Chapter 27
Shapley Supercluster Survey

P. Merluzzi, G. Busarello, C.P. Haines, A. Mercurio, A. Grado, L. Limatola, and K.J. Pimbblett

Abstract Our multi-wavelength survey of the Shapley supercluster (z ∼ 0.05) covers a contiguous area of $260\,h_{70}^{-2}\,\mathrm{Mpc}^2$ including the supercluster core. The project's main aim is to quantify the influence of cluster-scale mass assembly on galaxy evolution in one of the most massive structures in the local Universe. The Shapley supercluster survey (ShaSS) includes nine Abell clusters (A 3552, A 3554, A 3556, A 3558, A 3559, A 3560, A 3562, AS 0724, AS 0726) and two poor clusters (SC 1327-312, SC 1329-313) showing evidence of cluster-cluster interactions. Optical (*ugri*) and near-infrared (*K*) imaging acquired with VST and VISTA allow us to study the galaxy population down to $\mathrm{m}^\star + 6$ at the supercluster redshift. A dedicated spectroscopic survey with AAOmega on the Anglo-Australian Telescope provides a magnitude-limited sample of supercluster members with 80 % completeness at $\sim\mathrm{m}^\star + 3$.

27.1 Survey Objectives and Target Choice

In a Lambda-CDM universe in which structures assemble hierarchically, the galaxies evolve but also move, tending towards denser regions with time, while the environments change too, thus what we actually observe is *galaxy evolution in an evolving environment*.

The prototypes of evolving environments are the superclusters, where cluster-cluster collisions and group-cluster mergers occur, and different environments from

P. Merluzzi (✉) • G. Busarello • A. Mercurio • A. Grado • L. Limatola
INAF – Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, I-80131 Napoli, Italy
e-mail: merluzzi@na.astro.it

C.P. Haines
Departamento de Astronomía, Universidad de Chile, Casilla 36-D, Correo Central, Santiago, Chile
e-mail: cphaines@das.uchile.cl

K.J. Pimbblett
Department of Physics and Mathematics, University of Hull, Cottingham Road, Kingston-upon-Hull, HU6 7RX, UK
e-mail: k.pimbblett@hull.ac.uk

N.R. Napolitano et al. (eds.), *The Universe of Digital Sky Surveys*, Astrophysics and Space Science Proceedings 42, DOI 10.1007/978-3-319-19330-4_27

cluster cores to filaments and the field coexist. Furthermore, within a dynamically active and locally dense structure the probability of observing evidence of environmental effects on galaxy evolution is dramatically enhanced, making these systems a sort of *magnifying glass* to identify the different physical mechanisms which transform the properties of galaxies. Finally, in order to study in detail the galaxy properties a resolution $\lesssim$1 kpc is required, across a wide range of galaxy masses, extending down to the dwarf regime where such galaxies are not quenched by internal processes, but are more susceptible to environmental transformations. With all this in mind, we have undertaken a study of the Shapley supercluster which is the largest conglomeration of Abell clusters in the local Universe.

The Shapley Supercluster Survey (ShaSS) will map a 23 deg^2 region ($\sim$260 Mpc^2) of the Shapley supercluster at $z = 0.048$, containing filaments and embedded galaxy groups, in order to identify the primary locations (groups, filaments, clusters) and mechanisms for the transformation of spirals into the S0s and dEs.

Our study has the following main objectives.

– To investigate the role of cluster-scale mass assembly on the evolution of galaxies, mapping its effects in the cluster outskirts and along the filaments with the aim of identifying the very first interactions between galaxies and their environment.
– To identify and measure signs of ongoing transformation in galaxies belonging to a complex structure with the goal of improving our comprehension of what drives their star-formation quenching and structural modification.
– To obtain detailed maps of the dark matter and baryonic matter distributions (galaxies, intra-cluster medium, ICM), combining weak lensing, X-ray and dynamical analyses.
– To quantify the variation in the stellar mass fractions going from cluster cores to groups, by comparing the near-infrared light distribution with the dark matter maps and dynamical masses.
– To build up a multi-band homogeneous data-set on this area of the sky, combining sub-kiloparsec resolution imaging and magnitude-limited spectroscopy, thus providing the community with a solid background for studies of the Shapley supercluster.

To address the above objectives we will explore the global and internal properties of galaxy populations extending outside the cluster/group virial radius and aim for an accurate characterization of the environment. This will be defined through galaxy density, dark matter distribution, dynamical substructure, and ICM properties. The different quantifications of the environment will allow us to disentangle the effects of local and large-scale density, cluster and group merging, dynamical state and mass of the host systems on the properties of galaxies in different ranges of mass (for details see [1] and references therein).

We will map a region of $\sim$260 Mpc^2 including the Shapley supercluster core (SSCC) and other six galaxy clusters, see Fig. 27.1). The supercluster region is chosen to ensure to map the structures directly connected to the SSCC.

