Active and star-forming galactic nuclei in WINGS

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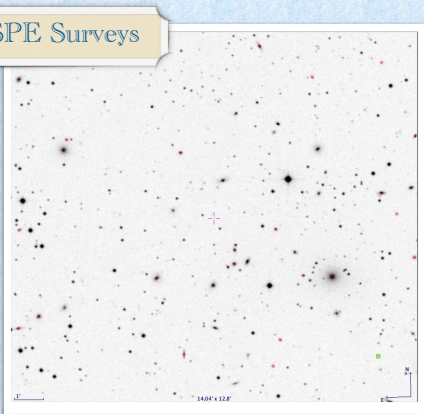
ABSTRACT

We analyzed the spectra collected under the wide-field nearby galaxy clusters survey (WINGS) to reveal emission lines in cluster galaxies. After removing stellar emission with dedicated population synthesis models we found evidence of faint emission line activity in a sizable number of cluster galaxies. Diagnostic diagrams were used to define or at least constrain the origin of the emission line activity. Cross-correlation with radio surveys is also being used for the identification of "true" active nuclei. We report preliminary results on prevalence and basic properties of the active and star forming galaxies we identified.

The WING and WING SPE Surveys

The WIde field Nearby Galaxy Cluster Survey (WINGS) is an imaging and photo metric study of the brightest X-ray clusters at redshift $0.04<z<0.07$ selected from the ROSAT all sky survey (Fasano et al. 2006). Follow up spectrophotometry (WINGS SPE) provided data for 48 of the original 77 clusters at intermediate spectral resolution $\lambda/\delta\lambda \geq 500$ (Cava et al. 2008). While the original aim of the spectroscopic observations was to measure the individual galaxy redshifts and hence to compute the cluster velocity dispersion, the wide spectral coverage makes it possible studies of the dominant stellar populations (Fritz et al. 2011) as well as of the ionized gas content of each galaxy.

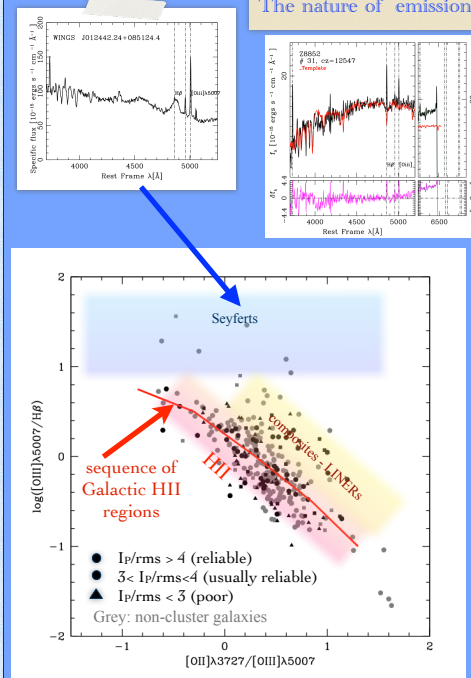


Abell 376, a cluster belonging to WINGS. The red diamonds indicate the galaxies observed in the spectroscopic survey. 88 objects were surveyed in the area of this cluster, with 66 of them actually belonging to the cluster.

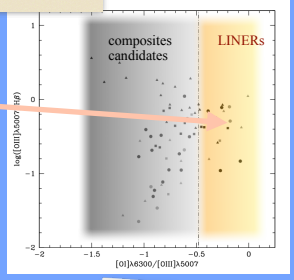
The approach: population synthesis and diagnostic diagrams

