The MUNICs project – a multicolor survey of distant galaxies

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Abstract. The MUNICS project is an ongoing imaging survey designed to cover 3 sq. degrees in V,R,I,J,K$'$. We describe here partial results of the project concerning the clustering properties of K$' < 19.5$ galaxies in scales of $3.6''$ to $63.0''$ over an area of ~ 800 arcmin^2. We present K$'$ data for a sample of 20 fields, five of which contain $z > 0.5$ radio-loud quasars with steep spectra, eight contain $z > 0.5$ radio-loud quasars with flat spectra and seven are high-galactic latitude fields with no quasars in them. The two-point angular correlation function for the total sample shows significant clustering at $\sim 5\sigma$ level of K$'$=19.5 galaxies. The correlation angle of the galaxies is $\theta_0 = 1.7'' \pm 0.4''$ for K$' < 19$ mag and $\theta_0 = 1.0'' \pm 0.2''$ for K$'$ < 19.5 mag. When the correlation functions for the subsamples are considered, the mean $\omega(\theta)$ amplitude of the fields which contain steep-spectra $z > 0.5$ radio-loud quasars is determined to be $\sim 2.0 - 2.5$ that of the high-galactic latitude fields.

1 Introduction

The MUNICs project has four main goals: 1) determine the space density of $z \sim 1$ clusters; 2) measure large-scale structure at redshifts $z > 0.5$; 3) test the number density evolution of elliptical galaxies; 4) select a sample of large–z elliptical galaxies for populations studies. The basic observational set-up and some preliminary results were described in [5].

We describe below the preliminary results on the clustering properties of K$' \sim 19.5$ mag galaxies for three subsamples: 1) seven "empty" high-galactic latitude fields, 2) five fields containing $z > 0.5$ radio-loud quasars with steep-spectra, i.e., with spectral indices (as derived from the ratio of the fluxes at the 11cm- and 6cm-bands), of $\alpha > -0.6$ and 3) eight fields containing $z > 0.5$ radio-loud quasars with flat spectra, with $\alpha < -0.6$. The quasars were chosen from [6] and the criteria used for their selection were that they have $z > 0.5$, their galactic latitude be $b > 40$ degrees, to avoid heavy star contamination and they be detected at 6 cm and 11 cm.

The K$'$ images used in this study were taken at the 3.5m-tel at Calar Alto with the Omega camera. The typical usable area for each field was 40 arcmin^2.

2 The angular correlation function in the K$'$ band

A measurement of the degree of galaxy clustering in our fields can be made by determining their projected 2-point correlation function, i.e., the angular 2-point correlation function, $\omega(\theta)$. This is generally fit by a power law of slope –0.8 and amplitude given by integration of Limber's equation for the 3-d 2-point correlation function over the galaxy redshift distribution.

We calculate the galaxy angular correlation function for the three subsamples and the complete sample of 20 fields using the formula $\omega(\theta)$=(DD–2DR+RR)/RR [4], where for a given angle separation DD is the number of galaxy pairs in our data sample, DR is the number of pairs between the data and a uniform random sample and RR is the number of random pairs. We calculate $\omega(\theta)$ between $3.6''$ and $63.0''$ in log bins of width 0.25.

The fitted $\omega(\theta)$ amplitudes at $\theta = 1$ degree, assuming a $\theta^{-0.8}$ power-law for the radio/steep-source, radio/flat-source and empty fields and for the combined sample are given in Table 1. The corresponding plots for the three subsamples are shown in Figs. 1 and 2. The correlation function was determined for each field individually and the plotted values are the averages over the fields. The error bars indicate the rms scatter between the fields. The 1σ error in the mean is comparable to the symbol sizes. To account for the field sizes we calculate an integral constraint (IC) assuming that the form of $\omega(\theta)$ is given by a power law with a slope of –0.8. The solid lines in Figs. 1 and 2 correspond to the best least-squares fits to the function A($\theta^{-0.8}$ – 13.5) where the value for the amplitude A is given in Table 1 and the average IC is 13.5 ± 1. Only angular separations for which the IC is $< 50\%$ the raw correlation function are considered. The error on A was estimated from the field-to-field scatter derived by fitting $\omega(\theta)$ of the individual fields.

3 Results

The correlation function of galaxies in the K$'$ band as a function of limiting magnitude is not well determined mainly due to the small sizes ($< 2' - 3'$ on a side) of the NIR detectors which have not allowed wide-field K$'$ imaging surveys to be performed. This will certainly change with the several wide-field ongoing or planned surveys (see this conference).