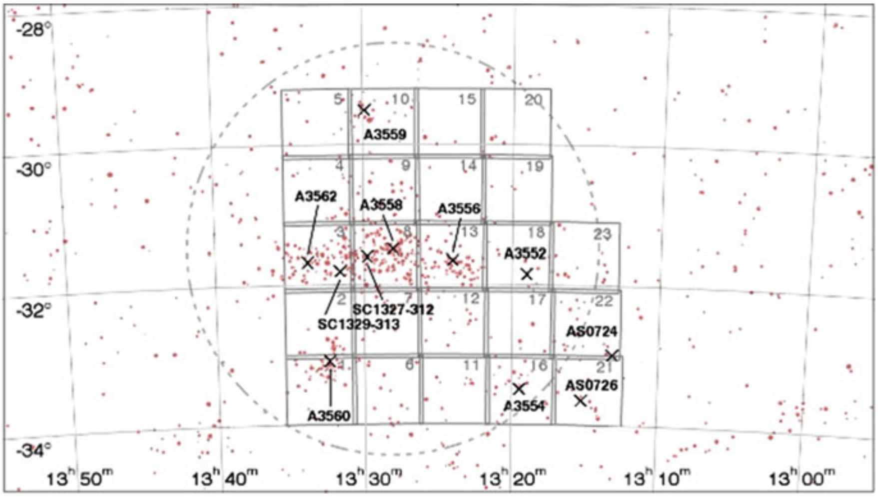

Fig. 27.1 The 23 1 deg^2 VST fields mapping the ShaSS region. *Red dots* indicate the supercluster members in the range $V_h = 11{,}300$–$17{,}000\,\mathrm{km\,s^{-1}}$ taken from literature. The size of the dots are proportional to the *K*-band flux. *Black crosses* show the cluster centres. The 10 Mpc radius *dotted circle* encloses the supercluster region believed to be dynamically bound. The SSCC corresponds to fields #3,8,13. The positions of all structures present in the plotted area are indicated

The data-set includes optical (*ugri*) and NIR (*K*) imaging acquired with VST and VISTA respectively, and optical spectroscopy with AAOmega.

The optical and near-IR data allow us to study the global and internal properties of the supercluster galaxies down to $m^\star + 6$. For the morphological analysis we will use the *r*-band imaging collected with seeing ~0.6 arcsec (0.75 kpc at $z \sim 0.05$). Near- and mid-IR (3.4–22 μm) imaging from the WISE satellite is also available for the whole area reaching a depth corresponding to $\sim m^\star_{3.4\,\mu m} + 5$ for supercluster galaxies. The spectroscopic survey carried out with AAOmega spectrograph at the 3.9 m Anglo Australian Telescope provided us with a final sample which is 80 % complete down to $i = 17.6$ mag and a stellar mass $\mathscr{M}_\star \sim 8.7 \times 10^9\,M_\odot$.

27.2 Galaxy Density

To map the structure of the supercluster, and determine its extent in redshift space and across the plane of the sky, we take advantage of our redshift survey which allows us to demarcate the supercluster in redshift space as lying within the recession velocities 11,300–17,000 $\mathrm{km\,s^{-1}}$ selecting a supercluster sample of 2,281 galaxies across the ShaSS area. Figure 27.2 shows the resulting density map in which each galaxy is further weighted by its 3.4 μm flux as a proxy for its stellar mass (for details see [1]).

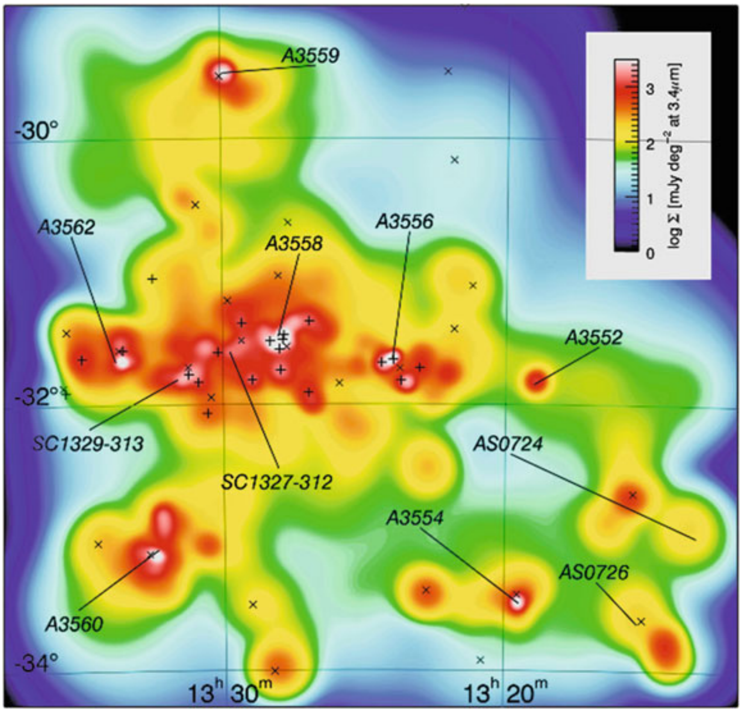

Fig. 27.2 ShaSS density map in units of mJy per square degree at 3.4 μm. Abell clusters and groups are labelled, the *black straight lines* pointing to the X-ray centre for all the systems except AS 0726 and A 3559. Cluster substructures and groups identified by previous studies (+ and × symbols) are shown in the map. The *upper right corner* is not covered by ShaSS

The map shows a clumpy structure both in the SSCC and the surrounding clusters with several substructures, most of them already identified in previous works. All the clusters in the ShaSS area are embedded in a common network. We estimate the mean overdensity across the SSCC being ∼40× with respect to the cosmic total stellar mass density for galaxies in the local Universe ($z < 0.06$).

Some new substructures with respect to previous works have been identified in the ShaSS density map. The most important new feature is however the 7 Mpc filament connecting the SSCC and the cluster A 3559 as well as the less pronounced overdensity extending from the SSCC towards A 3560. Both of them support a scenario of dynamical interaction among the clusters.

Reference

1. Merluzzi, P., Busarello, G., Haines, C.P., et al.: Shapley supercluster survey: galaxy evolution from filaments to cluster cores. MNRAS **446**, 803–822 (2015)