Planetary Nebulae: A Universal Toolbox in the Era of Precision Astrophysics
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NGC 3242 and the enigmatic nature of its Low Ionization Structures: A MUSE perspective

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Abstract. The objective of our study was the spectroscopic analysis of the PN NGC 3242, which contains a pair of low-ionization structures (LISs). For our analysis, MUSE data were used in conjunction with the SATELLITE code for a spectroscopic analysis in two spatial dimensions. Additionally, infrared images from Spitzer Space Telescope (SST) were employed to search for potential H_2 emission at the LISs. The preliminary results revealed that the electron temperature calculated from [N II] diagnostics lines is approximately 12,000 K at the LISs, while the thorough examination of MUSE data has led to the identification of the [C I] 8727 Å emission line emitted only from the LISs. This result may imply that LISs are the optical counterpart of a dense molecular core. Spitzer's data didn't reveal the existence of H_2 at LISs, but three rings were identified around the main body of the PN.

Keywords. (ISM:) planetary nebulae: individual (NGC 3242), techniques: spectroscopic, ISM: atoms, ISM: abundances

1. Introduction

Planetary nebulae (PNe) are formed when low-to-intermediate mass stars expel their outer envelopes to the interstellar medium during the AGB phase. The intense ultraviolet (UV) radiation from the central star ionises the gas, leading to homogeneous nebular structures. However, in some PNe, distinct small-scale structures, characterized by lower ionization degree than the surrounding nebular gas, are observed. Although there are some theoretical scenarios for the origin of these low-ionisation structures (LISs), their nature remains poorly understood (Gonçalves et al. 2001; Mari et al. 2023; Akras & Gonçalves 2016). Our study is focused on the spectroscopic characterization in 2D of the multiple shell PN NGC 3242, which contains a pair of LISs. The SATELLITE code, developed from Akras et al. (2022), was used for the spatial analysis of the MUSE data and a physico-chemical analysis was carried out.

2. Results

2D maps for several nebular physico-chemical parameters were constructed. The electron temperature derived from [N II] diagnostic was representative only for the LISs with mean value 12,000 K (Fig. 1, left panel), which is in good agreement with the results from previous studies (e.g., Monteiro et al. 2013). Our analysis, also, revealed the existence of the far red atomic line [C I] 8727 Å, to originate only from the LISs (Fig. 1, right panel). This finding in conjunction with the enhanced low-ionisation lines such as [N II] and [O I] at LISs implies a partially ionised gas, which may surround a dense molecular core. The

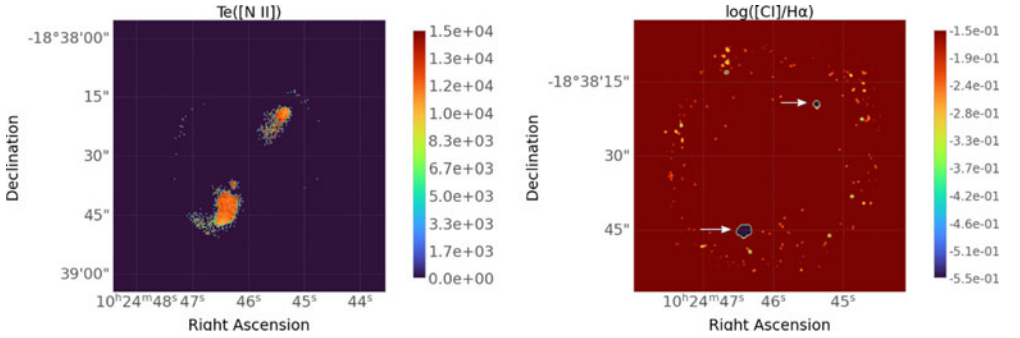

Figure 1. Left panel: electron temperature 2D map, calculated from [N II] emission lines. Right panel: smoothed 2D map of log([C I]/Hα). The white arrows point out the positions where atomic carbon was detected.

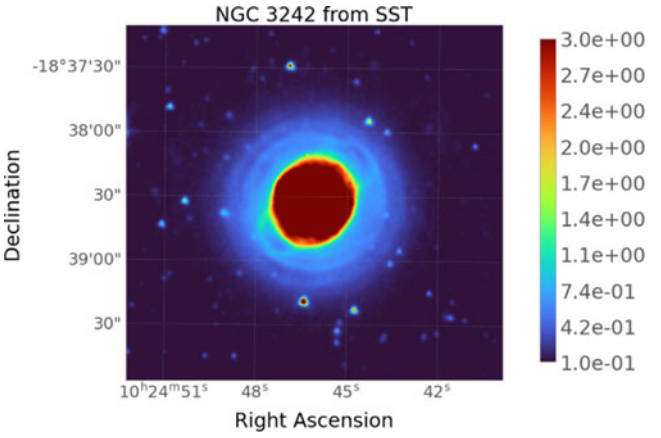

Figure 2. [4.5] Spitzer/IRAC band image of NGC 3242. Three rings are seen at the halo of the nebula. The colourbar indicates the surface brightness.

detection of the [C I] 8727 Å emission line at the pair of LISs provides further support of the scenario in which LISs are potentially mini photodissociation regions embedded in PNe.

In the investigation of Spitzer's image data, we couldn't find any evidence for H_2 emission to emanate from the LISs. We argue that the H_2 emission is either faint and not detectable by narrowband imaging or absent, but further investigation is required to confirm the presence of H_2 gas in the LISs of NGC 3242. In addition, three rings were identified around the main body of NGC 3242 (Fig. 2). These rings are probably related to different mass loss episodes during the AGB phase (Phillips et al. 2009).

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1743921324000024

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