Searching and characterizing the Faint Haloes of Planetary Nebulae: A Study Case for Integral Field Spectroscopy

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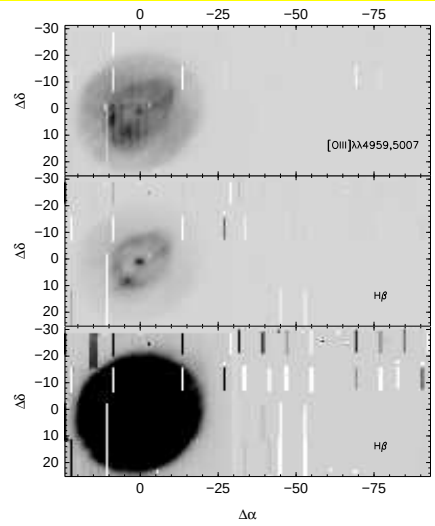
ABSTRACT

This poster presents the first results of a research project devoted to the characterization of the physical properties of the Planetary Nebulae Haloes. We have performed integral field observations of the PNe NGC 3242 and NGC 4361 with the VIMOS instrument attached to VLT-UT3. By co-adding a large number of spaxels we reach an emission line detection limit of 5×10^{-18} erg cm^{-2} s^{-1} arcsec^{-2}. In the case of NGC 3242, we succeed in determining some properties of the halo, being the most remarkable the determination of a T_e gradient for the first time. No line emission is seen in the suspected halo region of NGC 4361 down to the sensitivity limit. A more extensive discussion about what it is shown here can be found in Monreal-Ibero et al. (2005).

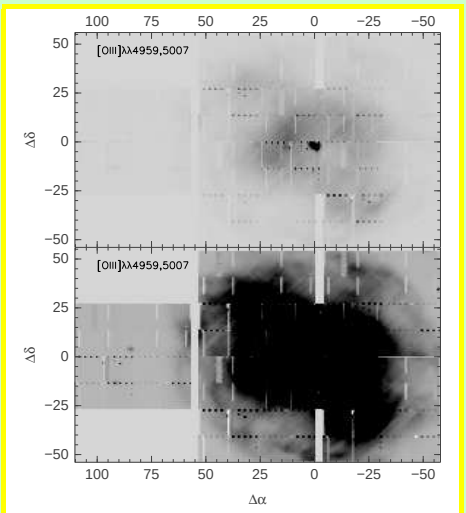
1. THE DATA



Data were obtained using the VIMOS-IFU, in LR_blue mode. Figure 1 and Figure 2 show maps of NGC 3242 and NGC 4361 in the emission lines of [O III]λλ4959,5007 and Hβ. Various IFU defects are scattered over the FOV as distinct rectangles, which needed to be discarded from the subsequent analysis. Despite these cosmetic limitations, the fundamental morphological appearance as described in Corradi et al. (2003) is clearly visible as far as the brighter parts of the nebulae are concerned: central star, central cavity with enhanced rim, and shell.

Figure 1: Maps of NGC 3242 in [O III]λλ4959,5007 (top), Hβ low contrast (middle), and high contrast (bottom). Orientation: N up, E left.

Figure 2: Maps of NGC 4361 in [O III]λλ4959,5007. Low contrast (top), high contrast (bottom). Orientation: N up, E left.



2. RADIAL PROFILES

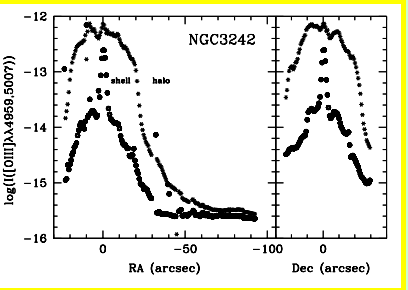


Figure 3: Radial intensity profi les in [O III] + background (asterisks) and background (circles) for NGC 3242 (top) from central cuts one spaxel wide and along right ascension and declination. The [O III]λλ4959, 5007 emission line intensity is integrated over the interval 4900–5068 Å, the background is determined from the interval 5100-5150 Å and corrected for the different band width. The intensity scale is is in erg cm^{-2} s^{-1} arcsec^{-2}.

In Figure 3 and Figure 4, the radial profi le along RA and DEC are shown. The halo of NGC 3242 is clearly visible but, having a more than two orders of magnitude fainter surface brightness than NGC 3242, no halo emission is seen for NGC 4361.

