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AMIGA project: Active galaxies in a complete sample of isolated galaxies.

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Abstract. The project AMIGA (Analysis of the interstellar Medium of Isolated GAlaxies) provides a statistically significant sample of the most isolated galaxies in the northern sky. Such a control sample is necessary to understand the role of the environment in evolution and galaxy properties like the interstellar medium (ISM), star formation and nuclear activity. The data is publicly released under a VO interface at http://amiga.iaa.es/. One of our main goals is the study of nuclear activity in non-interacting galaxies using different methods. We focus on the well known radiocontinuum-far infrared (FIR) correlation in order to find radio-excess galaxies which are candidates to host an active galactic nucleus (AGN) and FIR colours to find obscured AGN candidates. We looked for the existing information on nuclear activity in the Véron-Cetty catalogue and in the NASA Extragalactic Database (NED). We also used the nuclear spectra from the Sloan Digital Sky Survey which allow us to determine the possible presence of an AGN and to study the properties of the underlying stellar populations. We produced a final catalogue of AGN-candidate galaxies which will provide a baseline for the study of the nuclear activity depending on the environment. We find that the fraction of FIR selected AGN-candidates ranges between 7% and 20%. There are no radio-excess galaxies in our sample above a factor 5 of radio excess which is the lowest rate found in comparison with other samples in denser environments. Finally, we obtained a fraction of about 22% of AGN using the optical spectra, a significant fraction for a sample of isolated galaxies. We conclude that the environment plays a crucial and direct role in triggering radio nuclear activity and not only via the density-morphology or the density-luminosity relations.

1. Introduction

Galaxy evolution depends strongly on the environment. In particular, galaxy-galaxy interactions can induce nuclear activity by removing angular momentum from the gas and, in this way, feeding the central black hole. Hence, a higher rate of nuclear activity would be expected in interacting galaxies. However, different studies of this topic lead to contradictory results. In order to understand the role of the environment in the nuclear activity we need a statistically significant sample of isolated galaxies which will act as the baseline for this study. The study was developed in the frame of the AMIGA project (for a detailed description of AMIGA see the contribution of J. Sulentic in this proceedings).

2. Selection of active galaxies

We applied a completeness test known as $< V/V_m >$ as explained in Verdes-Montenegro et al. (2005) and Lisenfeld et al. (2007) to the AMIGA isolated galaxies obtaining a complete subsample which contains 710 galaxies. This sample constitute the base for our statistical studies.

We made a catalogue of AGN candidates of isolated galaxies looking for data in the literature and using three selection methods: FIR colour, radiocontinuum-FIR correlation radio-excess and based on the optical spectra (Sabater et al. 2008; Sabater PhD 2009).

We did a cross-correlation of our sample with: a) The NED (NASA Extragalactic Database) database: 77 galaxies found, 22 of them AGN and b) Véron-Cetty & Véron active galaxies catalogue (12th edition): 25 galaxies found, 18 of them AGN.

In the work of de Grijp et al. (1985) is shown a method to identify AGN candidates using FIR properties. Galaxies hosting an AGN have, in general, a flatter spectrum in FIR. The advantage of this method is that it can find obscured AGN that cannot be observed using other wavelengths or methods. The success rate of the method is about 70%. We select the galaxies with an spectral index between $25\mu m$ and $60\mu m$ of $\alpha_{25,60} > -1.958$. There are 58 AGN candidates which amounts to 7% of the sample or 20% of the galaxies classified with this method.

The correlation between the FIR and the radio continuum emission is very tight and is attributed to star formation. (Condon et al. 1991). Deviation from this correlation may be produced by a radio-loud active nucleus. If the additional emission from the active nucleus is strong enough, an excess of radio emission will be found with respect to the radio-FIR correlation. Radio-excess galaxies are the ones whose radio luminosity is larger than 5 times the value predicted by the radio-FIR correlation (Yun et al. 2001). There are 7 radio-excess galaxies in the complete sample which amount $\sim 1\%$ of the sample. This is a very low rate. There is a chance that the radio excess found using the NVSS data is in fact due to a background/foreground source projected in the line of sight of the galaxy. We estimated that 14 of the radio detections in our sample could be due to unrelated sources. In order to determine which sources were genuine detections and which not we obtained high resolution VLA radio continuum images of the radio-excess galaxies. Finally, we found that all the radio emission excess in the radio-excess sources was produced by unrelated sources. This leads to a final rate of radio-excess galaxies of 0%.

We also used the nuclear spectra from the Sloan Digital Sky Survey. There are 353 spectra of AMIGA galaxies in the 6th Data Release. We obtained the underlying stellar populations using the Starlight code. Subtracting the estimated emission from the stellar populations we obtained the nebular emission and determined the presence of an AGN, star formation or a transition object (TO; with properties in between the former two types) using the typical diagnostic diagrams. We also determined the type of AGN when possible. Only $\sim 7\%$ lack of emission lines, $\sim 56\%$ are classified as star forming, $\sim 16\%$ as TOs and $\sim 22\%$ as AGN. This is a significant fraction for a sample of isolated galaxies.

