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MAPPING THE CENTRAL REGIONS OF ACTIVE GALACTIC NUCLEI USING HIGH-IONIZATION LINES

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RESUMEN

Presentamos resultados de un trabajo encaminado a estudiar líneas coronales en una muestra de AGNs próximos. Los datos nos permitieron resolver y mapear la extensión del gas emisor de líneas coronales y compararlo con el que emite líneas de ionización baja y media. La muy buena coincidencia entre la emisión radio y la CLR sugiere que parte del gas de alta ionización es impulsado por el chorro. Modelos de fotoionización donde el AGN es la única fuente de fotones ionizantes fallan al reproducir las razones de línea observadas a distancias mayores que 60 pc del centro. Discutimos otros procesos que deben estar operando para producir esta emisión. Sugerimos que la presencia de líneas coronales en AGNs es una prueba unívoca de procesos de retroalimentación en estas fuentes.

ABSTRACT

We present results of an ongoing work aimed at studying coronal lines (CLs) in a sample of nearby AGNs. The data allowed us to resolve and map the extension of the CL gas and compare it to that emitting low- to mid-ionization lines. The very good match between the radio emission and the CLR suggest that part of the high-ionization gas is jet-driven. Photoionization models, where the AGN is the only source of energy input fail at reproducing the observed line ratios, mainly at distances larger than 60 pc from the centre. We discuss other processes that should be at work to enhance this energetic emission. Our results suggest that coronal lines in AGNs are unambiguous signature of feedback processes in these sources.

Key Words: galaxies: infrared — galaxies: nuclei — galaxies: Seyfert — ISM: jets and outflows

1. GENERAL

Apart from the classical broad line region (BLR) at small core distances, and the extended classical narrow-line region (NLR), active galactic nuclei (AGN) show, in their spectra, lines from very highly ionised atoms (Penston et al. 1984). The precise nature and origin of these lines remain uncertain. Advances on this matter include the determination of the size and morphology of the coronal line region (CLR) by means of optical HST and ground-based AO imaging/spectroscopy in a few AGNs. The results indicate emission regions with sizes varying from compact (∼30 pc) to extended (∼200 pc) and aligned preferentially with the direction of the ionisation cones seen in these sources (Mazzalay et al. 2010; Müller-Sánchez et al. 2011).

Due to their high IP (>100 eV), coronal lines (CLs) provide direct look into the NLR and probe dynamical forces associated with the AGN. Several models have been proposed to explain their strengths in AGNs: *(i)* winds originated in the inner wall of the dusty torus (Pier & Voit 1995; Rose et al. 2015); *(ii)* a high ionized component of the inner NLR (Komossa & Schulz 1997; Binette et al. 1997); *(iii)* photoionization by the central source (Ferguson et al. 1997); and shocks between the radio jet and the ISM coupled to photoionization by the central source (Contini & Viegas 2001). In order to help discriminating between these scenarios, we are interested in deriving the flux distribution, gas kinematics, size and morphology of the CLR. This is important to confirm if the CLs can be produced only by AGN photoionization. The gas kinematics will tell us if it is perturbed in regions where the radio-jet interacts with the NLR as well as if the bulk of CL gas is compatible with disc-rotation or if it is located out of the plane of the galaxy. To this purpose, we collected $K-$band adaptive-optics (AO) integral fiel unit (IFU) SINFONI/VLT and cross-dispersed, seeing limited, GNIRS/Gemini spectra of a slected sample of nearby AGNs. Here, we show the results found for NGC 1386 and NGC 4388. Details of the obser-

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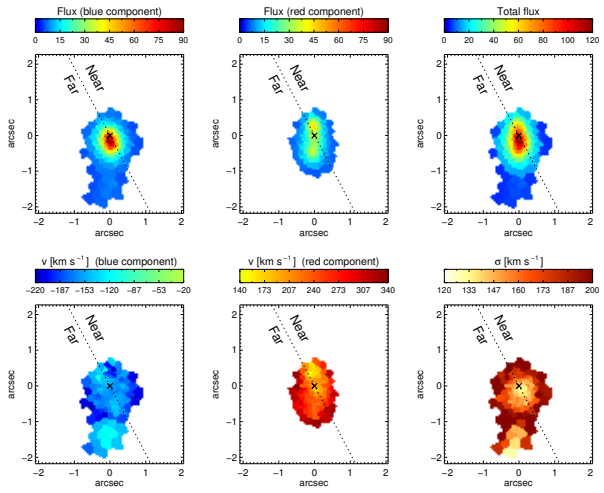

