Mergen-driven nuclear activity in galaxies

Close environment of AGN in the VISTA-VIDEO survey

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Motivation

In the context of the evolution of galaxies in the Universe, we analyze the statistics of the VISTA-VIDEO dry-run data of the XMM-LSS field, searching for a possible link between mergers and AGN. We select AGN at different wavelengths and compare the local environments of these different AGN populations.

Band	# of objects	Instrument
Z-K_s	151411	VISTA
0.5-2 keV	1049	XMM-Newton
24 μm	3670	Spitzer
1.4 GHz	1103	VLA

~1 deg^2

VISTA-VIDEO, XMM-LSS(tile 3), K_sJY composite image

VISTA
Deep
Extragalactic
Observations
(PI: Matt Jarvis)

Conclusions

We find that AGN selected in radio appear in over-dense environments at the closest radii, implying an excess of close companions. This lends support to a causal connection between merger events and nuclear activity.

X-ray selected AGN show the opposite behavior, implying systems at later evolution stages or systems following a different evolution path.

Main sample

We select our main sample from the VISTA-VIDEO catalog, requiring:

- 5σ detection in the K_s band (<23.45)
- extended structure (no point sources)

The K_s magnitude is a proxy for the stellar mass of the galaxies, hence used for the selection.

From this main sample all other wavelength samples and their control samples are drawn.

Method

Following [a] we cross-identify sources in the main sample with sources in the X-ray ([b]), mid-IR ([c]), and radio ([d]).

In all three wavelengths we expect to select mostly active galaxies (see also Analysis).

We then calculate a "3D" surface density around each AGN within a cylinder of fixed depth Δz=0.2 and varying radius (photometric z available).

Control samples

For each X-ray source we compile a random control group of X-ray non-detected sources within the same redshift and stellar mass range (ΔK_s=0.2). Averaging over the control group gives a control density value for that source. The same procedure is followed for the other wavelength-selected samples.

Figure 1 shows the average density around radio sources as a function of distance, compared to that of its control sample. We present average density ratios around AGN over those of their control samples (Figs. 2-4).

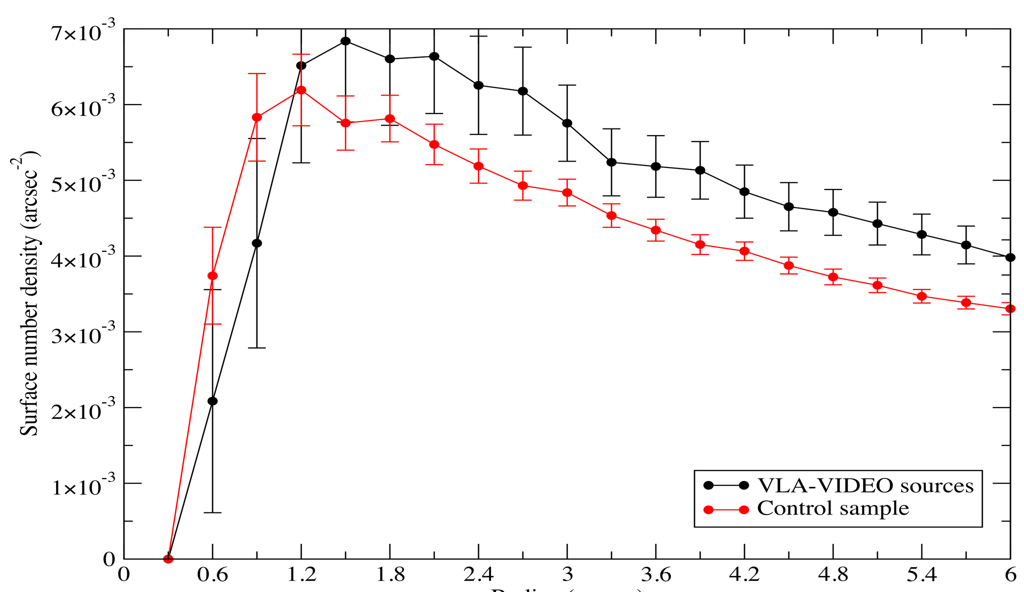

***Fig. 1**: Average surface density as a function of the radius around a source, within which the surface density is calculated for the VLA-VIDEO sources (black) and the control sample (red).*

