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Morphological analysis of intermediate redshift galaxies using the HST/ACS GOODS survey

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Abstract. We have been involved in performing photometry and morphological analysis of a large, complete sample of galaxies in the intermediate redshift range using the high resolution images obtained by the *Great Observatories Origins Deep Survey* (GOODS) with the *Advanced Camera for Surveys* (ACS) on the *Hubble Space Telescope* (HST). Imaging data is available in 4 HST bands, viz. F435W, F606W, F775W and F850LP. I had given a talk on the analysis work being carried out so far in this ongoing project at the *Mt. Abu Observatory symposium.* This paper summarises the work that we have carried out so far and the future plans.

Keywords : HST - galaxy survey GOODS - galaxy morphology - photometry

1. Introduction

The *Great Observatories Origins Deep Survey* (GOODS) (Giavalisco et al., 2004) is the latest in a line of deep, high galactic latitude surveys of representative fields being conducted with the aim to further our understanding of the distant universe. The two GOODS fields, the Hubble Deep Field-North(HDF-N) and the Chandra Deep Field-South(CDF-S), are the most data rich deep survey areas on the sky. These regions already have existing deep observations from the *Chandra X-Ray Observatory* and observations are scheduled with the *Space Infrared Telescope Facility* (SIRTF), as one of the Legacy projects to be executed in the first year of the mission. In addition to this, there is major commitments of observing time from ground based telescopes of ESO to provide spectroscopy (redshifts) for sources in the above mentioned fields.

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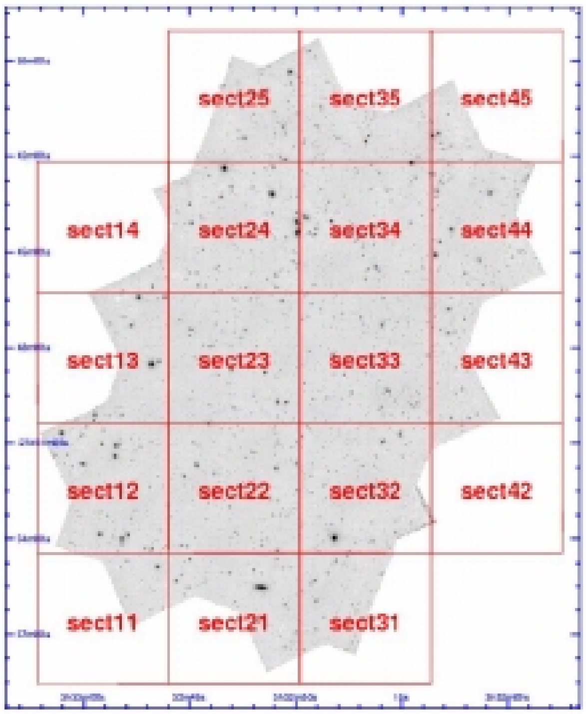

Figure 1. The CDFS half of the HST/ACS GOODS survey.

We have been using multiband(B,V,i,z) HST/ACS high resolution imaging data from the CDFS region of the GOODS survey. The area coverage of the CDFS region is $\sim$ 160 $arcmin^2$ with a final *drizzled* pixel scale of 0.03 arcsec/pixel. The total exposure times varies between $\sim$ 5000 to 10000 seconds in each of the 4 filters taken over 5 epochs.

2. Performing the analysis

Basic photometry and source catalogue preparation was performed by us using the SExtractor (Bertin and Arnouts 1996) software package. Typical parameters used for the detection and photometry include DETECT_THRESH 1.0 and DETECT_MINAREA 32. z band was used as the detection filter. Isophotal magnitudes with z_{lim} =24.7 mag/$arcsec^2$ were calculated in the z band and matched apertures were used in the B, V and i filters. In addition to magnitudes, Rhalf and CLASS_STAR were catalogued as well for all the objects. Finally this yielded 59208 *objects* in the CDFS.

2.1 Choosing an unbiased sample of galaxies

In any flux limited survey, it is crucial to carefully choose a subsample in that region of parameter space in which the survey is complete. In case of GOODS, the observing team have reported completeness limits for source detection in the magnitude-size plane based on extensive simulations (Giavalisco et al.,2004). We have made use of these completeness limits to select a sub-sample of galaxies from our source catalogue lying in that region of the magnitude-size plane in which the GOODS survey is *at least* 90 percent complete. This corresponds to $z_{iso} \leq 23.0$, Rhalf ≤ 1.3" and CLASS_STAR ≤ 0.8. This criterion yielded a sample of 1575 galaxies. This is shown in the figure 2. Notice the large number of objects lying nearly in a horizontal straight line at Rhalf ~ 0.1". These are foreground stars in our catalogue.

