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VIMOS integral field spectroscopy of the interesting planetary nebula Hen2-434

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Abstract. Planetary nebula are important laboratories for many aspects of stellar and Galactic evolution. In this context, finding objects that may challenge current consensus is an important endeavour. Here we present VIMOS integral field spectroscopy for one of these objects, the planetary nebula Hen 2-434. This is a poorly studied object due to its small size but that sparked some curiosity due to its low ionization structure. In this work we dissect the ionization structure of the nebula with the spatially resolved data revealing a peculiar morphology. We obtain emission line maps for the most important lines as well as some important physical condition diagnostics. Our results characterise two bright structures as FLIERS with a speed of 15 km/s, indicating also that the nebular structure is inclined with respect to the line of sight. We present preliminary results of the chemical analysis of the main nebula as well as the FLIER structures, showing that the latter have a higher He abundance than the surrounding nebula.

Resumo. As nebulosas planetárias são laboratórios importantes para muitos aspectos da evolução estelar e galáctica. Nesse contexto, encontrar objetos que possam desafiar o consenso atual é um esforço importante. Aqui apresentamos a espectroscopia de campo integral VIMOS para um desses objetos, a nebulosa planetária Hen 2-434. Este é um objeto pouco estudado devido ao seu pequeno tamanho mas que despertou alguma curiosidade devido à sua estrutura de baixa ionização. Neste trabalho dissecamos a estrutura de ionização da nebulosa com os dados resolvidos espacialmente revelando uma morfologia peculiar. Obtemos mapas de linhas de emissão para as linhas mais importantes, bem como alguns diagnósticos de condições físicas importantes. Nossos resultados caracterizam duas estruturas brilhantes como FLIERS com velocidade de 15 km/s, indicando também que a estrutura nebular é inclinada em relação à linha de visão. Apresentamos resultados preliminares da análise química da nebulosa principal, bem como das estruturas FLIER, mostrando que estas últimas possuem uma abundância de He maior do que a nebulosa circundante.

Keywords. planetary nebulae: general – planetary nebulae: individual: Hen 2-434 – ISM: abundances

1. Introduction

Stars with masses between approximately 1 and 8 $M_{\odot}$, at the end of their evolution, eject their outer layers, forming what we call a planetary nebula (PN). The remnant hot stellar core ionizes and heats the surrounding gas. These stars undergo nucleosynthesis processes during their existence which change their composition and the ejected material can contain atomic and molecular gas, as well as dust grains. As such, PN are an important class of objects which allows for the study of stellar evolution and the chemical enrichment of the interstellar medium.

In this context, finding objects that may challenge current consensus is important. In this work we investigate the nebula Hen 2-434 which is a poorly studied object with peculiar morphology. It was first imaged by Schwarz et al. (1992) and later analysed by Corradi et al. (1996), who observed two nodules in NP He 2-434 and classified them as two radially symmetrical nodes. Also, they suggested that these structures may be the result of a process of collimated mass ejection from the star. The spectral type of the central star of this nebula was obtained by Weidmann & Gamen (2011), finding absorption lines of He I and He II and classifying it as spectral type O. Kingsburgh & Barlow (1994) performed chemical analysis using long slit spectroscopy.

2. Methods

The observations analysed here were obtained with the Visible Multi-Object Spectrograph, mounted on ESO-VLT UT3 Melipal, Paranal Observatory, in Chile, between April 9th, 2007 and September 1st, 2007. The data are part of the observation program 079.D-0117A, led by H. Schwarz. The observations were performed with airmasses of 1.6 and 1.5 for the blue and red arms, respectively. The average seeing obtained from the DIMM was of 0.89 and 0.69 arcsec for the blue and red arms respectively. The spatial samplings 0.67 arcsec (2:1 magnification) was used in these observations. This provides a field of view (FoV) of 27x27 arcsec. Using the available high resolution modes HRorange and HRblue, we obtained a wavelength coverage from 4000-6700 and 5250-7400A with a dispersion of 0.53 and 0.6 Å per pixel, respectively. The regions observed generate two separated data cubes at the end of the reduction process. The spectral resolution achieved is approximately 2500, with 4096 pixels in the spectral axis. The data reduction was performed with the the VIMOS Interactive Pipelines, using standard procedures of bias and flat field correction, as well as wavelength and flux calibration. The data was also corrected for differential atmospheric refraction and sky contamination. From the final data cubes emission line maps and emission line intensities were obtained.

The gas diagnostics and abundance results were obtained with the code NEAT (Nebular Empirical Analysis Tool, version 2.2.40 as described in Wesson et al. (2012)) using the integrated spectrum line fluxes as input. Since the nebula showed two very distinct morphological components: 1) Low ionisation structures (LIS) and 2) the main nebula, we extracted distinct integrated spectra for each of those regions. For the LIS spectrum we subtracted the surrounding contribution from the main nebula to ensure we were investigating only the emission from the visible knots.

