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Origin of high ionization lines in active galaxy nuclei

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Abstract. We present strong evidence that the photoionization by radiation from the central engine cannot explain the emision of Coronal lines observed in Active Galactic Nuclei. Aparently, models accounting for both photoionization and shocks were required to explain both the continuum and NLR spectrum, including the CLs, observed in the spectra of active galaxies

Resumo. Apresentamos provas contundentes de que a fotoionização pela radiação emitida pelo mecanismo central não explica a emissão de linhas coronais observada em Galáxias de nucleos ativos. Aparentemente, modelos que consideram a fotoionização e os choques são necessarios para explicar o continuo e o espectro da NLR, particularmente, as linhas coronais, observadas nos espectros das galáxias ativas.

Keywords. Galaxies: active – Galaxies: Seyfert – Infrared: galaxies

1. Introduction

Active galactic nuclei (AGNs) present, in their spectra, lines of high ionization or coronal lines (CLs). Due to the potential necessary for its production (> 100 eV), the CLs trace a part of the ionizing continuum which is not always directly accessible from observations due to galactic absorption. It is known that CLs are generally emitted in compact regions near the central source, but the physical conditions of the gas and the mechanisms associated with its production are under discussion. In this work we analyze the most internal parsecs of a sample of 4 nearby active galaxies with prominent coronal emission to study the physical mechanisms responsible for the production of CLs. For this purpose, observations of high angular resolution (∼ 0.1"/px) collected with integral field spectroscopy and adaptive optics allowed the study of the spatial distribution of the high ionization gas and model the reasons [Si VI]/Brγ, [S IX]/Paβ, [Ca VIII]/Brγ and [S VIII]/Paβ using Cloudy. The width, shape of the profiles and position of the centroid lines are additional diagnostics used to determine the contribution of energy processes such as outflows and shocks between the jets and the NLR gas.

2. Observations

For this work, we use galaxies with multiwavelength data, because this allows a more complete analysis of the physics associated to the gas. In addition, we select objects with evidence of the presence of outflows and extended coronal emission.

- 4 AGNs: NGC1068, NGC1386, NGC4151 and ESO428-G014
- Observations with AO using NIFS/Gemini and SINFONI/VLT
- High-quality spectroscopic data spatially resolved at smaller scales of 0.15"/pixel, that translate to a angular scale of 15"/pix.

Visual inspection of Fig.1 shows that the region emitting [Si VI]λ1.963μm and Brγ for ESO428-G14 is highly inhomogeneus and elongated along the NE-SW direction. Fig. 2 shows

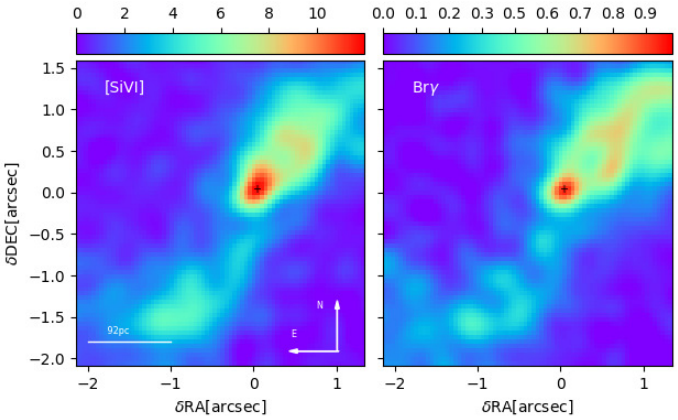

Figure 1. Flux distribution map of [Si VI]λ1.962μm and Brγ for ESO428-G14. The color bar indicates the values of integrated flux in units of 10^{-17} erg cm^{-2} s^{-1}. The orientation and spatial scale are the same for all panels.

the flux map of NGC1386. It can be seen that [Si VI]λ1.963μm is displayin one prominent region of emission. It is characterized by a blob of ∼1" in radius, centred at the AGN and slightly elongated in the N-S direction. The brightest region of this component is highly elongated in the N-S direction, with a size of ∼1.2"×0.6".

3. Kinematics of the CLs

It can be seen in 4 and 3 that [Si VI] is significatively broader than Brγ. Moreover, high-velocity clouds are observed at distances of up to ∼100pc from the centre and coincident with regions of strong radio emission, suggesting outflowing gas, probably due to interaction of the radio-jet with the interstellar medium (ISM).

4. Photoionization models

Cloudy models were employed (Ferland et al., 1998). A luminosity of L_{bol} = 2.9 × 10^{42} erg/s (NGC1386) and L_{bol} =

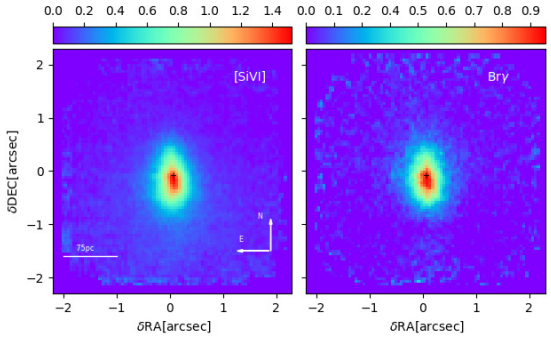

Figure 2. Flux distribution map of [Si VI]λ1.963μm and Brγ for NGC1386. The color bar indicates the values of integrated flux in units of 10^{-17} erg cm^{-2} s^{-1}. The orientation and spatial scale are the same for all panels.

