The TexOx Survey of Radio-Selected Galaxy Clusters

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Abstract. We present some initial results from the TexOx (Texas–Oxford) Cluster (TOC) survey – a new method of selecting distant galaxy clusters. The cosmic evolution of the radio source population suggests that some massive clusters at high redshift will contain several radio-loud AGN. We searched for extreme over-densities at \( \sim \) mJy levels in \( 7’ \times 7’ \) boxes within the NVSS radio catalogue, covering a large (\( \sim 1100 \text{ deg}^2 \)) sky area. We have acquired optical images for \( \sim 130 \) cluster candidates, and followed up a subset of these with the VLA, and with Calar Alto near-IR imaging. Ryle Telescope observations have yielded at least one Sunyaev-Zel’dovich (SZ) detection of a massive \( z \sim 1 \) system. Spectroscopic follow-up with 8-m class telescopes is in progress.

1. Introduction

Traditional methods of finding clusters, such as searching for peaks in galaxy counts within wide-field optical surveys, become increasingly difficult at high redshift due to contamination by foreground galaxies. The redshift distribution of faint radio AGN means that contamination effects are much reduced for any search for an over-density at redshift \( z \sim 1 \). The availability of wide-field radio surveys like the 1.4 GHz NRAO VLA Sky Survey (NVSS; Condon et al. 1998), suggests an alternative way of finding clusters which we have been pursuing.

2. The TexOx Cluster Survey and Follow-up Observations

If the NVSS catalogue were gridded into \( 7’ \times 7’ \) boxes, we would expect the mean number of sources per box to be \( \sim 0.8 \). We created a catalogue of candidate clusters by searching within \( 7’ \times 7’ \) boxes, centred on each NVSS source, for an additional four or more sources. In some cases, large low-redshift radio structures are seen by NVSS as several “individual” sources, but these were easily eliminated from our cluster sample by inspection of the NVSS images. The remainder of the fields were our candidate galaxy clusters. At the depth of the NVSS, there is a reasonable probability that the richest clusters will contain
several radio-loud AGN, and this probability is not a strong function of redshift out to $z \sim 1$ because of the cosmic evolution of the radio source population.

The cluster candidates were imaged over 30 clear dark nights with the 2.7-m telescope at McDonald Observatory, with typical exposures of 30 − 60 minutes per band in $R$ and $I$ (reaching a limiting sensitivity of $R \sim 24$). We recover some known low-redshift clusters, including several in the Abell catalogue at $z \sim 0.1$, and the $z = 0.37$ cluster around the quasar 3C48. Many of the fields contained optically-obvious clusters near the magnitude limit of our observations. Although any survey using AGN to find clusters will find only a subsample of the total population, the technique has proved very efficient at finding real clusters.

The cluster radio sources are typically associated with galaxies of $R \sim 23$, with the brightest cluster member a magnitude or two brighter, suggesting a typical redshift around 0.5. Importantly, about 25% of TexOx clusters have no radio source identifications to the limits of our 2.7-m observations, suggesting they are at $z > 0.7$. For those fields which we were convinced contained real but distant clusters, we used the Calar Alto 3.5-m telescope to obtain near-IR images. Our collaborators in Cambridge then used the Ryle telescope to try to detect Sunyaev-Zel’dovich (Sunyaev and Zel’dovich, 1972) decrements in some of these. This yielded a detection of an object with a minimum gas mass of around $5 \times 10^{13} M_\odot$, in which five of the NVSS sources are identified with host galaxies of $R \approx 24$, $J \approx 20$, $K \approx 18$ – presumably a rich cluster at $z \sim 1$ (Cotter et al. 2001; Croft et al. 2001 in prep.). We are using Gemini and the 9.2-m Hobby-Eberly Telescope to get spectroscopic redshifts for this and similar systems.

3. Conclusions

Targeting over-densities in the NVSS provides a powerful way to find high-redshift clusters, with different biases to X-ray, optical or infrared approaches. Our TexOx Cluster (TOC) survey will provide a unique sample of clusters, including some at $z > 1$, which can be used to confirm predictions of Large Scale Structure simulations, to analyse cluster properties, and to study the correlation between cluster dynamics, the intra-cluster gas, and AGN activity.

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