2.2 Getting the redshifts of the sample

Having obtained a complete sample of galaxies, we tried to get the redshifts for as many galaxies as possible using existing, published redshift catalogues in the CDFS region. We made use of two redshift catalogues, viz.

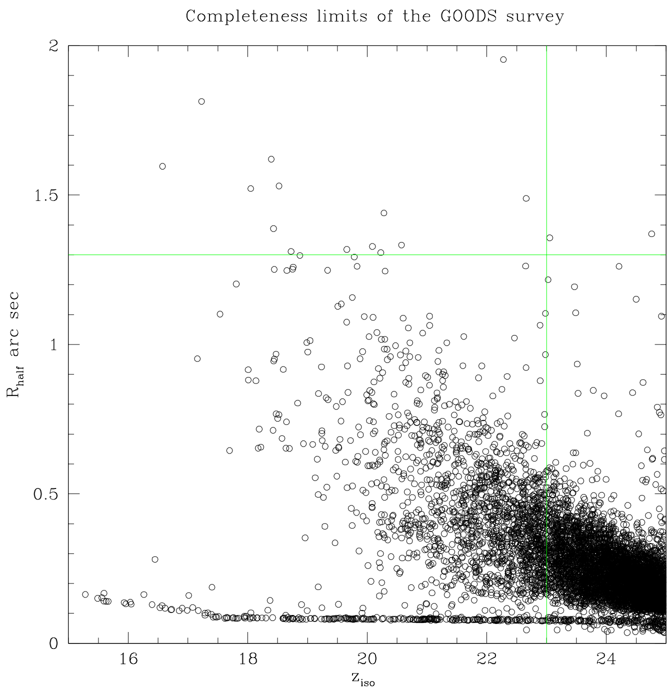

Figure 2. The completeness limits of our source catalogue.

- VVDS: ViMOS VLT Deep Survey. Le Fevre et al., submitted A&A(2004) having 1599 redshifts in an area $\sim 450\ arcmin^2$ overlapping with CDFS.
- GOODS/FORS2: Vanzella et al., submitted A&A(2004) having 234 redshifts in CDFS area.

Positional cross-correlation with a search radius of 0.5" was carried out between our *complete* HST/ACS GOODS catalogue having 1575 sources and the redshift catalogues mentioned above. This yielded unique redshift identifications for 493 out of the 1575 galaxies in our sample. We used only these 493 galaxies for further morphological analysis work. The redshift distribution of these 493 galaxies is shown in fig 3 below.

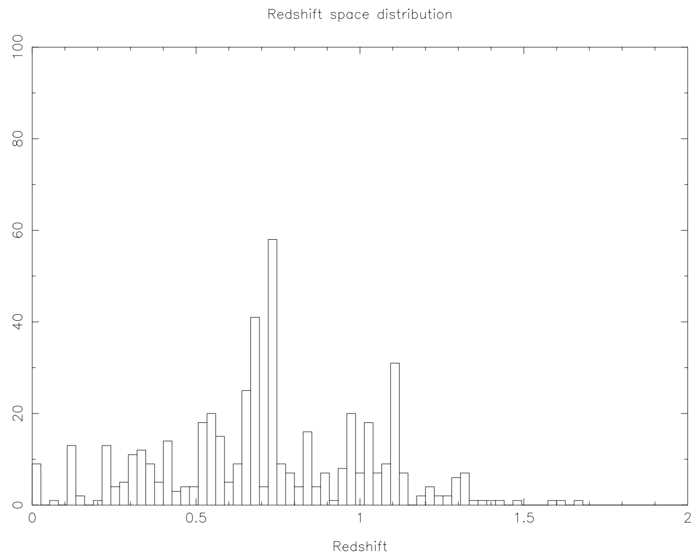

Figure 3. Redshift distribution of the galaxy sample.

3. Bulge disk decomposition

Having shortlisted a final sample of 493 galaxies with known redshifts, we started on the task of performing bulge-disk decomposition on all of them in all the 4 filters. We used the software *Galfit* (Peng et al., 2002) to derive the structural parameters of the galaxies through a two-dimensional modelling of their surface brightness distribution. We used a sersic bulge plus an exponential disk to model the galaxy. Foreground stars were used as the PSF. The quality of the fit is judged by the χ^2_{red} value of the fit, which should be close to 1 for a good fit. The model fits were also inspected visually for the quality of fit. The initial model fitting was performed in z band in batch mode on all the 493 galaxies which takes about 4 days CPU running time on a pentium 4 class machine. The final derived parameters were cataloged as ASCII files in a format which is amenable to further plotting and analysis etc. The same process is being replicated now for the other 3 filters. An example of a fit obtained with Galfit is shown in fig 4.