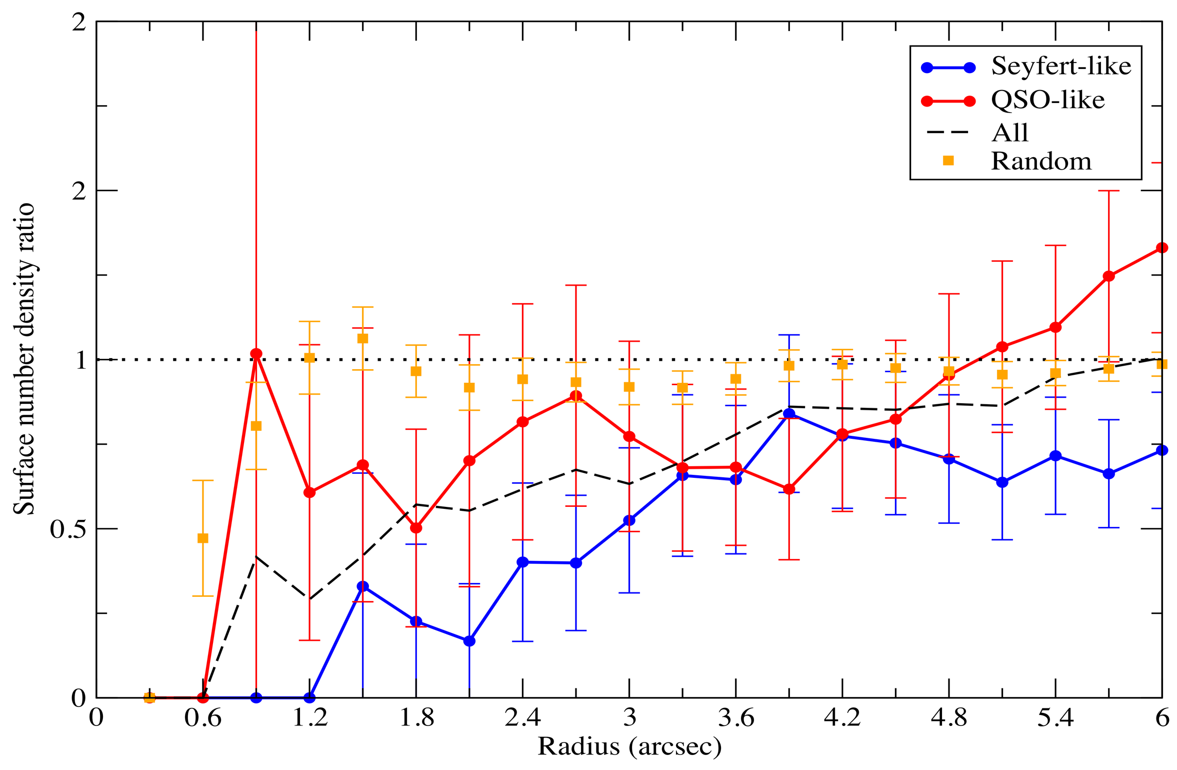

***Fig. 2**: Average surface density difference as a function of the radius around a source for XMM-VIDEO sources. Zero-level density difference line is also plotted (dotted line).*

