The Angular Two Point Correlation Function for the FIRST Radio Survey

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Abstract. The angular two-point correlation function is calculated for the first 300 square degrees of the FIRST radio survey. Results for various subsamples are also obtained. Double-lobed sources are shown to have a higher clustering amplitude than the sample as a whole. Small differences in the correlation function from one region of the sample to another and results of various flux cuts are discussed.

1. Introduction

The first 300 square degrees of the FIRST (Faint Images of the Radio Sky at Twenty centimeters) survey covers a strip from 07$^h$15 to 16$^h$30 in RA and from about 28.4$^\circ$ to 31$^\circ$ in dec. This yields a catalog of about 27,000 sources with positional accuracies better than 1$''$. About 30% of these sources are in double or multi-component systems. Becker, White and Helfand (1995) estimate that the catalog is 80% complete to 1.0 mJy and 95% complete to 2.0 mJy.

While some evidence for the clustering of bright radio sources (> 0.5 Jy) has been presented (e.g. Peacock & Nicholson, 1991), little is known about the clustering of fainter populations. FIRST provides an excellent opportunity to investigate this problem.

2. Determining the correlation function

Landy and Szalay (1993) (LS) discuss four methods for estimating the correlation function, $\omega(\theta)$. To make an independent estimate of the uncertainties associated with each method, we used the following procedure: 16 random fields (R) with surface densities equal to that of the survey (D) were generated using

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the random number generator ‘ra n1’ given in Press et al. (1986). The correlation function was determined for each of the random fields using all four of the methods. For each method and for each $\theta$, then, there were 16 estimates of $\omega(\theta)$ distributed around zero. The standard deviation of this distribution was taken as an estimate of the uncertainty in the $\omega(\theta)$ calculated for the survey. In qualitative agreement with LS, we find that on large angular scales ($> 10^\circ$) their methods (iii) and (iv) have smaller associated uncertainties. On smaller scales, we find the uncertainties for the four methods to be similar.

The correlation function for the whole sample is calculated using both methods (ii) ($\omega(\theta) = DD/DR - 1$) and (iii) ($\omega(\theta) = (DD - 2DR + RR)/RR$).

To avoid over-counting double-lobed radio galaxies and other multi component systems, sources separated by less than 0.02$^\circ$ were counted as a single source. This yields about 22,000 sources for correlation function analysis. The random fields were not corrected for the bias resulting from this procedure; that is, random sources separated by less than 0.02$^\circ$ were included in the random catalogs.

3. Results

3.1. Whole Strip

The results for all the sources in the sample are shown in Figure I. Error bars are shown for method (iii) calculations only. They are obtained from the random field process described above. Out to 1$^\circ$ or 2$^\circ$ the correlation function clearly shows power law behaviour. Fitting a function of the form $\omega(\theta) = A\theta^\gamma$ out to 1.5$^\circ$ yields $A=0.012\pm0.001$, $\gamma=-0.88\pm0.05$ for method (ii) and $A=0.007\pm0.001$, $\gamma=-1.03\pm0.1$ for method (iii). These slopes are somewhat larger than those determined for optical surveys (a value of -0.8 is often taken as a standard estimate which is consistent with our results at the 2$\sigma$ level.) It’s possible that our uncertainties are underestimated enough for the results to be consistent. The first FIRST catalogue does contain a few bad fields and some widely spaced doubles could still be in the sample. These would both push up the counts in the small angle bins, increasing the slope somewhat. However, Figure I does not really show any evidence for this.

There is an obvious flattening of the curve just past 1$^\circ$. It should be pointed out that this is half the width of the survey strip: analysis of the larger portion of the survey will hopefully reveal whether this flattening is physically significant. The other obvious feature is the drop off near 20$^\circ$. The correlation between the position of this cutoff and the size of the sample can be tested when the extended catalogue becomes available.

We intend to use estimates of the radio luminosity function to infer information about the spatial correlation function. This will allow a more meaningful comparison of the correlation amplitude with those obtained for other samples.

3.2. Different regions of sky

The strip was divided into four portions and the correlation function was determined using method (ii) for each quarter. There is some evidence for variation in the slope and amplitude of the correlation function amongst these different
2.5 × 34° cells, although the larger sample will be needed before a quantitative statement can be made.

There appears to be some correlation between the position of Abell clusters and the strength of the correlation signal. In an attempt to establish how much the radio sources in Abell clusters contribute to the correlation function, sources within 0.4° of the center of all Abell clusters were excluded from the calculation. We found that the surface density of sources was indeed larger than average within 0.4° of clusters, but that removing these sources did not significantly affect the correlation function (except to increase the uncertainties). Section 3 (11h48 to 14h00 in RA) appears to have the highest correlation amplitude. This could be related to the presence of nearby clusters such as Coma in this region.

3.3. Correlation of Double and Multi-Component Sources

A catalogue of 3800 double-lobed and multi-component sources was created by collapsing all sources within 0.02° of each other to a single source. The angular correlation function for these sources (determined using method (ii)) is shown in Figure II. The best fit to the doubles correlation function yields $A=0.032\pm0.003$, $\gamma=-1.10\pm0.05$. The large correlation seen could be explained if these resolved doubles were on average closer to us than the remainder of the sample.

We also analysed a sample which included all sources except double and multi-component systems. The best fit yielded $A=-0.01\pm0.001$, $\gamma=-0.76\pm0.05$, more consistent, in slope, with optical survey results.

3.4. Flux Cuts

The correlation function was also determined for samples where all sources below a certain flux limit were omitted. The samples with 2 mJy, 4 mJy and 10 mJy cuts showed similar correlation functions (although the scatter increased as the number of sources decreased). At 1.0 mJy the expected ratio of the number of starburst galaxies to the number of AGN’s is of order unity. Above 2 mJy this ratio becomes orders of magnitude larger (Condon 1991). It appears that removing these relatively nearby starburst galaxies does not result in a significant loss of signal. This provides some evidence that we are finding structure in more distant populations.

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