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THE DAFT/FADA SURVEY STATUS AND LATEST RESULTS

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Abstract. We present here the latest results obtained from the American French collaboration called the Dark energy American French Team/French American DArk energy Team (DAFT/FADA). The goal of the DAFT/FADA collaboration is to carry out a weak lensing tomography survey of z = 0.4-0.9 rich clusters of galaxies. Unlike supernovae or other methods such as cluster of galaxy counts, weak lensing tomography is purely based on geometry and does not depend on knowledge of the physics of the objects used as distance indicators. In addition, the reason for analyzing observations in the direction of clusters is that the shear signal is enhanced by about 10 over the field. Our work will eventually contain results obtained on 91 rich clusters from the HST archive combined with ground based work to obtain photo-zs. This combination of photo-z and weak lensing tomography will enable us to constrain the equation of state of dark energy. We present here the latest results obtained so far in this study.

Keywords: cosmology, dark energy, gravitational lensing: weak, galaxies: clusters: general

1 The DAFT/FADA survey

1.1 Overview

The discovery ten years ago of the acceleration of the expansion of the Universe (Riess & al. 1998) which is typically explained by assuming that most of its energy is in the form of an unknown dark energy (DE), is one of the most puzzling issues of modern cosmology. Efforts have therefore been undertaken, such as the Dark Energy Task Force (Albrecht & al. 2006) or the ESA-ESO working group on fundamental physics (Peacock & al. 2006) to design projects to measure DE and determine its nature. As highlighted by these reports, understanding DE requires big surveys to overcome cosmic variance and shot noise as well as new experiments to control the unknown systematic uncertainties. In this context, galaxy clusters, together with several other probes, are expected to play a major role (e.g. Nichol 2007). These objects have indeed long held a place of importance in astronomy and cosmology. Zwicky (e.g. Zwicky F. 1933) inferred from observations of the Coma cluster that the matter in our universe could be in the form of a dark component (this component was first supposed to be low surface brightness diffuse light). Galaxy clusters can also be used to test the redshift-distance relation (e.g. Supernovae as standard candles, Baryon Acoustic Oscillations or weak lensing tomography with clusters, e.g. Hu 1999) or the growth of structures through weak lensing, cluster number counts, or integrated Sachs-Wolfe effect. Clusters are also intrinsically interesting in many aspects, including the influence of environment on galaxy formation and evolution. Building a detailed picture of galaxy and large-scale structure growth (e.g. clusters) is therefore necessary to understand how the Universe has evolved. The Dark energy American French Team (DAFT, in French FADA) has started a large project to characterize statistically high redshift galaxy clusters, infer cosmological constraints from weak lensing tomography, and understand biases relevant for constraining DE and cluster physics in future cluster and cosmological experiments. This work is based on a sample of 91 high redshift (z = [0.4; 0.9]), massive ($\geq 3 \times 10^{14}$ M$\odot$) clusters with existing HST imaging, for which we are presently performing complementary multi-wavelength imaging. This will allow us in particular to estimate accurate photometric redshifts for as many galaxies as possible. The requested accuracy depends on both our ability to discriminate between cluster and background field galaxies without loosing too many objects and on the weak lensing tomography method internal parameters. Catalogs of cluster galaxies (e.g. Adami & al. 2008) typically show photometric redshifts spanning a total ($\sim 3\sigma$) interval of ±0.15 in photo-z. This means that the

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goal of our survey is to have photometric redshifts with a 1σ precision better than 0.05. With such a precision, the photo-z uncertainties would not be the expected dominant source of errors in our method. Our goal is to describe the method used to obtain these photometric redshifts on all the available clusters at the moment. This will allow us in the future to combine photo-z with weak lensing shear measurements to carry out tomography and build mass models for clusters.

1.2 Obtained results

We computed photo-zs with the LePhare package for ten relatively distant cluster lines of sight selecting B, V, R, I, F814W, z , Spitzer IRAC 3.6 μm, and 4.5 μm images. These images were reduced and aligned at the pixel scale using the SCAMP and SWarp tools. The zero points of the various bands were adjusted by LePhare using publicly available spectroscopy. The photo-zs prove to be reliable in the z $\sim$ [0.4, 1.5] redshift range and in the magnitude range F814W $\sim$ [19.5, 24.5]. They are also relatively reliable in the z $\sim$ [3.75, 6.0] redshift range and in the magnitude range F814W $\sim$ [19.5, 24.]. We remarked that catastrophic errors mainly occurred towards the high photometric redshifts (at z $\geq$ 1.5). This will obviously not affect our survey when limiting our analysis to the [0.4, 1.5] redshift range. The only consequence would be to remove a small number of galaxies. If we also consider the z $\sim$ [3.75, 6.0] redshift range, we will include in our future weak lensing analyses some galaxies (of the order of 2% from the spectroscopic redshift sample estimate) with completely wrong redshifts. Given the limited amount of such galaxies, the consequences on our survey will however remain limited. We achieved a photo-z precision of the order of 0.05 for the full sample. This precision is degraded by a factor of two when considering blended objects.