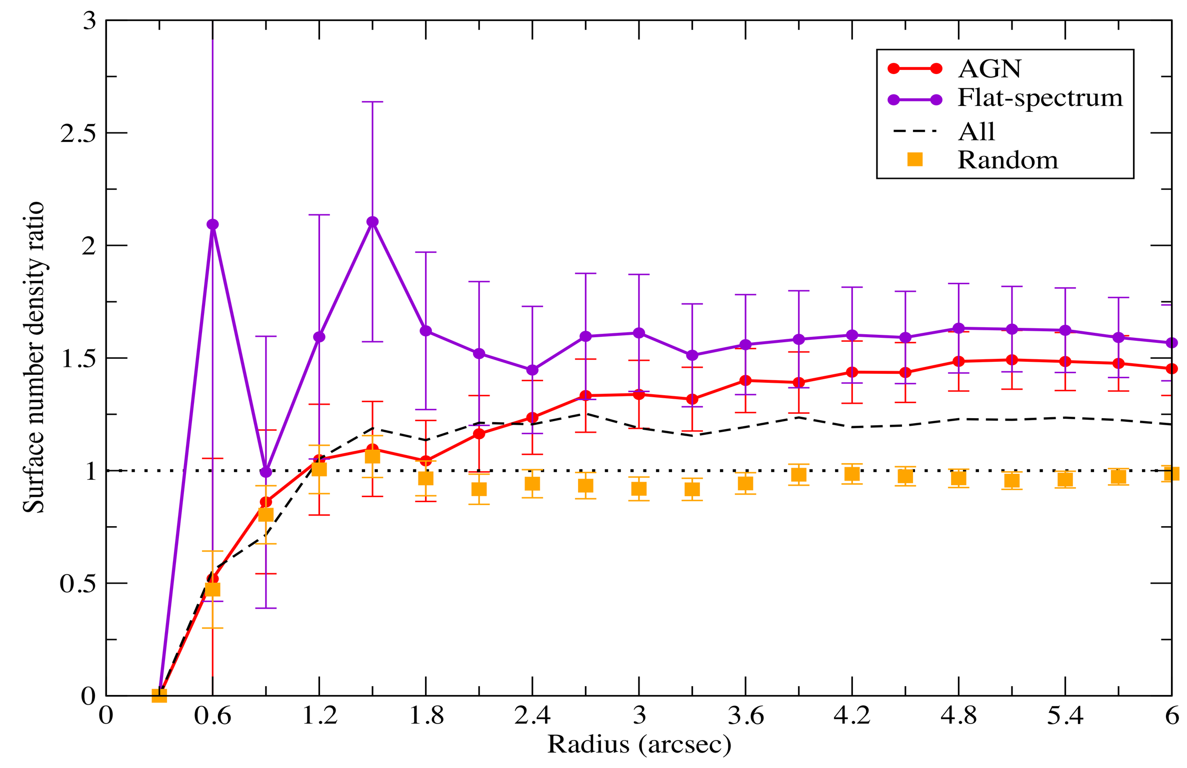

***Fig. 3**: As in Fig. 2 for all VLA-VIDEO sources (black dashed line), AGN (red), starburst sources (blue), flat-spectrum sources (purple), and the randomly selected sample (yellow).*

