The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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Is the (J-Ks) excess in the nuclear region of NGC 1241 due to dust or to C-stars?

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Abstract. NGC 1241 is a Sy 2 galaxy with a 1.4 kpc circumnuclear ring (CNR) of star formation revealed in Paα. A 0.3 kpc long Paα emitting bar centered on the nucleus is present, apparently without associated absorption features. GEMINI (+QUIRC+Hokupa) IR pixel-photometry reveals instead an azimuthally symmetric $(J - K_s)$ color which is redder at the nucleus than at the CNR. This property may well be due to the increasing importance of dust when going from the ring inward into the nucleus. Nevertheless the $(V - H)$ color does not indicate special absorption conditions in the nucleus with respect to the CNR, and no absorption features are evident, as normally expected near emitting bars. Then, we propose as an alternative explanation an excess of C-stars in the nuclear region which decreases outwards until reaching the CNR and its colors. We have compared the pixel color-magnitude diagram with the 2-MASS $(J - K_s)$ vs. K_s diagram for the Large Magellanic Cloud: about 5×10^2 C-stars and 2.5×10^4 AGB Oxygen-rich stars inside $r \sim 50$ pc, are enough to reproduce the observed nuclear tip in the diagram. This stars would release gas that, gravitationally bounded, pollutes the nuclear environment and could amount 10^{-2} to 10^{-1} M$_\odot$ yr^{-1} of fuel for the central engine during the lifetime of stars with masses $2\,M_\odot < M_{CStars} < 6\,M_\odot$. This scenario may also explain the observed increased strength of the CN-bands in the stellar populations of Sy 2 nuclei, and the recent claim of a significant contribution of intermediate age stars to the optical continuum of low luminosity AGNs.

1. Introduction

Circumnuclear structures as well as the kinematics and perturbing patterns at hundred parsecs scale, were studied in the interacting Sy galaxy NGC 1241 by Díaz et al. (2003).

In this paper we use the Gemini and HST imagery to investigate further the 2D and radial light distribution in Paα, K_s, J, H and V bands. Standard data reduction procedures were applied to images, and the achieved full width at half maximum (FWHM) of the Gemini+Hokupa'a optic system was FWHM$\sim$ 0.3". The image quality was good enough to be compared with HST NIC3 (Paα) data, which have 0.2"-0.3" resolution. HST H and V data have FWHM$<$ 0.1", but all the images were gaussian filtered to match the poorest resolution (FWHM$\sim$ 0.3").

One goal of the present work is to develop methods that could allow to quickly evaluate the stellar contribution and reddening effects in galactic nuclei far enough to have their stars not resolved but with a resolved circumnuclear structure.

2. Preliminary Results and Discussion

The Paα image shows intense star formation at the nucleus and CNR (Díaz et al. 2003). Nevertheless their star formation does not show dust in the form of lanes and patches (Regan & Mulchaey 1999). So, if dust is present it has to be uniformly distributed along the studied region. Regan & Mulchaey (1999) interpreted that the CNR $(V-H)$ is redder to the SW of the line of nodes because it is the nearest side of the disk. The $V-H$ integrated radial profile, shows that the nucleus is redder than the farther ring side and bluer than the nearest one.

On the other hand, the $(J-K_s)$ integrated radial profile shows that both ring sides present a uniform color $(J-K_s) \simeq 0.8$ mag, while the nucleus has $(J-K_s) \geqslant 1.1$ mag. Since the behavior of the nuclear $(J-K_s)$ with regard to the SE and NW sides of the ring is distinct from that of the $(V-H)$ color, we infer that the nuclear $(J-K_s)$ color excess has a distinct origin than the $(V-H)$ one. We propose that the nuclear $(J-K_s)$ color excess is due to C-stars.

We constructed a 0.1" pixel color-magnitude diagram for the central 2 kpc of NGC 1241. We compared this diagram with the 2-MASS integrated $(J-K_s)$ vs. K_s diagram for the Large Magellanic Cloud, by Nikolaev & Weinberg (2000). We found that:

1) If the stellar population at the nucleus is similar to that of the LMC, the pixel colors and magnitudes would be achieved by the contribution of about 40 carbon (C-) stars –zone J in the color magnitude diagram of Nikolaev & Weinberg (2000)– homogeneously distributed, together with more than 2500 asymptotic giant branch oxygen rich (AGBO-) stars –zones E and F– in each pixel, which would be necessary to reproduce the observed tip towards redder colors at the nucleus. This values imply about 5×10^2 C-stars and 2.5×10^4 AGB Oxygen-rich stars inside $r \sim 50$ pc.

2) The same diagram suggests bluer colors towards the CNR and the surrounding external regions, which could be explained by a subjacent population of 30 disk dwarf and early AGB stars per pixel, which is of the order of 1 disk star -of zone D in the color magnitude diagram of Nikolaev & Weinberg (2000) - per 10 square pcs.

3) Both plots show that the CNR is reddened, probably by the presence of significant amounts of dust arisen in the star forming regions.

C-stars and AGBO stars evolve rapidly ($\tau < 3 \times 10^4$ yr) and eject considerable amounts of gas with velocities low enough ($V_{gas} < 100\,\mathrm{km\,s^{-1}}$) to be trapped by the gravitational potential barrier of the central mass concentration ($M_{kep} \sim 10^9\,\mathrm{M_\odot}$, $r < 300$ pc; Díaz et al. 2003). The 5×10^2 C-stars and 2.5×10^4 AGB Oxygen-rich stars inside $r \sim 50$ pc would release gas that, gravitationally bounded, could amount 10^{-2} to $10^{-1}\,\mathrm{M_\odot\,yr^{-1}}$ of fuel for the central engine during the lifetime of stars with masses $2\,\mathrm{M_\odot} < M_{CStars} < 6\,\mathrm{M_\odot}$. Therefore the red giant stars could provide an important fraction of the material that must be provided to the Sy 2 nucleus at this evolutionary phase coeval with the C-stars originated in the circumnuclear star formation. This scenario may also explain the systematically observed increased strength of the optical (cyanogen) CN-bands in the stellar populations of Sy 2 nuclei (e.g. Gu et al. 2001), and the significant contribution of intermediate age stars to the optical continuum of low luminosity AGNs (Gonzalez Delgado et al., this symposium).

References

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