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Comparing active and non-active galaxies

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Abstract. In order to understand the fueling mechanism that powers low level AGNs, a large effort was made by the DEGAS consortium to collect the necessary observational material for a sample of isolated Seyferts and a well matched control sample of normal spirals. Based on the analysis of their NIR images, on long slit spectroscopy at various slit position angles in the Hα emission and Calcium triplet absorption lines we conclude that: (a) the morphology and large scale kinematics of Seyfert hosts and normal spirals are equivalent; (b) the differences claimed to be related to the mechanisms driving AGN activity may only be found in details related to circumnuclear regions still unresolved by our observations; (c) the presence of drops in the stellar velocity dispersions seems related to the existence of a central elongated structure, probably an inner disk, where the CaT equivalent width also reaches a maximum. We have started a project to study a much larger sample of AGN and normal host spirals with better spatial and spectral resolutions to see whether inner disks, velocity drops and young stellar populations are related phenomena, as suggested by present day numerical simulations. Optical and NIR HST images of all these galaxies have already been analyzed, and the spectroscopic data is being collected.

Key words. Galaxies – Nuclear Activity – Spirals

1. Introduction

Non-axisymmetric components of the galactic potential have frequently been invoked as an efficient way to transport gas to the center to fuel the active galactic nucleus (AGN). Interactions and merging naturally provide such non-axisymmetrical components, and have been shown to be related to the high power nuclear activity in quasars. For low level AGN activity, galactic bars appear as an attractive mechanism to make the gas lose angular momentum and facilitate the fueling mechanism. Bars are elongated, rigid, dynamically stable structures found in at least two thirds of spirals. They help to stabilize the disk by producing disk heating, trigger the formation of spiral arms and give rise to flat metallicity gradients. Bars are easily formed in minor mergers, and also provide the mechanism to transport material to the center in the early stages of some major mergers. They produce net inflows of material toward the center which induce efficient star forming processes and may also provide the fuel to feed the AGN activity. Nevertheless, a direct connection with AGN activity is not straightforward to derive since

⋆ The results presented in this contribution come from the work done in collaboration with the members of the DEGAS consortium (F. Durret, R.M. González Delgado, J. Masegosa, J. Maza, M. Moles, E. Pérez and M. Roth) and the RENOIR consortium (C. Boisson, F. Durret, M. Joly, J. Masegosa and M. Moles).

the percentage of barred galaxies among those hosting AGNs seems to be indistinguishable from that of non-active ones (see for instance (1995), (1995), (1997), (1999), (1997); note that (2000), (2002) and (2004) conclude that Seyfert spirals are only marginally more frequently barred than non-Seyferts).

In order to understand the fueling mechanism for low power AGNs, a large effort has been done by the DEGAS (Dynamics and nuclear Engine of Galaxies of Spiral type) consortium to collect the necessary observational material. We defined a Seyfert sample which is not contaminated by interacting galaxies and a control sample made of normal spirals with the same properties than the Seyfert sample, i.e. luminosity and redshift distribution, morphology and percentage of bars. All the galaxies are isolated with the following criteria: not having a companion within 0.4Mpc and cz< 500 km/s. In total we have analyzed a sample of 17 active galaxies and 16 normal spirals.

2. Morphology

The analysis of their NIR morphologies (Márquez et al. 1999 and 2000) have shown that there seem not to exist a clear distinction between AGN and normal spirals. Their disk and bulge structural parameters show the same properties; bar characteristics are similar in both types of objects. The only difference, if any, has to be found in the very central colours (down to a few cent central parsecs). The AGNs seem to be redder than normal spirals, probably due to the contamination of the light from the central engine. Therefore, regarding the hosts of active and not active galaxies, they look similar in all respects.

3. Gaseous & Stellar Kinematics

The other approach we have taken in our analysis has been to study the kinematics of the ionized gas, through the Hα emission, and the stellar component by using the Calcium triplet, CaT. Active and non active spirals define similar Tully-Fisher relations, populating the region occupied by the early type spirals. A pure rotation model fails to account for large scale peculiarities in the rotation curves or small scale deviations indicative of non circular and/or decoupled disks. We cannot identify, however, a kinematical distinction between active and non active galaxies (Márquez et al. 2004).

4. General conclusions from DEGAS

The large scale properties of the spiral galaxies in the DEGAS sample are equivalent in all respects. The differences related to the mechanism driving AGNs have to be searched for in the very central nuclear regions, barely resolved in our observations. Considering the growing evidence that all galaxies above a certain luminosity host central, massive compact objects, our results are fully compatible with the idea that the AGN activity could take place recurrently in a given galaxy and the AGN would be seen when fuel is made available in the most internal regions.

5. Central Velocity Dispersion Drops

To search for such effects in the very central regions of AGNs, the CaT velocity dispersion for the eight galaxies with high spatial and spectral resolution data has been investigated (see Márquez et al. 2003). In four of them we have detected drops in the velocity dispersion of the CaT, together with a hint of such a drop in another galaxy, similar to those reported by Emsellem et al. (2001) using CO IR lines. For all of them their archival HST images have been analyzed to search for the presence of any central structure. In addition to this, we have also considered the inner morphology in nine galaxies with drops reported in the literature. Disk like structures have been detected in 12 out of the total 14 galaxies.

