AGN Clustering in deep Chandra surveys

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ABSTRACT

We present the clustering properties of 1537 X-ray selected sources with spectroscopic redshifts in the CDF-N,CDF-S ,ECDF-S,C-COSMOS, AEGIS in the full band (0.5-10keV) in the redshift interval 0<z<3. This analysis presents the most detailed direct measurement to date of the X-ray clustering at faint X-ray fluxes and high (z~1) redshifts. We perform a spatial correlation function analysis for each field and for the whole sample finding a clustering length of ro~ 6 Mpc. Furthermore, we investigate whether there is X-ray luminosity dependence on the clustering length in the redshift range z=0.7-1.4. We provide the most robust evidence yet for such dependence in the sense that the clustering length increases at higher luminosities.

INTRODUCTION

The coevolution of galaxies and supermassive black holes at their centers is a commonly accepted scenario, albeit the details of this interplay are not yet fully understood. The clustering of AGN, as a function of luminosity and redshift are powerful tests of models in which AGN feedback affects the host galaxy evolution. Numerous works estimate a clustering amplitude which is comparable or higher than that of red galaxies. Moreover, theoretical models (e.g. Marulli et al. 2008) predict a dependence of clustering on luminosity. Plionis et al. (2008) found indications for a luminosity dependent clustering of X ray selected AGN in the CDFs fields using the projected angular clustering and then via Limber's equation derived the corresponding spatial clustering. Gilli et al (2009) investigated the dependence of the AGN clustering parameters on the X-ray luminosity in the XMM-COSMOS and did not confirm such dependency. Coil et al (2009) measure the clustering of X-ray AGN in the AEGIS field using AGN-galaxy cross correlation function and found no significant dependence on X-ray luminosity. However, recent studies of Krumpe et al 2010 of low redshift AGNs using a cross correlation analysis and Cappelutti et al 2010 in 15-55keV using the auto correlation function, found that X-ray luminosity appears to correlate with the clustering strength.

Results

The projected correlation function for the whole sample (1537 sources detected in the 0.5-10 keV band) and for the samples of CDF-S,CDF-N,ECDF-S,C-COSMOS AEGIS is shown in Figure 1. For the combined sample we found ro=5.55±0.2 h^{-1}Mpc for γ=1.8. This is in good agreement with the results of Starikova(2010) for Bootes field who used 1282 X-ray selected AGNs with spectroscopic redshift and found ro=6.27±0.33h^{-1} Mpc for γ=1.97 In Figure 2 we present the spatial clustering scale for the full band as a function of the X-ray luminosity, binning together the five fields. We found weak indications for luminosity dependence of clustering strength.

TOTAL (5 Fields together) 1537 sources			
γ(free)	ro(h^{-1}Mpc)	γ(fixed)	ro(h^{-1}Mpc)
1.390±0.016	4.36±0.22	1.8	5.55±0.2

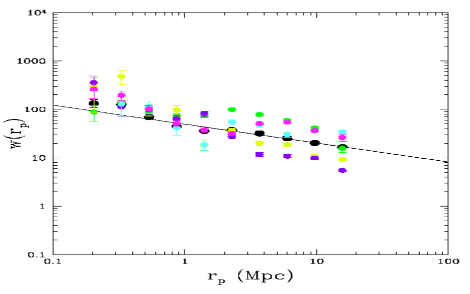

Figure 1. **Projected correlation function for 5 fields (black), CDF-N (green), CDF-S(yellow), ECDF-S (cyan), COSMOS (magenta),AEGIS (blue) for redshift interval 0<z<3.**

