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The Environment of Active Galaxies in the SDSS DR2

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Abstract. The environment of active galaxies in the redshift range $0.05 \leq z \leq 0.15$ is here analyzed using the Second Data Release (DR2) of the Sloan Digital Sky Survey (SDSS). Active galaxies are divided into Active Galactic Nuclei (AGN) and Starburst Galaxies (SFGs) by means of their emission lines ratios. AGN are further classified as Seyfert-1 and Seyfert-2 galaxies according to their emission lines widths. Environmental properties are defined by means of a density parameter and the number of companions, and they are compared for the different types of galaxies. We find that Seyfert-2 galaxies are in a denser environment than Seyfert-1 galaxies: these properties are more similar to those found for SFGs.

Key words. Galaxy: active – Galaxy: starburst – Galaxy: environment

1. Introduction

Thanks to the data provided by large surveys such as the 2dF Galaxy Redshift Survey (Colless et al. 2000) and the Sloan Digital Sky Survey (York et al. 2000), it is now possible to study the galaxy environment for statistically meaningful samples. The influence of the environment on galaxy parameters such as morphology and star formation rate is widely accepted (see Dressler 1980, Hashimoto et al. 1998, Miller et al. 2003), whereas the situation is less clear for Active Galactic Nuclei (AGN). Here we explore the relation between galaxy activity and environment in a complete sample of 143,159 galaxies from the SDSS-DR2, in the redshift range $0.05 \leq z \leq 0.15$.

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Three types of galaxies were defined: 38,859 Passive Galaxies (PGs) with no detectable emission lines, 1,486 (1%) AGN and 36,663 (∼ 26%) SFGs. AGN and SFGs have been selected according to the theoretical line-ratio models proposed by Kewley et al. 2001. AGN have been then classified as Seyfert-1 and Seyfert-2 on the basis of the presence of a significant broad component for the emission Balmer lines, compared to the width of [OIII]λ5007. As a result, the AGN sample is composed of 307 Sy1 (∼ 21%) and 1,179 Sy2 (∼ 79%), implying a ratio 3.8:1 between Sy2 and Sy1, in agreement with what expected from the *Unified Model*.

The density parameter is defined as:

$$\Sigma = \frac{N_{neigh}}{\pi r_{\max}^2} \quad (1)$$

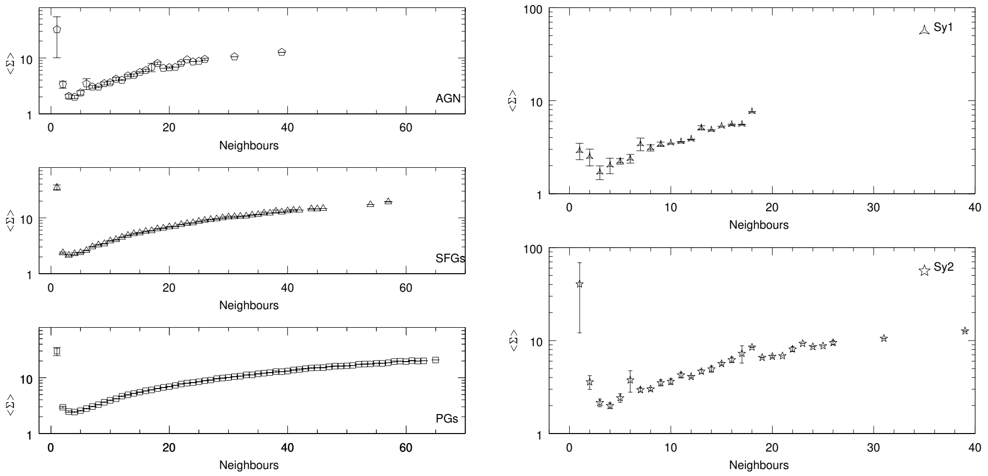

Fig. 2. Density parameter vs. the number of neighbours.