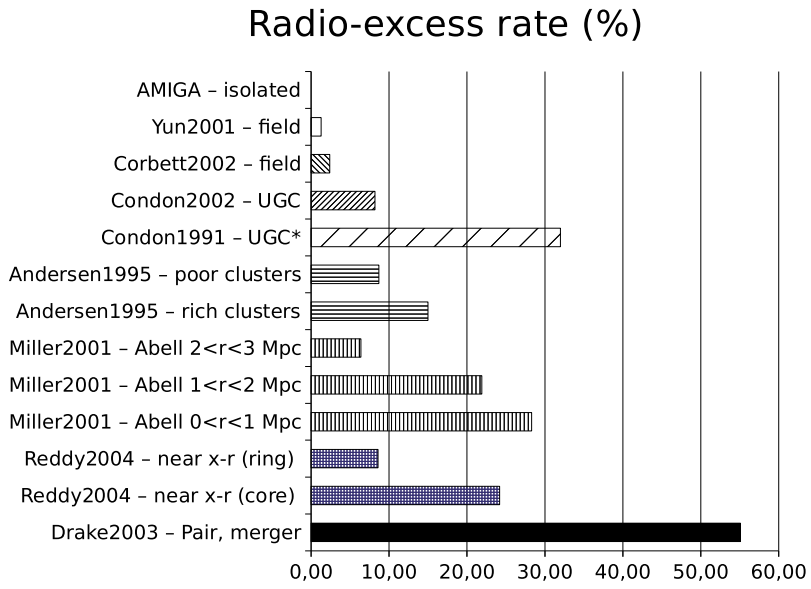

Figure 1. Percentage of galaxies above a factor 5 of radio excess in the comparison samples. Notice that the percentage for the AMIGA sample is 0%.

3. Comparison with denser environments

We compared the radio-excess rate with other samples in denser environments: those referred to as field galaxies in the literature (e.g., Condon & Broderick 1991; Yun et al. 2001; Corbett et al. 2002; Condon et al. 2002; Drake et al. 2003) where usually no environmental selection criterion has been applied, and cluster samples (e.g., Andersen & Owen 1995; Miller & Owen 2001; Reddy & Yun 2004). The results are summarized in Figure 1. We also took into account the possible effect of the luminosity as well a the morphology on the rate of radio-excess galaxies to avoid the biases coming from the morphology-density and luminosity-density relations. We found the same increase of the fraction of radio-excess galaxies toward denser environments independently of the luminosity or the morphology.

We compared the rates of nuclear activity derived from the optical spectra with the ones found by Martinez PhD (2008) for two samples of galaxies in compact groups (CG). The reduction of the data and the measurement method were very similar. The results are summarized in Table 1. We will take into account the morphology and luminosity of galaxies in a future to avoid possible biases.

Table 1. Fraction of the different types of AMIGA galaxies and compact groups galaxies from Martinez PhD (2008). Fractions given in percentages with respect to the total number of galaxies.

Sample	AMIGA	Hickson CG	UZC-CG
Non-emission:	7.1	37.5	31.0
Emission:	92.9	62.5	69.0
SF	55.8	20.1	20.9
TO	15.5	13.4	12.6
AGN	21.7	29.0	35.5

4. Conclusions

We produced a final catalogue of AGN-candidate galaxies which will provide a baseline for the study of the nuclear activity depending on the environment. We find that the fraction of FIR selected AGN-candidates ranges between 7% and 20%. There are no radio-excess galaxies in our sample above a factor 5 of radio excess which is the lowest rate found in comparison with other samples in denser environments, independently of the luminosity or the morphology. Finally, we obtained a fraction of about 22% of AGN using the optical spectra, a significant fraction for a sample of isolated galaxies.

We conclude that the environment plays a crucial and direct role in triggering radio nuclear activity and not only via the density-morphology or the density-luminosity relations.

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References

Andersen, V. & Owen, F. 1995, AJ, 109, 1582
Condon, J., Anderson, M. & Helou, G. 1991, ApJ, 376, 95
Condon, J. & Broderick, J. 1991, AJ, 102, 1663
Condon, J., Cotton, W. & Broderick, J. 2002, AJ, 124, 675
Corbett, E. et al. 2002, ApJ, 564, 650
Drake, C. et al. 2003, AJ, 126, 2237
de Grijp, M. H. K. et al. 1985, Nature, 314, 240
Karachentseva V. 1973, AIISAO, 8, 3
Lisenfeld, U., et al. 2007, A&A, 462, 507
Martinez, M. A. 2008, PhD thesis, IAA-CSIC
Miller, N. & Owen, F. 2001, AJ, 121, 1903
Reddy, N. & Yun, M. 2004, ApJ, 650, 695
Sabater, J., et al. 2008, A&A, 486, 73
Sabater, J. 2009, PhD thesis, IAA-CSIC
Sulentic et al. 2006, A&A, 449, 937
Verdes-Montenegro L. et al. 2005, A&A, 436, 443
Yun, M., Reddy, N., & Condon, J. 2001, ApJ, 554, 803