DATA & ANALYSIS

The 2Ms CDF-N and 2Ms CDF-S cover an area of 448 and 391 arcmin^2 respectively, with flux limits ~10^{-17} ergs^{-1}cm^{-2} for the full 0.5-8 keV band. The ECDF-S survey consists of 4 Chandra ACIS-I pointings covering ~0.3 square degrees surrounding the original CDF-S. The flux limit for ECDF-S is ~10^{-16} ergs^{-1}cm^{-2}. The Chandra COSMOS survey has imaged the central 0.5 deg2 of the COSMOS field with an effective exposure of ~160ks. The limiting source detection depths are 10^{-17} ergs^{-1}cm^{-2} in the full band. The AEGIS-X survey comprises of pointings at 8 separate positions, each with nominal exposure 200ks, covering a total area of approximately 0.67deg^2 in a strip of length 2 degrees with flux limit 10^{-16} ergs^{-1}cm^{-2}. We use the source catalogs of Alexander (2003),Luo (2008) Lehmer (2005) Elvis (2010) Laird et al 2008, for CDF-N,CDF-S,ECDF-S, COSMOS, AEGIS respectively. Spectroscopic redshifts were used for 243 X ray sources in CDF-N, 246 in CDF-S, 288 in ECDF-S, 423 in COSMOS, 430 in AEGIS, from Trouille et al 2008, Luo et al 2010, Silverman et al (2010), Brusa et al (2010), DEEP2 (Davis et al 2000,2003)+Coil (2009), respectively. In order to produce random catalogs we reshuffle only the source redshifts, while angular position are conserved as for the real sources (see Gilli et al. 2008). For quantifying the clustering in the AGN we use the projected two point correlation function ξ(rp,π) which measures the excess probability over random, at separation perpendicular and parallel to the line of sight rp and π. ξ(rp,π) is calculated using the estimator ξ(rp,π)=ND/NR*(NDD/NRR)-1, where NDD and NDR is the number of data-data and data-random pairs respectively and ND and NR are the total number of data and random points, respectively. The list of all possible pairs are binned and counted in intervals of projected separation. We derive the luminosity distribution of the sources of the five fields so that we can divided the sample in each field in 2 Lx bins. In order to exclude any implied Lx dependence due to the redshift dependence, we checked the redshift distribution for the high and low luminosities subsamples of each field taking into account ro have approximately the same populations.

	CDF-N N.of.S	γ (free)	ro (h^{-1}Mpc)	γ(fixed)	ro (h^{-1}Mpc)
All 0.5<z<1.2	243	1.550±0.067	4.02±0.25	1.8	4.37±0.25
logLx<42.2 LL	73	1.595±0.26	3.35±0.43	1.55	3.26±0.45
logLx>42.2 HL	79	1.495±0.124	4.91±0.6	1.55	5.16±0.61

	N.of.S	(free)	(h^{-1}Mpc)		(h^{-1}Mpc)
All 0.6<z<1.4	246	1.580±0.047	6.26±0.34	1.8	6.05±0.31
logLx<42.2 LL	78	2.120±0.116	5.11±0.42	1.8	4.52±0.49
logLx>42.2 HL	58	1.470±0.162	6.46±0.97	1.8	6.92±0.88

	EDF-S N.of.S	γ (free)	ro (h^{-1}Mpc)	γ(fixed)	ro (h^{-1}Mpc)
All 0.7<z<1.6	288	1.565±0.014	5.96±0.32	1.8	6.63±0.33
logLx<43 LL	81	1.850±0.098	6.69±0.66	1.740	6.41±0.66
logLx>43 HL	50	1.660±0.198	7.69±1.4	1.740	8.09±1.5

	COSMOS N.of.S	γ (free)	ro (h^{-1}Mpc)	γ(fixed)	ro (h^{-1}Mpc)
All 0.6<z<1.6	423	1.665±0.024	5.40±0.2	1.8	5.98±0.18
logLx<43.2 LL	152	1.555±0.038	4.85±0.27	1.575	4.96±0.27
logLx>43.2 HL	109	1.595±0.131	7.53±1.03	1.575	7.41±1.04

	AEGIS N.of.S	γ (free)	ro (h^{-1}Mpc)	γ(fixed)	ro (h^{-1}Mpc)
All 0.5<z<1.5	430	1.780±0.042	4.12±0.2	1.8	4.18±0.22
logLx<43 LL	143	2.120±0.064	4.58±0.23	2.2	4.45±0.24
logLx>43 HL	99	2.245±0.110	6.31±0.45	2.2	6.30±0.61

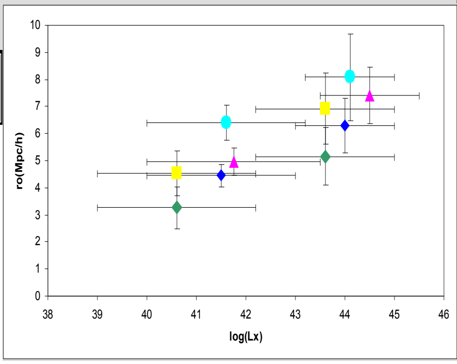

Figure 2. Spatial clustering scale for LL and HL as a function of X-ray luminosity, CDF-N (green), CDF-S(yellow), ECDF-S (cyan), COSMOS (magenta),AEGIS (blue) .

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