Highlights of Spanish Astrophysics XI, Proceedings of the XV Scientific Meeting of the Spanish Astronomical Society held on September 4–9, 2022, in La Laguna, Spain. M. Manteiga, L. Bellot, P. Benavidez, A. de Lorenzo-Cáceres, M. A. Fuente, M. J. Martínez, M. Vázquez- Acosta, C. Dafonte (eds.), 2023

How common are outflows in low luminosity AGNs?.

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Abstract

Outflows play a major role in the evolution of galaxies and are said to be ubiquitous within the Active Galactic Nuclei (AGNs) population. However, we are far from having a complete picture of their properties, specially considering their impact on the evolution of Low-Ionisation Nuclear Emission-line Regions (LINERs). Although resolved kinematic information has proven to be crucial for the fully characterisation of these phenomena, imaging techniques can be really useful for the systematic search of outflow candidates. We have obtained narrow-band optical Hα images with ALFOSC/NOT and retrieved soft-X ray and narrow-band Halpha images from Chandra and HST archives, respectively, for a total of 70 LINERs. We classified the ionised gas morphologies based on the extension and overall shape of the Hα emission. We find that the soft X-ray and ionised gas emission coincide in the great majority of LINERs (60%), as previously seen for Seyferts [1], suggesting a common origin for both emissions. Our results show that approximately one third of the targets present extended, filamentary emission with a distinguishable bubble-shaped morphology. When combining imaging and spectroscopic data from the current literature we find that outflows are present in 48% of the nearby LINERs.

1 Introduction

Feedback processes driven by outflows have been detected in a large variety of systems, mostly related to star-forming processes or active galactic nuclei (AGNs) [7]. Many works focused on analysing the impact that outflows may have in the evolution of the galaxies through the study of their main properties, such as their kinematics, energetics, etc. (see [16, 17] for a review). The exploration of outflows has generally targeted the most powerful events, as they are detected more easily and, thus, their global properties can be better characterised. The power of the outflow has been suggested to scale with the luminosity of the AGN in active systems [5]. Nevertheless, the presence of outflows in the low luminosity end of the AGN family is largely unstudied, except for a few works on Low-Ionisation Nuclear Emission-line Regions (LINERs) [3, 9]. LINERs [8, 13] are the most numerous AGNs in the local Universe, up to a 60% [11]. Although they are intrinsically faint, their relative proximity makes them in principle ideal targets to study AGN physics and, particularly, to search for outflows.

We aimed to explore the presence of outflows in LINERs through a systematic search using imaging, a technique already proven to be useful for detecting outflow-like morphologies, even at the lowest AGN luminosities [14, 15]. The inital sample was selected from [6, 3], and included the results from previous similar works [14, 15].

We have produced the largest atlas up-to-date of ionised gas images for LINERs. In total, our sample consists on 70 nearby LINERs (z<0.025), with an average luminosity of L_{bol} $\sim 10^{41.8}$ erg s^{-1}. We gathered data from the Hubble Space Telescope (HST) archive for 38 targets, and we observed the remaining 32 with the Alhambra Faint Object Spectrograph and Camera (ALFOSC) at the Nordic Optical Telescope (NOT) during several observing campaigns. We obtained three individual exposures per target using both broad-band and narrow-band filters (see Tables C.2 and C.3 in [10] for more details), the latter centered around the expected observed wavelength of Hα at the redshift of our targets. Additionally, we obtained Chandra soft X-ray data for 52 LINERs, in order to compare the origin of both X-rays and ionised gas emissions, and test whether they originate in the same region of the AGN as it is the case for more luminous systems [1, 2].

2 Methodology

The data gathered from the HST archival were already fully reduced. We reduced the ALFOSC/NOT imaging data as standard using IRAF, and then we applied a dedicated background subtraction of the images to ensure a proper sky determination (see Sect. 3 in [10] for details). In both datasets, to obtain exclusively the Hα emission from the galaxy, we applied a similar technique as in [14], eliminating the continuum from the narrow-band images. The broad-band images were scaled and subtracted from the narrow-band images to obtain our final continuum free, pure Hα images.

As for the Chandra soft X-ray images (0.3-2 KeV), they were reduced using the software CIAO v4.13.

