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NGC7469 as seen by MEGARA at the GTC

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Abstract. We present the main results from the analysis of the Hα-[NII] emission lines with integral field spectroscopy observations gathered with MEGARA at the GTC of the nearby Seyfert 1.5 galaxy NGC7469. We obtained maps of the ionised gas in the inner 12.5 arcsec $\times$ 11.3 arcsec, at spatial scales of 0.62 arcsec, with an unprecedented spectral resolution (R $\sim$ 20 000). We characterized the kinematics and ionisation mechanism of the distinct kinematic components (Cazzoli *et al.* 2019).

Keywords. galaxies: active, galaxies: kinematics and dynamics, techniques: spectroscopic.

1. Introduction

With the advent of MEGARA (*Multi-Espectrógrafo en GTC de Alta Resolución para Astronomía*, Gil de Paz *et al.* 2018) the new integral field unit at the 10.4m Gran Telescopio Canarias (GTC) high spectral resolution (from 6 000 up to 20 000) integral field spectroscopy observations have become available. MEGARA started the operation in 2017 and during the commissioning run the NGC7469 galaxy was observed.

NGC7469 is a nearby ($z \sim 0.016$), grand-design spiral galaxy hosting a Seyfert 1.5 AGN (Landt *et al.* 2008). Powerful star formation activity, SFR = 48 $M_\odot$/yr (Pereira-Santaella *et al.* 2011), is mainly occurring in its circumnuclear ring bright at various wavelengths (e.g. Davies *et al.* 2004). Features of non-rotational motions, such as outflows, have been found in the infrared and X-rays bands (Müller Sánchez *et al.* 2011; Blustin *et al.* 2007).

2. Main Results

After data reduction (as in Pascual *et al.* 2019), we modeled the H$\alpha\lambda$6563-[NII]$\lambda\lambda$6548,6584 emission lines with four kinematic components that can be discriminated according to their width. Figures 1, 2 and 3 show the kinematic maps (velocity

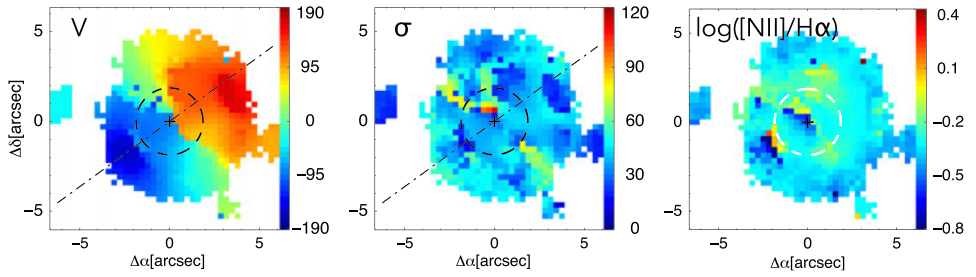

Figure 1. Ionised gas maps derived from the fit to the Hα-[NII] emission lines for the narrow component: velocity field (V), velocity dispersion map (σ) and $\log([\mathrm{NII}]/\mathrm{H}\alpha)$ maps. The cross marks the photometric center, the dashed circle indicates the nuclear region. Kinematic maps are in $\mathrm{km\,s^{-1}}$ units. The photometric major axis is marked with a dot-dashed line.

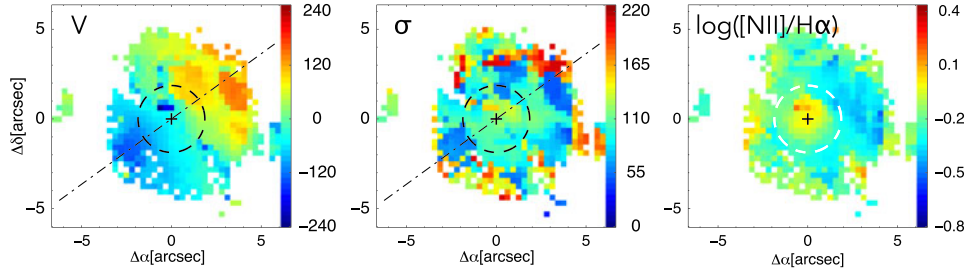

Figure 2. The same as Fig. 1 but for the second (narrow) component.