2 Other work: IntraCluster Light

2.1 Overview

Another important aspect of this survey is the search for intracluster light (hereafter ICL) which provides a complementary way of determining the mechanisms occurring inside galaxy clusters, as well as constraining the properties and formation history of the ICL. These studies promise to yield possible answers to many fundamental questions about the formation and evolution of galaxy clusters and their constituent galaxies. In addition, it is important to determine how and when the ICL formed, and the connection between the ICL and the central brightest cluster galaxy (see e.g. González & al. 2005). Cosmological N-body and hydrodynamical simulations are beginning to predict the kinematics and origin of the ICL (see e.g. Dolag & al. 2010). The ICL traces the evolution of baryonic substructures in dense environments and can thus be used to constrain some aspects of cosmological simulations that are uncertain, such as the modeling of star formation and the mass distribution of the baryonic light-emitting component in galaxies. The study by Da Rocha & al. (2005) also produced important results about the significant presence of ICL in groups, which are crucial if we assume that groups are the basic building blocks of clusters, that are able to bring their own ICL to the cluster-building process. From a technical point-of-view, modern CCD cameras now allow us to study the properties of the diffuse light in clusters, i.e. its morphology, radial distribution, and colors, in a quantitative way (e.g. Uson & al. 1991; Bernstein & al. 1995; Gregg & West al. 1998; Mihos & al. 2005; Zibetti & al. 2005; González & al. 2007; Krick & Bernstein 2007; Rudick & al. 2010). However, accurate photometric measurements of the diffuse light are difficult to perform because its surface brightness is typically fainter than 1% of that of the night sky, and it can be difficult (especially at high redshift) to distinguish the extended outer halos of the brightest cluster galaxies (BCGs) in a cluster core from the stars floating freely in the cluster potential. This explains why, until now, most studies of the ICL have been performed on galaxy clusters at redshifts below z$\sim$0.3 (see e.g. Toledo & al. 2011). However, since it is crucial to understand how the evolution of galaxy clusters affects that of the ICL, we must study the ICL within a range of clusters at various redshifts. It would be ideal to investigate as much as possible the period between z=0.3 and z$\sim$2, and investigate clusters since their birth. We propose here to fill part of this gap in the 0.4-0.8 redshift range for a sample of ten clusters. This redshift range is sufficient to cover about half of the typical cluster lifetimes.

2.2 Obtained results

We studied the diffuse light in ten different clusters in one band up to z$\sim$0.8 based on deep HST ACS images and in three of them (up to z$\sim$0.58) in two bands with FORS2 data. However, these deep data would not have been sufficient if we were not using a very sensitive wavelet-detection technique, the ov_wav method (Pereira & al. 2003; Da Rocha & al. 2005), itself a variant of the à trous wavelet transform described by) Starck et al. (1998, see also Starck & Murtagh (2002)). This method is independent of both the galaxy and star modelling, and of the sky level subtraction.

To help us analyze the mechanisms taking place in galaxy clusters, and place constraints on their formation history and physical properties, we have searched for intracluster light (ICL) in ten galaxy clusters at redshifts $0.4 < z < 0.8$. For the first time, we have detected significant diffuse light sources in an unprecedentedly high redshift bin z=[0.4,0.8] based on very deep HST ACS images to which we have applied a very sensitive wavelet detection method. So our study represents a significant step forward in measuring any ICL evolution with redshift.

In the F814W filter, we have detected diffuse light sources in all the clusters with typical sizes of a few tens of kpc (assuming that the diffuse light sources are at the cluster redshifts). The ICL detected by stacking the ten F814W images shows a very clear 8σ detection in the source center extending over a $\sim 50 \times 50$ kpc^2 area. The total absolute magnitude of this source is -21.6 in the F814W filter, equivalent to about two L^* galaxies for each of the 10 clusters.

Finally, besides the extended ICL, we have also found Wavelet-detected compact objects (WDCOs). Since these sources are very faint, we only considered those detected in both the HST/ACS/F814W and FORS2/V-band filters, in the three clusters for which sufficiently deep data in both bands are available. The fit of a two-dimensional Gaussian plus a constant background on each of the WDCO images suggests that they are very unlikely to be faint Galactic stars. On the other hand, part of the WDCOs are located on the cluster red sequences in color-magnitude diagrams and their spatial distribution also suggests that they could be very faint compact galaxies belonging to the considered clusters and comparable to faint Local Group Dwarfs.

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