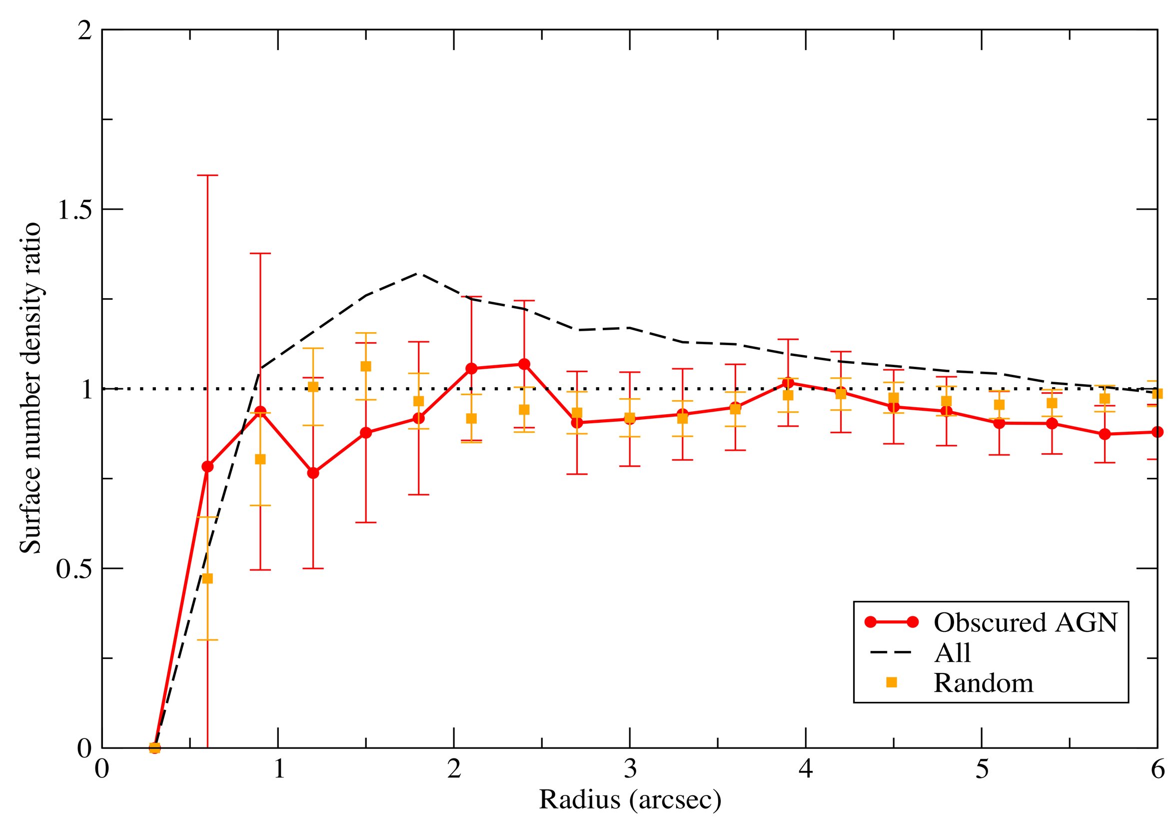

***Fig. 4**: As in Fig. 2 for all 24μm-VIDEO sources (black), 24μm-VIDEO obscured AGN (red), and the random sample (yellow).*

Method 2

We define the surface number density ratio as follows:

$$\rho^r = \frac{d^r_{AGN}}{d^r_c}$$

where d^r_x is the average density of sample x (AGN/control) when calculated within a cylinder of radius r. Uncertainties are calculated through error propagation.

Analysis

We define AGN subsamples in the radio by means of their spectral-index (flat-spectrum; α>-0.5) and luminosity ([e]):

$$L_{AGN,radio} > 5.3 \cdot 10^{21} \nu^{-\alpha} \cdot SFR(M \geqslant 5M_{\odot})$$

In the X-rays, we distinguish between QSO- and Seyfert-like sources through their K_s band to X-ray flux (F_X). QSO-like sources are expected to show SEDs dominated by the X-ray component (i.e., K_s/F_X<2).

At 24μm we use color cuts ([f]) to select obscured AGN. These systems should be associated with merger events.

We also define a sample of randomly selected VIDEO sources (shown in yellow in Figs. 2-4). Their density is consistent with being the same as that of their control sample.

Results

1. X-ray selected VIDEO sources are consistently found to be in under-dense environments (Fig. 2).
2. Radio-selected VIDEO source are found to be under-dense at the smallest radii, but appear over-dense at distances >1.5" (Figs. 1,3).
   a. Flat-spectrum radio-sources are consistently over-dense at all radii.
   b. Radio-AGN appear over-dense at r>2.5".
3. 24μm-VIDEO sources are found in over-dense environments. Obscured AGN however do not show significant deviations from their control sample (Fig. 4).

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References: [a] Downes, A. J. B., Peacock, J. A., Savage, A., & Carrie, D. R., 1986, MNRAS, 218, 31 [b] Pierre,M., Chiappetti, L., Pacaud, F. et al., 2007, MNRAS, 382, 279P, [c] Lonsdale, C., Smith, Harding E., Rowan-Robinson, M. et al., 2003, PASP, 115, 897L, [d] Bondi M, Ciliegi,P., Zamorani, G. et al , 2003, A&A, 403, 857, [e] Condon, J.J., 1992, ARA&A, 30, 575C, [f] Lacy, M., Storrie-Lombardi, L.J., Sajina, A. et al., 2004, ApJS, 154, 166L