Fig. 1. Integrated emission line flux distribution for [Si VI] 1.963 μm. The top left and middle panels present the results for the blue and red components, respectively. The right panel shows the total flux measured in that line. The bottom panels show the velocity map of the blue and red components (left and central panels, respectively), and the velocity dispersion of the observed profile (right panel).

vations and data reduction are found in Rodríguez-Ardila et al. (2017a,b).

2. RESULTS

2.1. *NGC 1386*

The coronal gas is distributed asymmetrically, being mostly elongated to the N-S direction. To the north, it extends up to 75 pc while to the south it reaches up to 140 pc (see Figure 1).

The high-ionization gas is non-rotational dominated, with splitted emission line profiles. The gas that contributes most to the blue component is located in the central circular blob and along the extended emission to the South. The region emitting the red profile is clearly elongated in the N−S direction and spatially restricted to the blob.

Theoretical models accounting photoionization by the central source are unable to reproduce the size and strength of the observed coronal emission. Our data suggest that shocks powered by the jet can provide additional energy input to explain the high-ionization spectrum detected.

2.2. *NGC 4388*

The analysis of the gas kinematics based on several lines of moderate to very high excitation shows that there is a significant parcel of gas that is not rotation-dominated and located out of the disk of the galaxy. High-ionization lines display flat position-velocity maps, suggesting that the bulk of this emission consists is outflowing. Double-peak [Fe II] lines SW of the nucleus give additional support to this picture. Only the molecular Hydrogen and the stellar component follow a rotation pattern consistent with disk rotation.

The CLs [Si VI] and [Si VII] are detected up to 600 pc along the spatial direction. Models that consider photoinization by radiation from the central engine fail at reproducing nuclear and off-nuclear line ratios. (see Rodríguez-Ardila et al. 2017a, for additional details). Theoretical models that include the effects of shocks coupled to AGN photoionization are able to account for the observations. This result is supported by observational evidence that suggests interactions between the radio-jet and the ISM in the central few hundred parsecs of this AGN.

The picture that emerges from our observations highlights the very complex nature of the nuclear and circumnuclear region of NGC 4388. This Seyfert 2 is one of the best pieces of evidence of the intricate mixture of an AGN, a radio-jet, dust and a rich ISM.

3. FINAL REMARKS

- AO observations show spatially resolved CLRs of sizes varying from tens to a few hundred of parsecs. This rules out the scenario where CLs are produced only in the inner face of the torus.
- Models invoking photoionization by the AGN are unable to explain the observed radial extension of the CLR. Either additional mechanism must be sought or the continuum seen by the high-ionization gas is different to the one we see.
- The very good match between radio emission and FHIL distribution seen in some sources suggest that shocks driven by the radio-jet and the interstellar gas can produce the necessary input energy to drive the coronal lines at distances > 50 pc from the central source. This result suggest that the CLs can be employed as genuine probes of feedback from the AGN.

REFERENCES

Binette, L., et al. 1997, A&A, 327, 909
Contini, M., & Viegas, S. M. 2001, ApJs, 132, 211
Ferguson, J. W., et al. 1997, ApJS, 110, 287
Komossa, S., Schulz, H. 1997, A&A, 323, 31
Mazzalay, X., et al. 2010, MNRAS, 405, 1315
Müller-Sánchez, F., et al. 2011, ApJ, 739, 69
Penston, M. V., et al. 1984, MNRAS, 208, 347
Pier, E. A., Voit, G. M. 1995, ApJ, 450, 628
Rodríguez-Ardila, A., et al. 2017a, MNRAS, 465, 906
Rodríguez-Ardila, A., et al. 2017a, MNRAS, submitted
Rose, M., et al. 2015, MNRAS, 448, 2900