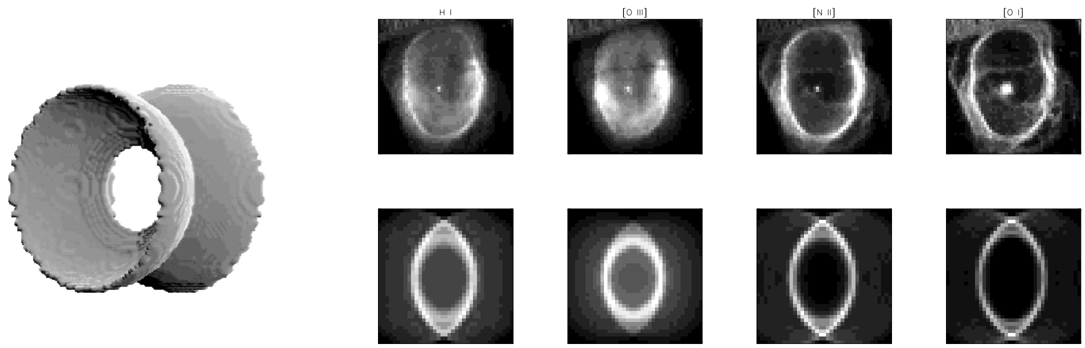


Fig. 1. (*Left*) The Diabolo shape showing high density region with $n = 1300$ cm. The background density is 300 cm. (*Right*) *HST* observations (top) and corresponding line images of the Diabolo model (bottom).

et al. 1988). On the other hand, the Diabolo model successfully reproduces the density decrease, as well as the high resolution images and the global spectroscopy. The high resolution images obtained with the *Hubble Space Telescope* (*HST*) are compared to the ones obtained from the Diabolo model, with the symmetry axis oriented 40 degrees relative to the line of sight (Fig. 1). It is clear from these images that the ellipsoidal appearance, as well as the general ionization structure are reproduced.

The emission line profiles observed through various apertures can also be modeled adopting a given velocity law. The profiles observed by Sahu & Desai (1986) for the line [O III]5007 have been modeled according to this procedure, and the results obtained for the Diabolo model using a linear velocity law. The general aspects of the profiles are well reproduced except for the asymmetry in the central aperture, which could be due to density fluctuations, not included in the present model. For more details, including the profiles obtained, see Monteiro et al. (2000).

## 3. CONCLUSIONS

In this work it is shown that, due to a lack of high resolution imaging and of a 3D modeling tool, erroneous conclusions concerning PNe morphologies can be made. In particular, these tools applied to the modeling of NGC 3132 show that this PNe, which is usually classified as an elliptical, is well explained with a Diabolo shape, a kind of bipolar structure. This structure is successful in reproducing the decrease in density in the central regions as well as the [O III] velocity profiles observed at external parts of the nebula. Both observations are not well reproduced by the ellipsoidal shell model.

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