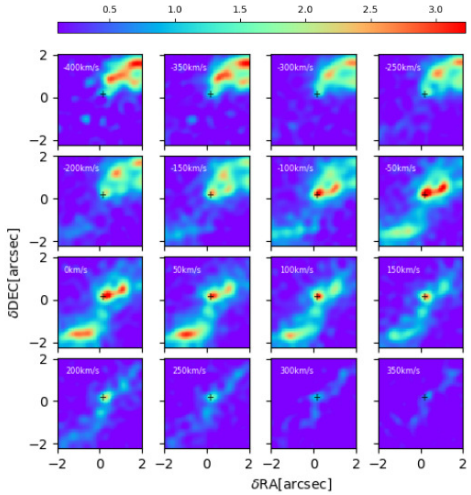

Figure 3. Channel maps derived for Brγ for ESO428-G14. A velocity bin of 50km/s is used to slice the datacube. The color bar indicates the values of integrated flux in units of 10^{-17} erg cm^{-2} s^{-1}.

10.6×10^{42} erg/s (ESO428-G14) for the central source was assumed. The density varies from n_H=500 cm^{-3} to 10^5 cm^{-3}. Solar metallicity was employed. Notice that the observed line ratios

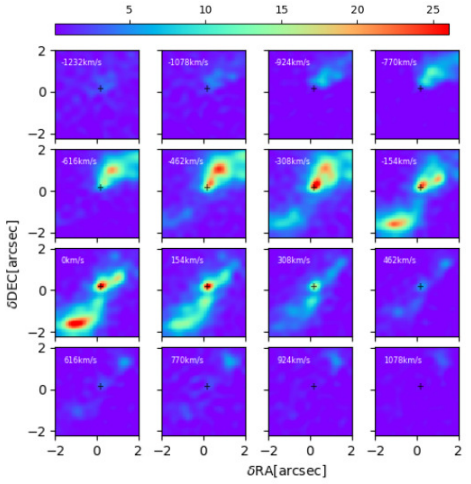

Figure 4. Channel maps derived for [Si VI] 1.963μm for ESO428-G14. A velocity bin of 154km/s is used to slice the datacube. The color bar indicates the values of integrated flux in units of 10^{-17} erg cm^{-2} s^{-1}.

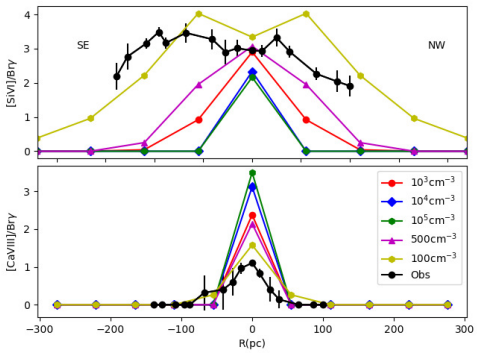

Figure 5. Predicted emission lines ratios [Si VI]/Brγ (upper panel) and [Ca VIII]/Brγ (bottom panel) for clouds with different densities (10^3cm^3 red, 10^4cm^3 blue, 10^3cm^5 green and 500cm^3 purple) for ESO428-G14. The full circles are the observed line ratios.

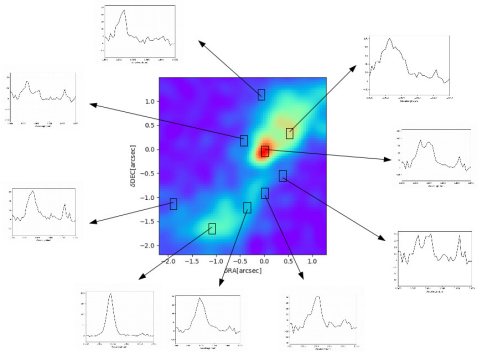

Figure 6. [Si VI] emission-line profiles for ESO428-G14. The spectra were extracted from different spatial regions of ~0.25×0.25 arcsec^2. [Si VI] emission display a very intrincate profile, with multiple components and strong variations in their form and width from region to region.

for the extended gas cannot be reproduced by photoionizacion by the central source.

5. Morphology and extension of the CLR

The CLs of ESO4028-G14 display very intricate profiles, with multiple components and strong variations in their form and width from region to region. As an example, Fig. 6 shows the [Si VI] line profiles of spectra extracted from different spatial regions ~0.2"×0.2".

6. Conclusions

- For [Si VI] and Brγ in NGC1386 the light distribution is compact and clearly resolved.
- For ESO428-G14 [Si VI] is emitted by gas with a wide range of velocities, both positives and negatives, reaching values as high as ~ 1000 km/s and ~ −1000 km/s. The gas in the central regions (~ 0.5 arcsec) is more turbulent, emitting at practically all the observed velocities.
- Our observations cannot be explained solely as due to photoionization by radiation from the central engine.

References

Ferland, G. J., Korista, K. T., Verner, D. A., Ferguson, J. W., Kingdon, J. B., & Verner, E. M. 1998, PASP, 110, 761