We classified the Hα emission in four different categories, as defined in [14]: Core-halo, when the emission is diffuse or unresolved around the nucleus; Disc-halo (or disky), when the emission is concentrated along the disc, spiral arms or nuclear rings; Bubble-like (or outflow), when the emission showed a bubble-like, biconical or filamentary structure; and Dusty, when there was a dust lane covering the nuclear region. We added an additional category, Unclear, whenever we could not clearly include the ionised gas morphology of a galaxy into one of the previous classes. We classified the Hα images considering the emission above the 3σ level from the background. Figure 1 shows an example of the different morphologies that we found per each category; all the images can be found in Appendix B of [10].

Given that imaging alone is not sufficient for claiming the detection of an outflow, we searched in the literature for previous kinematical information for all the galaxies. We found the requested information for 60 out of the 70 targets (86%), the majority coming from the long-slit spectroscopic works from [3, 9]. We compared the morphological classification from the

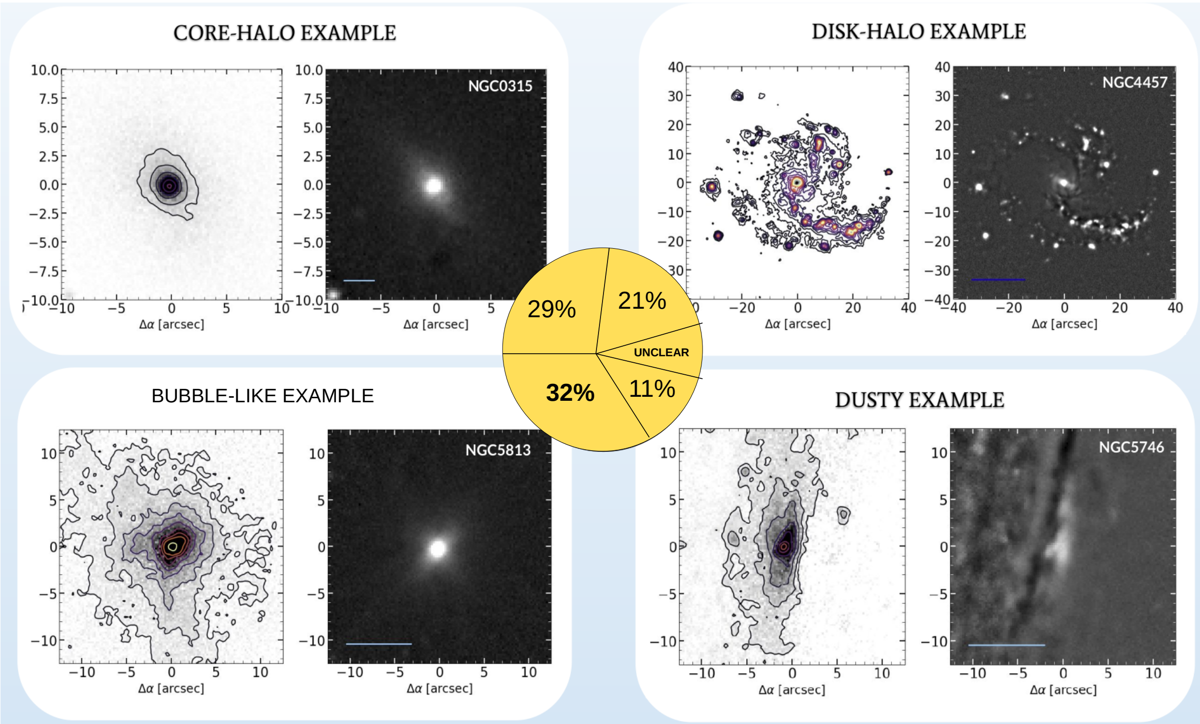

Figure 1: Examples of each morphological class including the percentages of detection per each category. In each panel, the left figure are the Hα images, overimposed by the contours of the emission (levels above 3σ). The right figures are sharp-divided images [12], which highlight non-symmetrical structures. The blue line indicates the 1 kpc scale.

imaging data with the kinematical signatures coming from different sources to further discuss the possible presence of outflows in our LINERs.

3 Results and discussion

As indicated in Fig. 1, we identified a total of 20 LINERs with Core-halo ($\sim$29%), 15 with Disky ($\sim$21%), 8 with Dusty ($\sim$11%), and 22 with Bubble-like morphologies ($\sim$32%). Finally, 7% of the sample was classified as Unclear. The morphological classes in which we found more LINERs is Bubble-líke, which are our candidates for hosting outflows. We did not detect any correlation of the classification of the ionised gas with the morphological type of the host.

