CLUSTERING AT $Z \geq 0.8$

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Abstract. We discuss recent observational results describing exploratory steps taken to describe the evolutionary status of the clustering of galaxies in the Universe on scales $\sim 1$ Mpc. The clustering of galaxies is seen to be strongly evolving from the distribution of galaxies in the Canada France Redshift Survey, from epochs when the universe was 40% of its current age. Massive clusters of galaxies are being identified around radio galaxies at $z \sim 1$, indicating that deep potential wells are already in place at these epochs. At yet higher redshifts, tentative evidence for clustering is seen around radio-galaxies. We speculate that we are only now entering a very rich era in which the evolution of the clustering in the universe and its evolution will be examined in details.

1. Introduction

Understanding the formation and evolution of large-scale structures is of considerable importance to modern cosmology. While galaxy formation and evolution is receiving much warranted attention, the observational study of the formation and evolution of clusters of galaxies or other large-scale structures is only now developing.

While the observational data on the large-scale structure of the local universe is now substantial, our knowledge of the clustering of galaxies above $z \sim 0.5$ was, until recently, limited to theoretical descriptions illustrated by numerical simulations. With new technology being implemented on the largest telescopes, and in particular the advent of efficient multi-object spectrographs, our observational exploration of the clustering properties of galaxies at high redshifts is now progressing rapidly. I review here some of the recent work I have carried out in the framework of several collaborations.

2. Canada France Redshift Survey: Evolution of the clustering of galaxies since $z \sim 1$

2.1. INTRODUCTION

It is expected that the clustering of galaxies may well change with epoch in an expanding universe in which structures evolve and grow under the action of gravity. As a consequence, the two-point correlation function $\xi(r)$ should change with cosmic epoch, but the exact form of this evolution is at present poorly known.

There have been many studies of the local $\xi(r)$ in surveys such as the CfA, Stromlo-APM, SSRS, IRAS and others (see e.g., Davis & Peebles 1983, Loveday et al. 1995, Fisher et al. 1994, Benoist et al. 1995). They indicate a power-law behaviour with $\xi(r) = (r/r_0)^{-\gamma}$. Values for the correlation length $r_0$ range from 3.8 to 7.5 $h^{-1}$ Mpc with a possible dependence on luminosity and galaxy type (Loveday et al. 1995) and $\gamma \sim 1.7$. At higher redshifts, two approaches can be followed to measure $\xi(r)$. The first is to invert the projected angular two-point correlation function $w(\theta)$ through the Limber equation using an observed or predicted redshift distribution $N(z)$ appropriate to the observed limiting magnitude of the galaxy sample. From the angular correlation function $w(\theta)$, Efstathiou et al. (1991) have shown that faint galaxies, which are associated with the “excess” in the blue number counts, are rather weakly clustered. At shallower depths, where spectroscopic surveys are possible, Hudon and Lilly (1995) inverted a measurement of $w(\theta)$ using the redshift distribution based on the CFRS and find a correlation length of $r_0 = 1.9 \pm 0.1h^{-1}$ Mpc at $z \sim 0.5$.

The alternative approach is to directly compute $\xi(r)$ from the distance information for individual galaxies that is present in deep redshift surveys. The deep $I$-band selected CFRS sample (see Lilly et al. 1995a, CFRS-I; Le Fèvre et al. 1995, CFRS-II; Crampton et al. 1995, CFRS-V) provides for the first time the opportunity to directly evaluate the evolution of the two-point correlation function $\xi(r)$ over the redshift range $0 < z < 1$.

2.2. THE CANADA-FRANCE REDSHIFT SURVEY SAMPLE

The statistically complete CFRS sample consists of 943 objects selected in five $10' \times 10'$ fields to have $17.5 < I_{AB} < 22.5$, without regard to color or morphology, and with minimal surface brightness selection. The sample is 85% spectroscopically identified, 591 galaxies in the CFRS have secure redshifts. The redshifts extend up to $z \sim 1.3$, with a median redshift $< z > = 0.56$. More than 350 galaxies have $z \geq 0.5$. The field dimension of 10 arcmin corresponds to a comoving dimension of $3.3 h^{-1}$ Mpc at $z \sim 0.5$ and to $5.3 h^{-1}$ Mpc at $z \sim 1$, dimensions comparable to the $z = 0$ correlation