We summarize in Table 2 the results of the four studies (including ours) which have derived the K$'$ band correlation functions to date. We list amplitudes normalized to $\theta = 1$ degree and their 1σ errors. As can be seen in Table 2, the $\omega(\theta)$ amplitude derived in this study from 800 arcmin^2 is similar to that estimated by [2] for 17 fields covering a total of 101.5 arcmin^2, each containing a radio-galaxy at $z \sim 1.1$, for a similar magnitude limit. Our results are within the values expected from models of stable clustering with $\epsilon = 0$ [2]. Further discussion of these results is deferred to a later paper.

We also find a marginally significant 2σ enhancement on the clustering

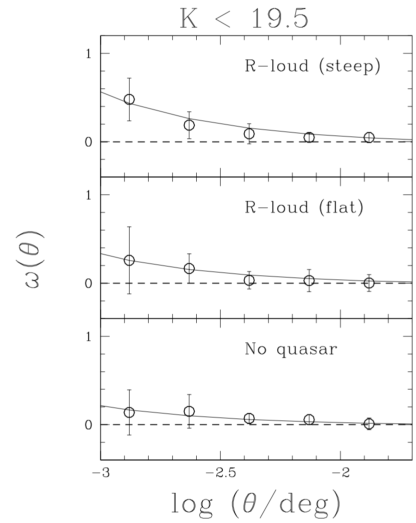

Figure 1: The angular correlation function, $\omega(\theta)$, of the K$'$ < 19.5 mag galaxies on five fields containing radio-loud steep-spectrum sources, eight with radio loud flat-spectrum sources and seven empty fields. The solid lines correspond to the best fits to the function A($\theta^{-0.8}$ – 13.5) where the amplitudes at $\theta = 1$ degree (A) are listed in Table 1 and the integral constraint is 13.5 $\pm$ 1. The error bars indicate the rms scatter between the fields.

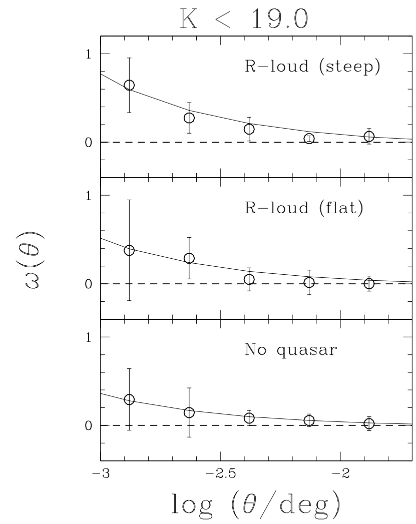

Figure 2: Same as Fig. 1, but for K$'$ < 19.0 mag galaxies.

amplitude by a factor of 2.0 – 2.5 for fields with steep-spectra radio-loud quasars, as compared to the fields with no quasars (see Table 1). This result has, however, a weak significance and must await confirmation for a larger sample. If this is correct it could be interpreted as an extension of the effect already observed for quasars at lower redshifts.

Table 1. Amplitudes of the $\omega(\theta)$ at $\theta = 1$ degree

	$K' < 19.5$	$K' < 19.0$	area (arcm^2)
Radio steep	$23.0 \pm 6.4 \times 10^{-4}$	$31.5 \pm 10.2 \times 10^{-4}$	200
Radio flat	$13.7 \pm 5.5 \times 10^{-4}$	$21.0 \pm 9.5 \times 10^{-4}$	320
Empty fields	$8.8 \pm 5.1 \times 10^{-4}$	$14.8 \pm 7.7 \times 10^{-4}$	280
All fields	$14.3 \pm 3.2 \times 10^{-4}$	$21.4 \pm 4.7 \times 10^{-4}$	800

Table 2. K$'$ angular correlation functions derived to date

K$'$ limit	Amplitude ($\times 10^{-4}$)	Environment	Reference
$K < 15$	430 ± 20	field	[1]
$K < 15$	350 ± 20	field	”
$15 < K < 16$	96 ± 5	field	”
$15 < K < 16$	84 ± 7	field	”
$K < 19$	21.4 ± 4.7	field+quasar	this work
$K < 19.5$	14.3 ± 3.2	field+quasar	”
$K < 19.5$	13.5 ± 3.2	radio galaxy	[2]
$K < 20.0$	13.3 ± 2.3	radio galaxy	”
$K < 20.5$	8.1 ± 1.6	radio galaxy	”
$K < 21.5$	11.4 ± 1.6	field	[3]

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