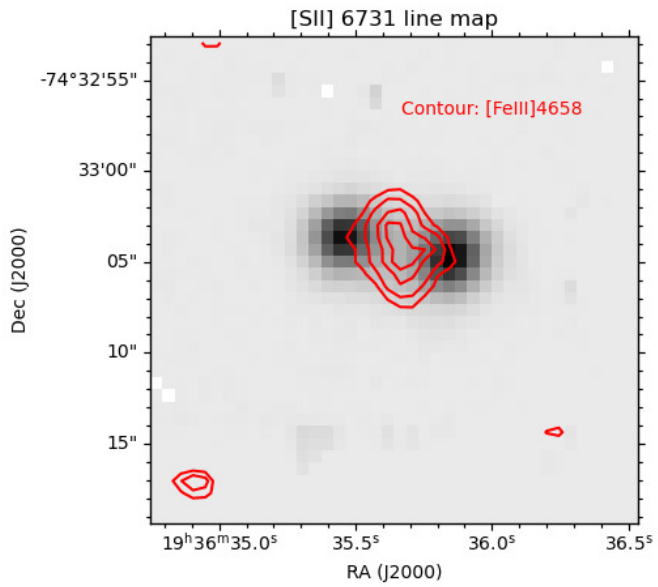

Figure 1. Comparison of the [SII]6731 emission morphology to the one from [FeIII]4658, indicating that they are aligned along distinct axis.

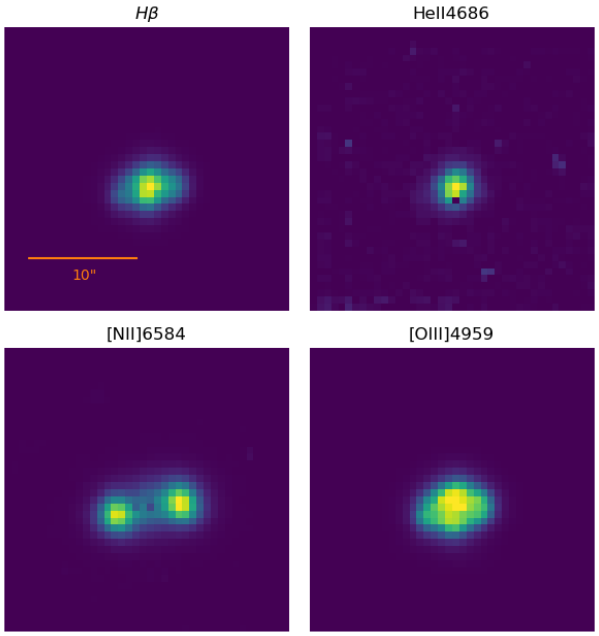

Figure 2. Intensity maps obtained from the VIMOS data cube for selected emission lines showing the distinct morphology for different ions. The first image shows a scale bar for reference.

3. Results

The emission line maps obtained from the data are shown in Figure 2. It can be seen that the nebula has quite different morphologies when low ionzation emission is compared to high ionization. The low ionization structures (LIS) were studied in detail in Gonçalves et al. (2000). The mid and high ionization emission reveal a bipolar structure with the LIS apparently residing in the tips of the lobes, which are not very open when compared to other bipolar objects. In Figure 1 we show a comparison of the [SII]6731 emission morphology to the one from [FeIII]4658, indicating that they are aligned along distinct axis. It is unclear why this peculiar arrangement is seen.

The plasma diagnostics based on lines emitted in the LIS show that it has a slightly larger electron density and temperature than the surrounding medium. Chemically the LIS appears to be enriched when compared to the main nebula which may indicate a late mass ejection event. In Figure 3 the velocity structure is shown indicating that the LIS has higher velocity than the surrounding medium.

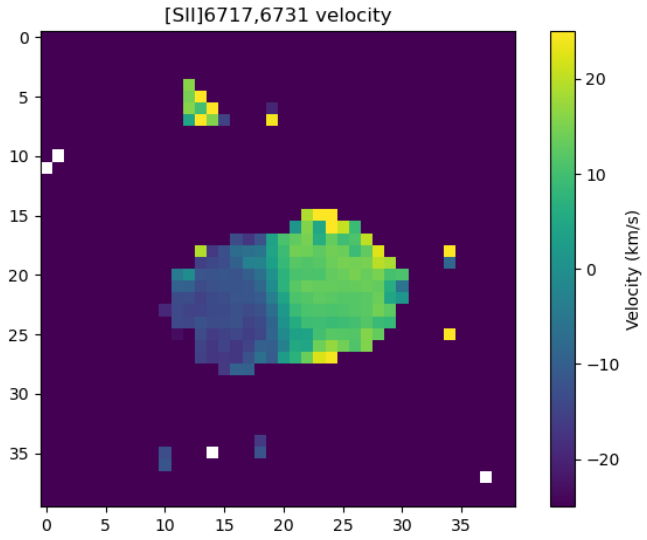

Figure 3. Velocity structure obtained from the [SII]6717,6731 emission lines.

4. Conclusions

In this work we studied the planetary nebula Hen 2-434 using IFU data obtained with the VIMOS instrument at the VLT telescope. The nebula presents a peculiar and distinct morphology in different ions. The abundance analysis indicates a presence multi-chemistry environment. The LIS temperature and density based on CELs is similar to main nebula, however they show enriched He and heavy element abundances. The observed LIS also have velocities higher than the ones from main nebula.

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