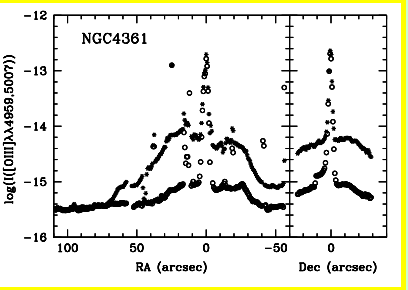


Figure 4: The same as Figure 3 but for NGC 4361.

3. IMPROVING THE S/N

We co-added very many spaxels over extended regions beyond the shell to obtain an estimate of the average emission line intensity of the halo. For NGC 3242, we have clearly detected Hβ, and the line blend of Hγ and [O III]λ4363.

In the case of NGC 4361, there is no detection of halo line emission. Our detection limit estimate in the halo of NGC 4361 is 5×10^{-18} erg cm^{-2} s^{-1} arcsec^{-2}, not sufficient for the typical intensity contrast of $\approx 10^3$ (Corradi et al 2003).

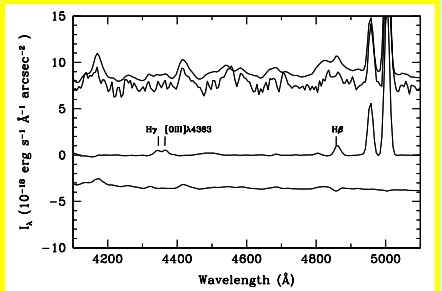


Figure 5: Mean halo spectra of NGC 3242 and NGC 4361, averaged from a total of 4547 and 4312 spectra, resp., and plotted in units of 10^{-18} erg cm^{-2} s^{-1} Å^{-1} arcsec^{-2}. From top to bottom: NGC 3242 co-added, NGC 3242 single-spaxel, NGC 3242 co-added + sky-subtracted, NGC 4361 co-added + sky-subtracted spectrum (shifted by -5×10^{-18} erg cm^{-2} s^{-1} Å^{-1} arcsec^{-2}).

Bibliography

— Balick et al. (1993), ApJ, 411, 778
— Corradi et al. (2003), MNRAS, 340, 417
— Corradi et al. (2004), A&A, 417, 637
— Fluks et al. (1994), A&AS, 105, 311
— Monreal-Ibero et al. (2005), ApJL accepted, (astro-ph/0506300)
— Schöneberner & Steffen (2002), RMA&A. Ser. Conf. 12., 144

4. THE HALO OF NGC 3242

The profi le of NGC 3242 show small intensity 'bumps' that can be attributed to the existence of halo 'rings'. The agreement with the radial positions given by Corradi et al. is good, except in a few cases.

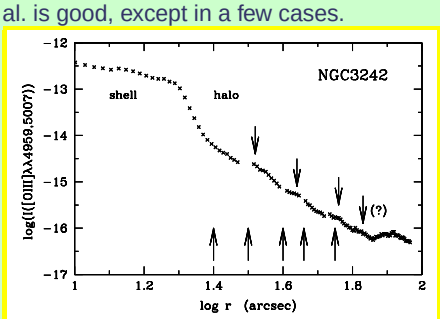


Figure 6: Radial background-subtracted [O III]λλ 4959,5007 Å intensity profi le for NGC 3242, one spaxel wide, along RA, in erg cm^{-2} s^{-1} arcsec^{-2}. The vertical arrows indicate the position of the 'rings' from our cut (*downwards*) and from Corradi et al. (*upwards*).

The halo of NGC 3242 is limb-brightened These haloes are very common and are explained by hydrodynamical effects when a strong AGB wind interacts with slower, less dense matter expelled earlier during the aftermath of a helium shell flash (Schönberner & Steffen 2002).

Halo region	Hγ	[O III]λ4363	Hβ	[O III]λλ4959,5007 (10^{-18} erg cm^{-2} s^{-1} arcsec^{-2})	T_e (K)
outer	8.9	9.9	19.8	411.9	20300
inner	51.4	66.8	114.7	4426.4	15700

Table 1: Measured line flux and derived T$_e$ for the halo of NGC 3242 from the [O III] lines. We have used the low-density limit, a value for the extinction of $c = 0.15$ (Balick et al. 1993) and the extinction curve of Fluks et al 1994.

We found an apparent temperature gradient across the halo which, if confi rmed, poses a challenge for evolutionary models of PNe.

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