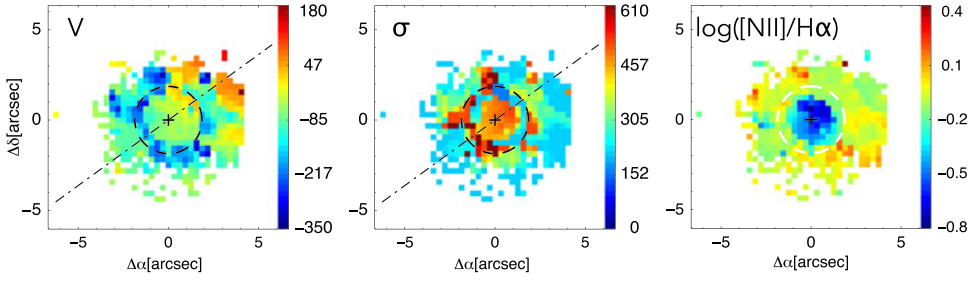

Figure 3. The same as Fig. 1 but for the third (intermediate-width) component.

and velocity dispersion, i.e. V and σ) and the $\log([\mathrm{NII}]/\mathrm{H}\alpha)$ map, for the narrow, second and intermediate-width line-components. An unresolved broad Hα component, from the AGN's broad line region (BLR), is present in the nuclear region (within the area of the PSF).

• *Kinematics, dynamical support and disc-height for the two narrow components.* *Narrow component.* The velocity field shows a pattern consistent with kpc-scale ordered rotational motions (Fig. 1, left). The peak-to-peak semi-amplitude is $163 \pm 1\,\mathrm{km\,s^{-1}}$, with the maximum velocity gradient oriented as the photometric major axis (∼125°). The σ-map is not centrally-peaked (Fig. 2, middle), contrary to what is expected for a rotating disc. The average velocity dispersion inside the nuclear region ($40 \pm 1\,\mathrm{km\,s^{-1}}$) is similar to that in the disc ($38 \pm 1\,\mathrm{km\,s^{-1}}$) that presents some perturbations. The dynamical ratio (V/σ) is 4.3 indicating a rotation-dominated kinematics. By using a thin-disc approximation (as in Cazzoli *et al.* 2014, 2016) we calculate that the disc height is ∼20 pc.

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Second narrow component. Kinematics maps show an irregular spider-pattern-like velocity field and a non-centrally peaked velocity dispersion map (Fig. 2). The disc has an important random-motion component ($V/\sigma = 1.3$) with height of about 200 (500) pc as inferred with a thin (thick) disc approximation (as in Cazzoli *et al.* 2014, 2016).

- *Velocity dispersion features: σ-drop and anomalies.*

For the narrow component, we found a decrease in the velocity dispersion radial profile of about 25 km s^{-1} at $r \leq 1.5$ arcsec. This feature is suggestive of the presence of a σ-drop related to dynamically cold gas funneled from the outer regions to the nucleus by a bar during a fast episode of central gas accretion.

We detect two kinds of 'velocity dispersion anomalies'. On the one hand, the velocity dispersion maps of both narrow components reveal a number of clumps with low-σ. On the other hand, a velocity dispersion enhancement along the minor photometric axis is found only in the σ-map of the narrow component. While the former could be potentially associated to star forming clumps, the origin of the latter is unclear.

- *Very turbulent emission probed by the intermediate-width component.*

The kinematics of this component lack of any rotating disc features, being irregular, with no peculiar morphology/orientation (Fig. 3). On the one hand, a broad blue-shifted component is indicative of outflows, even if not oriented perpendicular to the disc (e.g. as in NGC1068, García-Burillo *et al.* 2014). On the other hand, the ring-like emission with the highest turbulence could probe gas flows at the Inner Lindblad Resonance radius of the lens (Márquez & Moles 1994). Finally, the gas with $\sigma \sim 250$ km s^{-1} could be associated to either disc-perturbations or to diffuse and not virialised gas.

- *Ionisation mechanisms.*

For the narrow (second) component, the log([NII]/Hα) values (Figures 1 and 2, right) are indicative of star-formation as the unique (dominant) mechanism of ionisation. For the intermediate component, given the observed widths (> 300 km s^{-1} tipically), the log([NII]/Hα) values are indicative of shock-ionisation (Fig. 3, right).

- *BLR properties.*

In the unresolved nuclear region of NGC7469 ($r \leq 1.85$ arcsec) the broad (FWHM $\sim$ 2590 km s^{-1}) Hα component from the BLR is dominating the global Hα-[NII] profile.

3. Main conclusions

For the two narrow components, we found that a thicker disc nearly co-rotates with the thinner one, with similar velocity amplitudes (137 vs. 163 km s^{-1}), but different velocity dispersions (108 vs. 38 km s^{-1}) and dynamical status (4.3 vs. 1.3 in V/σ). The morphology and the kinematics of the intermediate-width component is suggestive of the presence of turbulent non-circular motions, possibly associated either to a wide angle outflow or to gas flows related to the lens. Part of the ionised gas traced by this component could also be due to turbulent motions outside the plane of the disc related to disc perturbations, and/or with diffuse gas gravitationally bound to the host galaxy, but not virialised.

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