If we consider the sample of the 60 LINERs for which there is kinematical information from the literature, for 29 (i.e. 48%) there is a reported detection of an outflow or an inflow. This percentage would indicate that approximately 1 out of every 2 LINERs in the local Universe host an outflow. The Hα emission of the galaxies with kinematically detected outflows were classified in all the different classes that we defined (see Sect. 2). In Fig. 2 we show the comparison of the morphological classification with respect to the percentage of kinematically

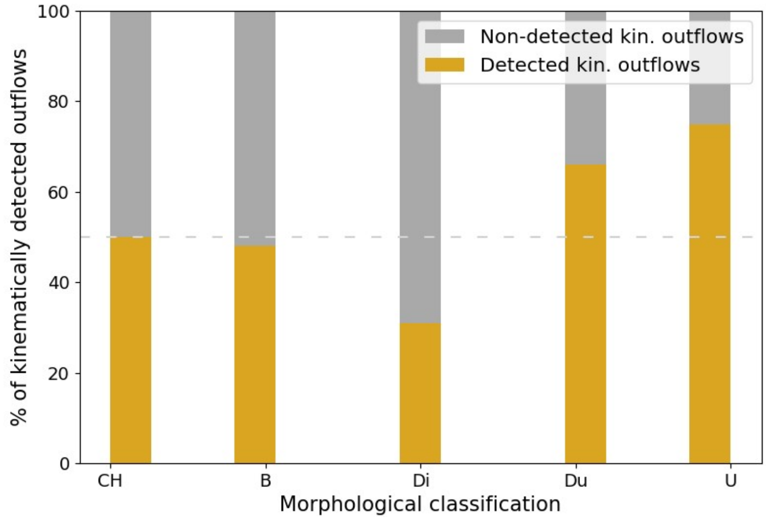

Figure 2: Comparison of the morphological classification of the objects with respect to the percentage of kinematically detected outflows, as obtained from the literature (see Sect. 3). The x-axis from left to right indicates the classes Core-halo, Bubble, Disky, Dusty and Unclear. The orange bars indicate the percentages of kinematical detections; the dashed grey line marks 50% of detection.

detected outflows. For the categories in which we have more than 10 objects (i.e. Core-halo, Bubble-like and Disky) there is a probability of 43% to find an outflow, irrespectively from the morphological distribution of the ionised gas. A lower percentage of kinematic outflows in Disky morphologies could be due to the outflow orientation and the inclination of the disk, which may challenge a possible detection, especially since outflows are expected to be fainter and more compact at the lower accretion rates of our objects [5]. We could also missidentify filamentary structures produced by interactions with Bubble-like morphologies that would not be associated with kinematic outflows.

Finally, when comparing the soft X-ray data with the Hα morphologies, we detected a correlation of both emissions for 60% of the sample. This suggests that the ionised gas and the soft X-ray emissions are correlated, as previously found for Seyferts [1], and already suggested by [14] to also occur in LINERs. We did not find any correlation about the existence of an outflow and a coincidence with the X-ray emission.

4 Conclusions

In this work, we have obtained imaging data for 70 nearby LINERs to study their ionised gas morphologies as traced by Hα. We classified them in four different categories depending on the overall shape: Core-halo, Disky, Bubble-like and Dusty (see Sect. 2). We found that the category with the largest percentage of targets is Bubble-like ($\sim$32%).

In order to confirm if the detected ionised gas emission was caused by an outflow, we searched for kinematical information in the literature for all the targets. We found data for 60 objects, from which 29 (48%) had a reported kinematical detection of an outflow or an inflow. This results imply that the detection rate of outflows in LINERs in the local Universe is approximately 1 out of every 2 objects. As there is no kinematical information for all our targets, these percentages may slightly vary. For better understanding the physical processes in these outflows, we are exploring the kinematics of the ionised gas for our best candidates using integral field spectroscopic data (see [4]).

Finally, we detected a correlation between the soft X-ray emission and the ionised gas for 60% of the LINERs. Such a co-spatiality points towards a common origin for both emissions in LINERs, as already found in Seyferts (see [1, 2]).

Acknowledgments

We acknowledge financial support from the Spanish Ministerio de Ciencia, Innovación y Universidades (MCIU) under the grants AYA2016-76682-C3, PID2019-106027GB-C41 and BES-2017-082471, and from the State Agency for Research of the Spanish MCIU through the 'Centre of Excellence Severo Ochoa' award to the Instituto de Astrofísica de Andalucía (SEV-2017-0709).

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