The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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AGNs vs. circumnuclear rings

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Abstract. We have analyzed the frequency and properties of the nuclear activity in two samples of galaxies, with and without circumnuclear rings and spirals (CNRs). We discuss the relevance of the results in the framework of the AGN feeding processes and some results are: (i) bright companion galaxies seem not to be important for the appearance of CNRs, therefore these would be more related to intrinsic properties of the host galaxies or to minor merger processes; (ii) the proportion of strong bars in AGN galaxies with a CNR is higher than the expected rate of strongly barred AGN galaxies from the sample of Ho and co-workers; (iii) the incidence of Seyfert activity coeval with CNRs is clearly larger than the expected rate from the morphological distribution of the host galaxies; (iv) the rate of Sy 2 to Sy 1 in galaxies with CNRs is larger than the expected proportion for galaxies without CNRs; this proportion would be in the opposite sense as expected from the geometric paradigm of the classical unified model for AGNs, but supports a scenario where Sy 2 activity is linked to circumnuclear star formation.

Introduction. It has been claimed that bars and rings are more prevalent in active and starburst galaxies than in otherwise normal objects and, in particular, some studies have yielded evidence that Seyferts have a preference for barred systems with inner or outer rings (Simkin et al. 1980, Arsenault 1989, Hunt & Malkan 1999). Notwithstanding, the subject is still controversial, bars seem to contribute significantly to circumnuclear star formation, but without an evident relation with nuclear "non-stellar" activity (Ho et al. 1997). This situation compelled us to systematically search for the presence of nuclear activity in galaxies with circumnuclear rings or ring-like nuclear spirals (hereafter CNR galaxies) and statistically compare the nuclear activity appearing in galaxies of similar global properties, with and without these structures.

Catalog and Analysis. A list of 81 galaxies with CNRs was compiled, from Buta & Crocker (1993) Catalog and 8 from different authors. The activity type of the objects was obtained from the catalogs of Véron-Cetty & Véron (1998) and Ho et al. (1997). 60 out of the 81 CNR galaxies are included in Tully's (1988) "Catalog of Nearby Galaxies". In order to asses the possible correlations we made a list of comparison objects, each one selected as the best match in Tully's (1988) Catalog under the following criteria: (i) the departure in B absolute magnitude from the CNR galaxy must be $\Delta M_B < 0.3$; (ii) the difference in corrected apparent sizes must be $\Delta D_{25} < 0.2\, D_{25}^{CNR}$; (iii) the difference in projected real sizes must be $\Delta R_{25}(kpc) < 0.4\, R_{25}^{CNR}(kpc)$; (iv) the departure in inclination must be $\Delta i < 9^o$; (v) the departure in morphological type numerical code must be $\Delta T \leqslant 2$. Then, 60 comparison galaxies were found without trace of CNRs according to the visual inspection in the Digital Sky Survey 2 and the 2MASS archives.

Environment & Strong Bars. The local density of bright galaxies around each object (CNR or comparison galaxy), taken from Tully's (1988) Catalog, shows that, within the uncertainties, there is no marked environmental effect associated to the phenomenon of circumnuclear star formation in disk galaxies. In order to study the proportion of strongly barred systems (classified as SB in the RC3 Catalog, de Vaucouleurs et al.

1991), we arranged the data with the same morphological type grouping that used Ho et al. (1997) in their complete sample of spiral galaxies (which excludes the category S0/lenticular objects): 21 of 55 CNR galaxies have strong bars, compared with 13/55 predicted using Ho and co-workers results, 13 of 30 AGN+CNR galaxies have strong bars, compared with 6/30 expected.

AGN incidence. 26 of the 81 objects ($\sim 1/3$) are Sy 1 or Sy 2 galaxies, being this percentage unusually high. Considering the analysis of Woltjer (1990) from the objects of Revised Shapley-Ames Catalog -using the catalog of Véron-Cetty & Véron (1998)- we weighted the expected AGN incidence for the distribution of morphological types in our sample. The predicted percentage for the comparison sample was 8%, which is close to the proportion (6 of 60) of Sy 1 and Sy 2 objects in the comparison sample. For the 60 objects with CNR and comparison galaxy, the value is still clearly over the expected rate, with 24 Seyfert nuclei instead of the expected 6. The high AGN rate could be ascribed to a strong AGN selection effect, nevertheless most of the objects with CNR were discovered by morphological searches (see Buta & Crocker 1993). Therein the correlation reported here must have statistical significance and presents an important restriction to the models that describe the fuelling of both types of activity, AGN like nuclei and circumnuclear star formation.

Activity types. The proportion of Sy 2 to Sy 1+1.5 is 3:1, instead of the expected rate for the distribution of morphological types in the sample, which should be around 1:1 (considering Table 5 in Woltjer 1990). This result has some statistical significance (26 Seyfert galaxies in the whole sample). This high Sy 2 to Sy 1 ratio is not affordable by the classical unified model of AGNs, because inclination of the host galaxy should have an important role in this scenario: we note here that there is an important bias towards face on CNR hosts, so the observed incidence of Sy 2's is in the opposite sense of what could be expected. In any case, the absence of correlation between galaxy inclination and AGN orientation (e.g. Kinney et al. 2000) would impose important restrictions in the way the gas is funnelled to the central engine in spiral galaxies.

Our results are in accordance with the observations of Malkan et al. (1998), who determined that the appearance of circumnuclear filamentary dust is more related with Sy 2 objects. Furthermore, the intense star formation that happens in most of the CNRs, could provide the ambient dust that in some way, still not very defined, affects the generally accepted obscuring of a Sy 1 nucleus needed to be observed as a Sy 2. These new results could help to understand the parallelism and co-evolution of these phenomena.

References

Arsenault, R. 1989, A&A, 217, 66
Buta, R., & Crocker, D. 1993, AJ, 105, 1344
De Vaucouleurs, G., De Vaucouleurs, A., Corwin, H., Buta, R., Paturel, G., & Fouque, R. 1991, Third Reference Catalog of Bright Galaxies. New York: Springer (RC3)
Ho, L., Filippenko, V., & Sargent, W. 1997, ApJ, 487, 568
Hunt, L. K., & Malkan, M. A. 1999, ApJ, 487, 568
Kinney, A., Schmitt, H., Clarke, C., Pringle, J., Ulvestad, J., & Antonucci, R. 2000, ApJ, 537, 152
Malkan, M., Gorjian, V., & Tam, R. 1998, ApJS, 117, 25
Simkin, S., Su, H., & Schwarz, M. 1980, ApJ, 237, 404
Tully, R., 1998, Nearby Galaxies Catalog, Cambridge University Press
Véron-Cetty, M., & Véron, P. 1998, A Catalogue of Quasars and Active Nuclei, 8th Ed
Woltjer, L. 1990, in Active Galactic Nuclei, eds. Courvoisier T., Mayor M., Springer-Verlag, Table 5