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A Multi-Wavelength Analysis of Planetary Nebula NGC 3132 using MUSE, JWST and SPITZER data

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Abstract. MUSE data regarding NGC 3132 were used and analysed through SATELLITE in order to obtain 2D maps of the physico-chemical parameters of the nebula. Furthermore, our results were compared with a 3D photoionisation model built with MOCASSIN with the aim to constrain its parameters. Lastly, we utilized JWST and Spitzer IR data and examined their radial distribution.

Keywords. planetary nebulae: individual (NGC 3132), ISM: molecules, ISM: dust, extinction, ISM: abundances, infrared: ISM

1. Introduction

Integral field spectroscopy or imaging spectroscopy has been established in the last decade as an important technique for the spatial analysis of ionised gas such as HII regions, galaxies and planetary nebulae. MUSE, which is mounted on VLT, is one of the most capable integral field units available. In this study, a two-dimensional spectroscopic analysis has been performed on the PN NGC 3132 using the MUSE data from Monreal-Ibero & Walsh (2020) and SATELLITE code (Akras et al. 2020). This particular planetary nebula was selected for the early observing phase of JWST and significant emission from molecular hydrogen fragmented in clumps as well as a multiple stellar system at its centre have been found (De Marco et al. 2022).

2. Results

We utilised MUSE data with SATELLITE, and we examined several physico-chemical parameters of the nebula like c(H_β), N_e, T_e, ionic and total elemental abundances (left panel Figure 1). The rims have $T_e \sim 10^4$ K and $N_e \sim 10^3$ cm^{-3}, while inside the elliptical ionized cavity $T_e \sim$ 9,700 K and $N_e \sim$ 400 cm^{-3} are found. Moreover, a 3D photoionization model build with MOCASSIN (Monteiro et al. in prep) was compared to MUSE's observational data in order to constrain its physical characteristics. The current model slightly underestimates N_e and overestimates T_e by a little. The ionic and total chemical abundances are in good agreement with the observational data.

From the radial analysis of the JWST data, it was found that H_2 gas shows two peaks at the inner and at the outer part of the rim as well. Extinction coefficient c(H_β) and H_2 emission appear to be co-spatial, indicating the presence of dust that likely prevents the dissociation of H_2 (Akras et al. 2020, 2022; Aleman & Gruenwald 2011). Furthermore, according to Phillips et al. (2010), the Spitzer IRAC [8.0]/[4.5] ratio takes its lowest values at low ionisation regions. Interestingly enough, in our analysis, H_2 peaks at the

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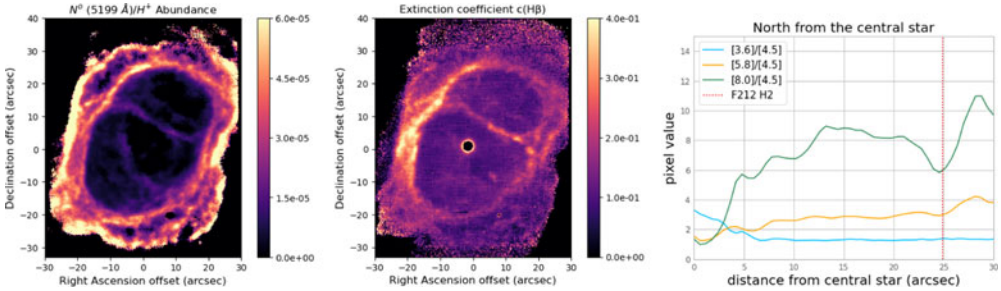

Figure 1. Left panel: 2D map of NGC 3132 for N^o/H^+ abundance. Middle panel: 2D map of NGC3132 for extinction coefficient $c(H_\beta)$. Right panel: Radial profiles for Spitzer IRAC channels ratios North from the central star of PN NGC 3132. The red dotted line represents the peak of 2.12 μm line of H_2 as obtained by JWST.

same distance from the central star where [8.0]/[4.5] ratio decreases (right panel Figure 1). Here, we provide for the first time confirmation between the link of H_2 2.12 μm emission line from JWST and infrared colours from Spitzer's IRAC [8.0]/[4.5] ratio.

3. Conclusions

The comparison of the MUSE data with the 3D photoionization modelled results of NGC 3132 with the SATELLITE code allow us to constrain and improve the model. In addition, this analysis will make possible the exploration of a potential spatial variation of ICFs throughout the nebula. Scrutinizing the JWST and Spitzer data, we verified the link between the H_2 emission line and the [8.0]/[4.5] ratio. On the other hand, the examination of the JWST and MUSE data revealed that c(Hb) and H_2 radial profiles peak at the exact same position, indicating that dust prevent the dissociation of H_2 and act as a catalyst for its formation.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1743921323005525

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