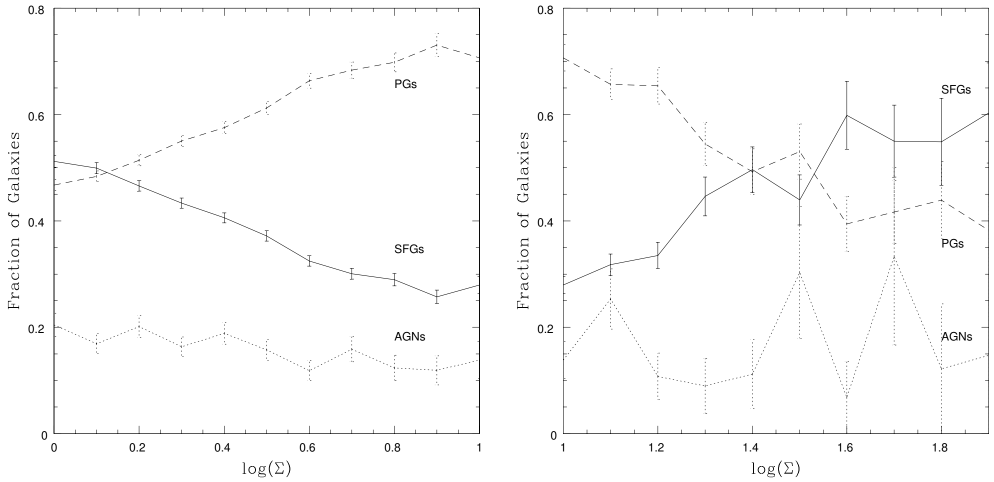

Fig. 3. Fraction of galaxies vs. density parameter.

where N_{neigh} is the number of neighbours, $r_{\max}$ is the separation between a galaxy and its most distant neighbour.

2. Discussion

When we analyze the environmental properties for the AGN sample we find a difference in the environment of Sy1 and Sy2 galaxies on a scale of 1 Mpc (H_0 = 75 km s^{-1} Mpc^{-1}). In fact, Sy2 are found in denser ($\langle\Sigma\rangle \sim 40$) systems compared to Sy1 ($\langle\Sigma\rangle \sim 3$); if we analyze the percentage of galaxies as a function of log(Σ) (Fig. 3), we find for *log* (Σ) $\leq$1 a decrease in the fraction of SFGs and an increase in the fraction of PGs. These relations are analogous to the SFR-density relation of (Gómez et al. 2003) and to the morphology-density relation of (Dressler 1980), and are also in agreement with those from (Miller et al. 2003). For

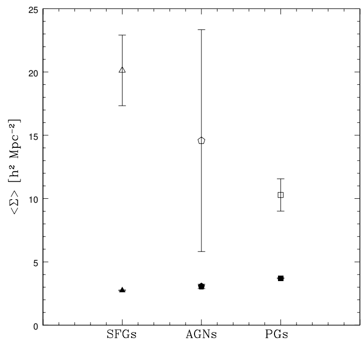

Fig. 1. Average density parameter ($\langle\Sigma\rangle$) for Star Forming Galaxies, Active Galactic Nuclei and Passive Galaxies. Empty and filled symbols show the values obtained with and without pair systems respectively.

values of $\log(\Sigma) > 1$ we find an opposite result: in denser environments the fraction of SFGs increases and the fraction of PGs decreases. We attribute this behaviour to the fact that small systems ($N_{neigh} < 4$) are more frequent in SFGs (Sorrentino et al. 2003), (Nikolic et al. 2004). In fact, without pair systems (Fig. 1), the average density parameter for SFGs ($\langle\Sigma\rangle \sim 2.7$) is comparable with the value found for PGs ($\langle\Sigma\rangle \sim 3.7$) and AGN ($\langle\Sigma\rangle \sim 3.1$). As in (Miller et al. 2003), we find a costant fraction of AGN for different values of $\log(\Sigma)$.

3. Conclusions

1. The ratio between Sy2 and Sy1 galaxies is 3.8:1, in agreement with what expected from the Unified Model. This ratio is the same when we consider either the whole sample or only isolated and paired galaxies.
2. PGs are found in environments richer ($N_{neigh} \leq 65$) than both SFGs ($N_{neigh} \leq 58$) and AGN ($N_{neigh} \leq 39$) (Fig. 2).
3. For pair systems, the mean density parameter $\langle\Sigma\rangle$ is higher for SFGs ($\langle\Sigma\rangle \sim 51$) than AGN ($\langle\Sigma\rangle \sim 30$) and PGs ($\langle\Sigma\rangle \sim 30$). This result indicates that there are closer pairs in SFGs than in AGN and PGs. In fact, if we don't consider pair systems, the mean density parameter is similar for all the samples ($\langle\Sigma\rangle \sim 2.7$ for SFGs; $\langle\Sigma\rangle \sim 3.1$ for AGN; $\langle\Sigma\rangle \sim 3.7$ for PGs).
4. Sy2 galaxies are found in denser ($\langle\Sigma\rangle \sim 17$) environments than Sy1 ($\langle\Sigma\rangle \sim 3$). For pair systems only, the average density is $\langle\Sigma\rangle \sim 40$ for Sy2 and $\langle\Sigma\rangle \sim 3$ for Sy1.
5. We do not find any evidence for a difference in the number of neighbour galaxies in Sy1 compared to Sy2 galaxies. The fact that pairs in Sy2 galaxies are denser than in Sy1 galaxies implies that they are closer systems.

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