**Kinematics and Physical parameters of NGC 7354**

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**Summary.** We present an observational study of the Planetary Nebula (PN) NGC 7354 consisting of narrow band imaging ([NII]6584 and Hα) as well as low and high dispersion spectroscopy. Based on our direct image data, NGC 7354 shows a double barrel-like structure. Expansion velocity of the inner barrel can be determined as \(\pm 30 \text{ km s}^{-1}\), which lead to a kinematical age of \(\sim 1800 \text{ yr}\), assuming a distance to the nebula of 1.2 kpc. Besides these large-scale structures, a series of bright knots is observed. Most of these knots are roughly concentrated in the equatorial region with electron density and temperature ranging from 2000 to 3000 cm\(^{-3}\) and from 10,000 to 12,000 K, respectively. Other interesting structures of the nebula are two asymmetrical jet-like structures, not aligned neither with the barrel-like structures axes, nor with each other. Both jet-like features show a low radial velocity of \(\leq 5 \text{ km s}^{-1}\), as seen in our P-V maps. The origin of these two features is still uncertain.

**Key words:** planetary nebula: individual: NGC7354 — ISM: kinematics — ISM: Abundances

**1 Introduction**

NGC 7354 is an elliptical PN, which possess a complex structure: double-envelopes, jet-like features and knots [1, 2, 4]. It has been included in extensive imaging and spectroscopic surveys where global physical and chemical conditions have been discussed [6, 7]. However, up to now, little attention has been paid to the several small-scale structures present in it, like a pair of faint spike-like tails (or jet-like features) as well as a collection of low ionization bright knots located at the minor axis of the nebula.
2 Observations

Optical Imaging: CCD direct images of NGC 7354 were obtained on July 24th, 1997 with the Nordic Optical Telescope (NOT), using two narrow-band filters: [NII]6584(\(\delta \lambda = 10\) Å) and H\(\alpha\). The scale was 0.11 arcsec/pix and exposure times were \(t_{\text{exp}} = 900\)s. Figure 1 shows a grey-scale mosaic of our images on both filters.

Low Resolution Spectroscopy: Low resolution long-slit spectra were obtained with the Boller & Chivens spectrograph mounted on the 2.1m telescope at the San Pedro Mártir Observatory (OAN, UNAM)\(^6\) during 3 observing runs: 2002 June 14, 2002 August 7 and 2002 December 10 and 11. A CCD SITe3 with 1024 \(\times\) 1024 pixels was used as a detector. We have used a 400 lines/mm dispersion grating and a slit width of 2 arcsec giving a spectral resolution of 7Å at FWHM. We have used four slit positions to cover specific regions observed in the [NII]6584 image (see Fig. 2a).

High Resolution Spectroscopy: Six long-slit spectra (see Fig. 2b) were taken on July 15, 16 and 17, 2002 with the Manchester Echelle Spectrometer (MES) in the 2.1m telescope at the San Pedro Mártir Observatory (OAN, UNAM). A CCD Site with 1024\(\times\)1024 pixels was used as a detector. Slit width was set to 1.6 arcsec to achieve a spectral resolution of 12 km s\(^{-1}\). Position-velocity maps, from the emission lines H\(\alpha\), [NII]6584 and HeI\(\lambda 6560\) are shown in Fig. 3.

3 Preliminary Results

3.1 Morphokinematic structure

Large-scale morphology: In Fig. 1 (top panels) we can see two large scale structures that we describe as a "double-barrel" morphology. The inner and outer barrel can be better distinguished in our low- and high-contrast H\(\alpha\) images, respectively. In the [NII]6584 image, the outer barrel main axis is oriented at \(\sim 18^\circ\) with the E-W sides quite straight, while the inner barrel walls are more rounded with its main axis at \(\sim 30^\circ\). Expansion velocity of the inner barrel can be determined from our P-V maps (Fig. 3) as 30 km s\(^{-1}\), which lead to a kinematical age of 1800 yr, assuming a distance of 1.2 kpc.

Microstructures: In our [NII]6584 images (Fig. 1, right panels) a collection of bright knots are roughly concentrated in the equatorial region with electron density and temperature ranging from 2000 to 3000 cm\(^{-3}\) and from 10000 to 12000 K, respectively (Table 1). Two asymmetrical jet-like structures are observed. These features are not aligned neither with the barrel-like structure, nor with each other, and show a low radial velocity of 5 km s\(^{-1}\). It is worth noting that despite of its morphology, the jet-like features do not show neither evidence of emission of shocked material nor a high-velocity component.

3.2 Chemical structure

We have determined ionic and total abundances wherever possible in the nebula. Ionic abundances were derived using the ALIEN software package [3]. Total abundances were derived using the method developed by Kingsburgh & Barlow [3] and they are shown in Table 1.

\(^{6}\) Observatorio Astronómico Nacional, Universidad Nacional Autónoma de México
Fig. 1. [NII]6584 and Hα mosaic of NGC 7354. Top panels show high-contrast images where we can see the large-scale structure of the nebula. Middle panels present low-contrast images where we can distinguish the large-scale cylindrical structure and a clear elliptical inner structure. On the low-contrast [NII]6584 image, a collection of bright knots is noticeable as well as the two protuberances lying in the direction of the main symmetry axis of the inner elliptical structure. Finally, bottom panels show unsharp-masking images to enhance fine details of the nebula.
Fig. 2. Fig. 2a) shows slit positions (labeled from A to D) for our low-resolution spectroscopy. On each slit position several regions were selected to study some interesting structures. Specific regions are denoted by a letter referring to the slit position followed by a sequence number along the slit. Fig. 2b) shows our six slit positions for high-resolution spectroscopy.

A comparison of abundance values between our different regions shows that there are no significant variations within the nebula except for the jet-like feature which is slightly overabundant in O/H, N/H and Ar/H. Comparing our derived abundances with the average PNe and Type I PNe values from [5], we found that the He abundances are consistent in all regions (except B3).

References

Fig. 3. Position-Velocity diagrams obtained for three filters along each slit across the nebula. Vertical dashed lines indicate systemic velocity, with approaching and receding velocities to the left and right sides, respectively.

Table 1. Derived Physical Parameters and Total Abundances

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<th>( N_\alpha ) [cm(^{-3})]</th>
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<th>( [\text{O III}] )</th>
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<th>( [\text{C III}] )</th>
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