It is very suggestive that these disk structures correspond to a nuclear disk decoupled from the general kinematic of the large scale galactic disk (see Fig. 1). The measure of the CaT equivalent width (CaT EW) shows that in the region where the drop has been detected, a higher CaT EW is measured which supports the idea that these disks have been formed from cold material accreted into a circumnuclear

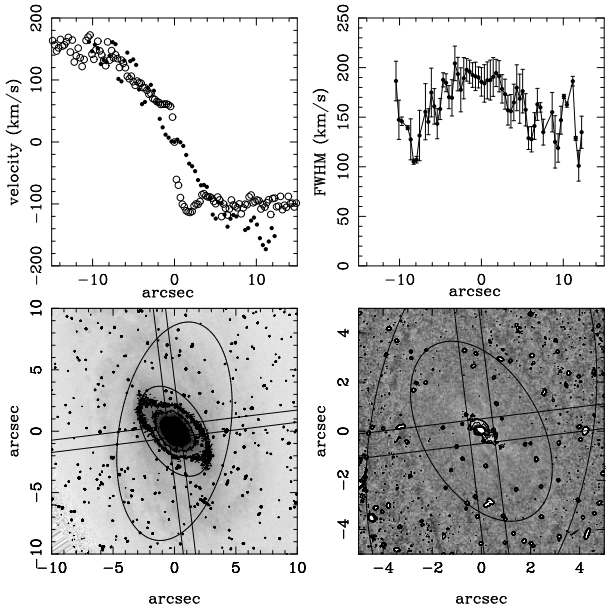

Fig. 1. The example of IC 184. Top left: velocity curve of the gas (open circles) and stars (black circles) along PA=7. Top right: FWHM of the stellar component along PA=7. Bottom left: HST image of IC 184 in the F606W band with the two slits superimposed; the ellipses correspond (PA and ellipticities) to the two bars detected in the infrared (Márquez et al. 1999). Bottom right: sharp divided image of the center. Details can be found in Márquez et al. (2003).

disk which is responsible of the dip in the velocity dispersion. These results seem to agree with the numerical simulations by Wozniak et al. (2003), that predict a young stellar population born from dynamically cold gas accreted to the central region.

6. Closer to the center: RENOIR

To analyze whether inner disks, velocity drops and young stellar populations are related phenomena, and if there is a link with the existence of an active nucleus, and/or with the presence of a bar (most galaxies with a stellar velocity dispersion drop do seem to have a bar) the study of a much larger sample of AGN and normal host spirals with better spatial and spectral resolutions is needed. We have therefore started the program RENOIR, aimed at studying the central regions of active and non-active galaxies in the NIR domain. High spatial resolution images are necessary to look for evidence for a nuclear disk. Besides, both active and non-active galaxy samples with matching morphologies are needed to study the connections with AGN activity. A large sample of 123 active and non-active, barred and non-barred galaxies, fulfilling these requirements has recently been made available by Martini et al. (2003). However, Martini's sample comprises galaxies covering a large range in redshifts, and therefore their physical spatial sampling is quite heterogeneous. To avoid this, we have selected a subsample limited in scale, with similar fraction of the galaxy light included in the 20×20 arcsec HST field and not considering highly inclined objects. These three conditions lead to a total sample of 83 galaxies. We have analyzed the optical (F606W filter) and NIR (F160 filter) HST images of these galaxies and created the corresponding sharp divided images, where central elongations are traced much more clearly (Fig. 2; see also Márquez et al. 1999, 2000).

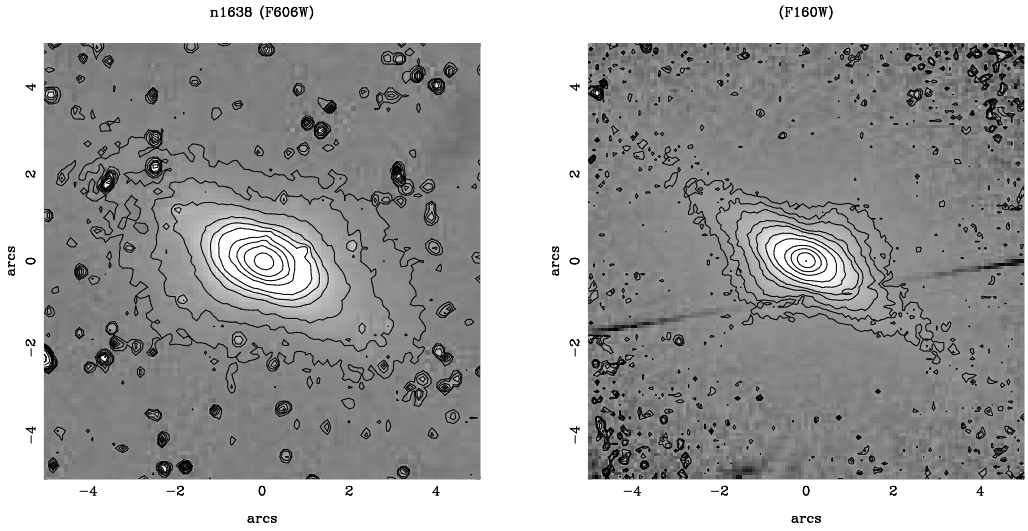

Fig. 2. HST sharp-divided images of NGC 1638 in the F606W (left) and F160W (right) filters, where the presence of a central elongation is clearly evidenced.

We have just started observing these galaxies in the CaT lines. This will provide us with the neccessary data to define a subsample of galaxies with stellar velocity dispersion drops, which we later plan to observe through infrared spectroscopy with 10m-class telescopes in the H band (where the contrast between stellar and non-stellar contribution is maximized, a large variety of stellar types contribute to the continuum and many line ratios are available to make a distinction between stellar populations of different ages and metallicities); better spectral and spatial resolution, higher signal to noise ratio data will then provide a finer database to search for the signature of young stars in these central regions (see e.g. Boisson et al. 2000, 2002), and therefore a robust observational test to validate numerical models. It would reinforce the possible link between a young population, gas accretion and AGN activity.

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