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The ORELSE Survey

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Abstract. The ORELSE Survey (Observations of Redshift Evolution in Large Scale Environments) is a multi-wavelength program to study the large-scale structure around a sample of 20 $z > 0.6$ clusters, with the goal of understanding transformative processes affecting galaxies in a broad range of environments. The survey includes (1) deep optical imaging to map structure around the clusters; (2) optical spectroscopy to confirm redshifts, map the galaxy distribution, obtain cluster masses via dynamical estimates, and measure spectral properties; (3) ground-based K-band imaging, to better constrain galaxy stellar masses and improve photometric redshift estimates; (4) near-IR spectroscopy to study post-starburst galaxies and AGN; (5) HST imaging to obtain galaxy morphologies; (6) Spitzer IRAC and MIPS imaging to separate starburst and AGN populations, and examine dusty galaxies; and (7) Chandra and VLA mapping to find X-ray and radio-loud AGN that are not evident from optical data. We discuss here the motivation and some early results.

Keywords. galaxies: clusters: general, galaxies: evolution, large-scale structure of universe, Surveys

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Clusters of galaxies trace the large scale structure of the Universe, forming at the nodes of filaments, and growing through the continuous accretion of individual galaxies and groups from the surrounding field. Precursors of the filaments should be present around distant clusters, containing many of the galaxies which will eventually infall into the virialized core and form the cluster population that is observed today. Such structures have been studied locally and out to $z \sim 0.5$ (e.g., Ebeling *et al.* 2003). However, the majority of studies at $z > 0.5$ have focused on the central regions of massive clusters. These find strong evolution in the properties of the cluster galaxy population, including: **(1)** a larger fraction of blue, star-forming, late-type galaxies, implying that some early-type galaxies formed in the last ~ 7 Gyr (Butcher & Oemler 1984); **(2)** a deficit of faint, passive, red galaxies on the red sequence, indicating recent truncation of star formation (van Dokkum & Franx 2001); **(3)** the star formation rates in cluster galaxies near the virial radius being comparable to that in field galaxies (Postman, Lubin & Oke 2001); **(4)** a larger fraction of K+A galaxies in cluster versus field environments, implying strong star formation activity in the recent past (Dressler *et al.* 1997); and **(5)** changes in the morphology–density relation (Postman *et al.* 2005).

These observations have not answered what physical mechanisms associated with the cluster environment are responsible for the suppression of star formation and the transformation of gaseous, disk galaxies into passive spheroids. Several mechanisms have been suggested, including galaxy harassment (Moore *et al.* 1998), ram pressure stripping (Gunn & Gott 1972), starvation (Larson *et al.* 1980), and merging (Mihos 1999). Most of these physical processes are associated *not* with the densest cluster regions, but rather with the infall regions and low-density environments far from the cluster centers. Because galaxy environment should change dramatically during the course of vigorous

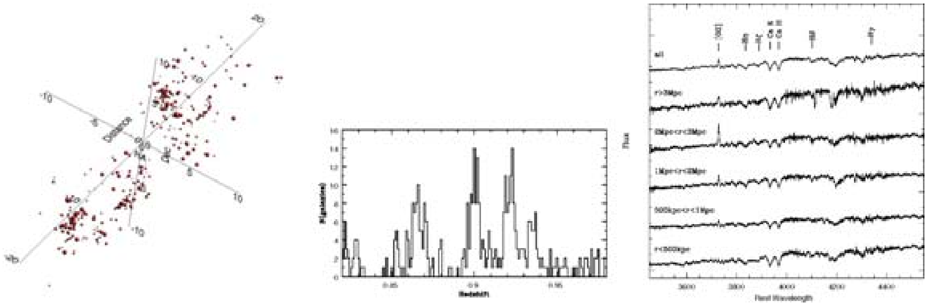

Figure 1. *Left and middle:* The spatial and redshift distributions of > 300 members of Cl1604. *Right:* Change in galaxy properties with radius from the center of NEP5281.

assembly, the large scale structure present around high-redshift clusters offers us the unique opportunity to probe, over the full range of local densities and environments, the physical effects on galaxies as they assemble into denser regions.

As a result, we have undertaken the ORELSE survey, a systematic optical search for structure associated with known high-redshift clusters. The ORELSE survey allows us to study a statistical sample of large scale structures during an epoch when clusters are actively forming and that their galaxy populations are undergoing significant modification. This program provides an essential comparison to wide-area field surveys, such as AEGIS, GOODS and COSMOS, conducted at similar redshifts, and intermediate redshift cluster samples, such as MACS, providing a crucial link between large scale structure and galaxy-scale physics.In addition to detecting these structures, the survey includes extensive follow-up components to address the issues described above.

One of the first structures studied is the Cl1604 supercluster, an optically selected system at $z \sim 0.9$, with nearly a dozen constituent clusters (Gal *et al.* 2005). Figure 1 shows the complex structure via the three-dimensional galaxy distribution, based on over 300 member redshifts, with dot sizes encoding luminosity (left), and the redshift histogram (middle). We find a very high incidence of [OII] emission, even among galaxies on the red sequence, suggesting recent star formation and/or AGN activity. Strong environmental dependences are seen in the X-ray selected cluster NEP5281 at $z = 0.82$, the strength of both [OII] emission and post-starburst Balmer absorption strengthens monotonically with distance out to a critical radius, where they begin to weaken (Fig 1, right). The strength and incidence of [OII] emission also depends on the overall cluster mass, with fully 100% of the galaxies in our poorest system being emitters. Understanding the physical origin of these features will require synthesis of the multi-wavelength datasets being obtained in this survey.

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