We analyzed a subsample of WING SPE that includes 22 clusters with absolute spectrophotometry for a total of 1305 sources. Line covered include [OII]λ3727, Hβ, [OIII] λλ4959,5007, [OI]λ6300 and Hα and [NII]λλ6548,6583 in fewer cases. The relatively high dispersion ($\lambda/\delta\lambda > 500$)) and the fairly good s/n (usually ~10 or higher) allows one to isolate the emission component of the Balmer lines and a reliable study of several lines. The emission component of the Balmer line was obtained subtracting underlying stellar emission computed either by dedicated population synthesis (722 SEDs by Fritz et al. 2011) or by the synthetic spectra provided by Bruzual & Charlot (2003) for the remaining sources. Two diagnostic diagrams (e.g., Baldwin et al. 1981; Dessauges-Zavadsky et al. 2000) are especially well suited to the data (see panel aside). The diagram involving [OII]λ3727/[OIII]λ5007 allows one to identify emitting regions associated to star formation (hereafter HII), and to discriminate in a clear way high-ionization active galactic nuclei (Seyfert 1 and Seyfert 2). The one based on [OI]λ6300/[OIII]λ5007 involves an emission line that is very weak (and should not be detectable with the present data) in HII regions gas, but that is especially prominent in Low-Ionization Nuclear Emitting Regions (LINERs): LINERs are defined also through the condition [OI]λ6300/ [OIII]λ5007>0.33. Our approach has been to start from the [OII] diagram, and then to use the [OI] to further discriminate LINERs/composites from other sources (see panel aside).

The nature of emission line galaxies

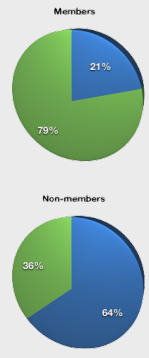


The ratio IP/rms, i.e., peak line intensity IP normalized to local rms is used as a first-order tool to assess each line detection and uncertainty.



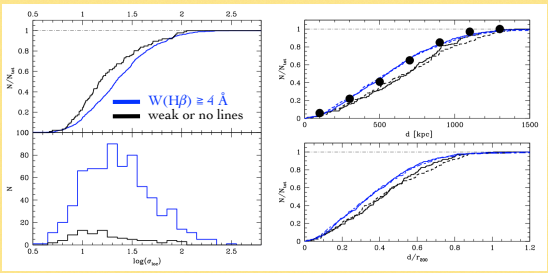
All of the Seyfert candidates do not belong to clusters. The absence of Seyfert candidates among 800 cluster member galaxies is striking. There is a sizeable population of HII sources and LINERs although the prevalence of star forming and low-luminosity AGNs in cluster is lower than in the field, as found in several previous studies (see also bottom left panel). The dependence on local projected density (bottom center panel) is consistent with the one derived by Miller et al. (2003).

A deficit of emission line galaxies



The prevalence of emission-line sources is different among cluster members and non-members. This result holds for the majority of cluster fields if they are considered individually as well as for the whole sample. Non-cluster galaxies could in principle provide a handy control sample since they were observed with the same settings of cluster galaxies. Unfortunately, non-members are usually background galaxies much farther than cluster members (and therefore systematically more luminous: the typical cluster member absolute magnitude is $M_V \approx -18.5$ vs. -20.5 for non-cluster galaxies). Non-members are also more frequently spirals. However, if a restriction to $M_V > -19$ is applied, the difference between the two samples is even larger (pie diagrams aside), and remains very large if ellipticals and spirals are separated.

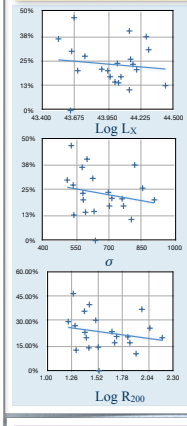
Local density and clustercentric distance



Left panels: the differential (bottom) and cumulative (top) distribution of cluster members with no or weak emission lines and with emission as a function of local projected density [Mpc^{-2}]. The two distributions are significantly different at a confidence level of $P \approx 0.998$, according to a K-S test.

Right panels: the distribution of clustercentric distances as a function of projected linear distance (top) and of distance normalized to virial radius (filled lines: from optical center; dashed lines: from X-ray center). The large spots show the cumulative distribution for spirals (de Vaucouleur's T>0) that agrees better with non-detections. Morphological segregation of spiral member galaxies seems insufficient to explain the lower frequency of emission line galaxies in the innermost cluster region.

Correlations with cluster properties



The fraction of galaxies with lines decreases as a function of the cluster velocity dispersion and virial radius. The correlation coefficients are not significant - but the trends in the figures are consistent with the results of Hwang et al. (2011), and may become significant once the full WING SPE sample is analyzed.

Conclusion

The preliminary results presented here suggest that emission line galaxies are preferentially found outside of the densest regions of clusters, in basic agreement with past studies.

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