Clustering of Submillimetre-Selected Galaxies

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Abstract. Using accurate positions from very deep radio observations to guide multi-object Keck spectroscopy, we have determined a substantially complete redshift distribution for very luminous, distant submillimetre(submm)-selected galaxies (SMGs). A sample of 75 redshifts for SMGs in 7 fields contains a surprisingly large number of 'associations': galaxies with redshifts within $1200\,\mathrm{km\,s^{-1}}$. This small sample provides tentative evidence of strong clustering at $z \simeq 2-3$ with a correlation length of $7.8 \pm 2.6 h_{100}^{-1}$ Mpc, using a simple pair-counting approach that is appropriate to the small, sparse SMG samples. The large correlation length could either indicate that SMGs trace the densest large-scale structures in the high-redshift Universe, and are evolutionarily distinct from optical-color-selected $z \simeq 3$ Lyman-break galaxies (LBGs) and QSOs, or that they are subject to a complex bias.

1 Submillimetre-Selected Galaxies (SMGs)

Since 1997 several hundred galaxies have been discovered using imaging arrays at mm and submm wavelengths (Blain et al. 2002; Smail et al. 2002; Bertoldi et al. 2004). The difficulties of identifying these galaxies at other wavelengths, and moreover determining their redshifts are significant, owing largely to the coarse positional accuracy ($\simeq$ 8 arcsec) of the discovery images. By exploiting the high-redshift analogue of the far-infrared–radio correlation between hot dust and radio synchrotron emission both powered by young, hot stars, sub-arcsec radio positions can be found for a substantial fraction of SMGs, enabling efficient multi-object optical spectroscopy to search for redshifts, given their surface density on the sky is around $500\,\mathrm{deg}^{-2}$ (Chapman et al. 2003). The redshift distribution of a large sample of 75 of these galaxies in seven independent fields (Table 1) – about 45% of all SMGs and 70% of those with radio detections – is presented by Chapman et al. (2004 & this volume).

This reasonably complete redshift distribution confirms absolutely SMGs as an important high-redshift galaxy population, that dominates the luminosity density from galaxies at redshifts $z \simeq 2$. The distribution can be represented reasonably well by a Gaussian with $\bar{z} = 2.4$ and $\sigma = 0.65$. The remaining $\sim 35\%$ of SMGs with no redshifts are likely split between those at higher redshifts and any with cooler dust temperatures and lower luminosities, neither of which yield radio detections, and galaxies in the redshift range $1.2 < z < 1.8$, whose optical continua are too faint to detect rest-frame ultraviolet absorption lines, and which have no emission lines detectable using LRIS-B (Chapman et al. 2004).

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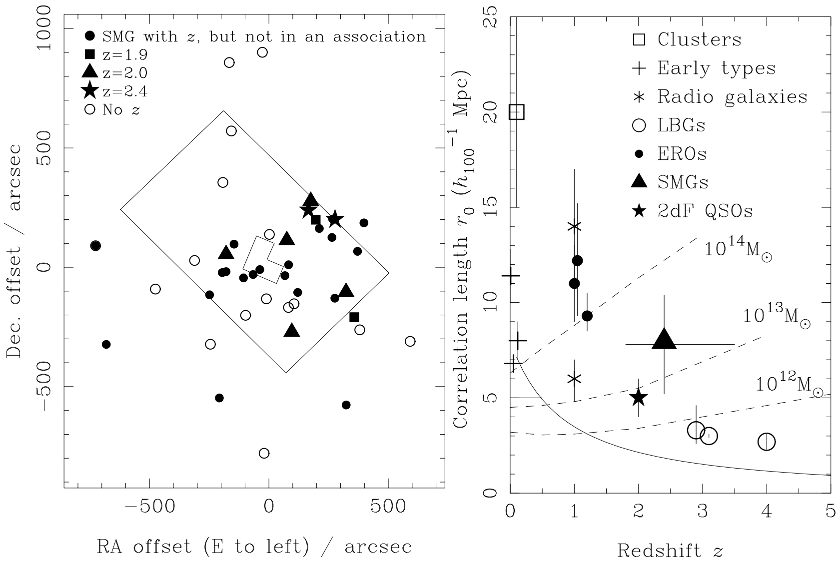

Fig. 1. Left: The positions of SMGs in the richest field in our redshift survey, surrounding the plotted boundaries of the HDF-N and GOODS fields. Galaxies in our catalog with and without redshifts, and those in the three associations present are shown by different point styles. **Right:** The correlation length of the SMGs inferred from our survey in contrast with other populations of low and high-redshift galaxies (see Overzier et al. 2003). The solid line shows a reasonable model for the evolution of an overdensity with decreasing redshift. The dashed lines show the expected correlation length of dark matter halos as a function of mass and redshift

2 The Importance of Galaxy Clustering

The detection of a clustering signal is important for understanding the distribution of different populations of galaxies as a function of dark matter density. In principle, in a dark-matter dominated Universe it provides an insight into the masses of the dark halos that host luminous galaxies (see Fig. 1 right panel).

Without redshifts, only limits to the projected clustering strength of SMGs in 2-dimensions have been obtained (Carilli et al. 2002; Scott et al. 2002; Borys et al. 2003; Webb et al. 2003). This is unsurprising given the narrow, deep geometry of SMG surveys: multiple structures along the line of sight overlap and dilute the clustering signal, as clearly shown in the left panel of Fig. 1.

The clustering strength of many types of high- and low-redshift galaxies have been probed by a wide variety of methods (see Fig. 1), as summarized by Overzier et al. 2003). At redshifts below those of SMGs, $z < 1.3$, large-scale structure of galaxies is being mapped in great detail by the DEEP2 survey (Coil et al. 2003). At higher redshifts, the clustering of many hundreds of LBGs can be measured (Adelberger et al. 1998). Note that published LBGs lie at higher redshifts than the SMGs: $z = 3 \pm 0.3$. This explains the lack of observed correlation between