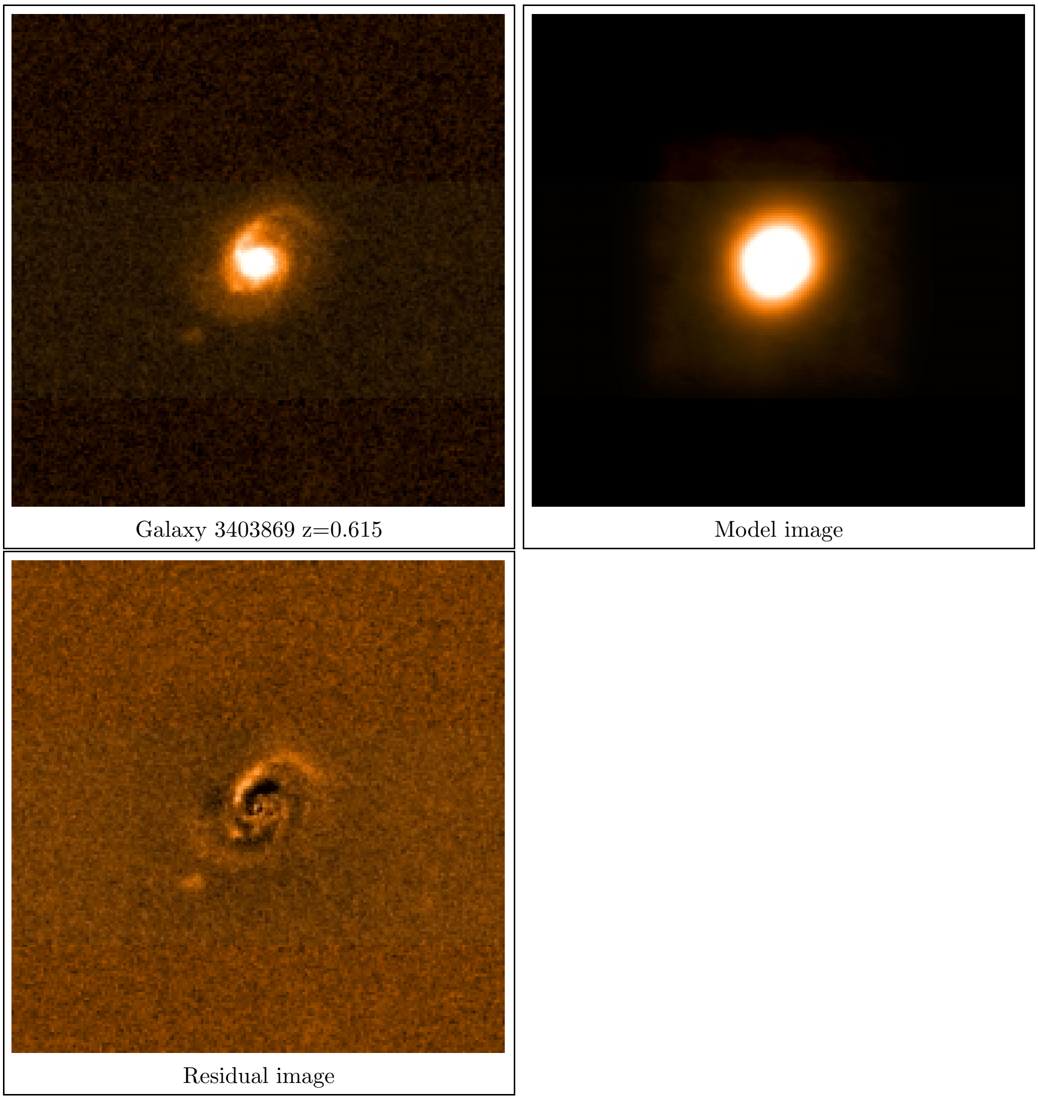

Figure 4. An example of galaxy modeling with Galfit.

4. Future plans

Once the bulge-disk decomposition work is finished, we intend to use the derived galaxy parameters to probe a variety of scientific questions. We intend to check the validity of the *photometric plane* (Habib et al., 2000) at higher redshifts. The photometric plane is a tight correlation between $< \mu_b(r_e) >$, r_e(kpc) and sersic index n for early type galaxies and bulges of spirals. It has been established at redshift z $\sim$ 0 only and it would be interesting to see whether it holds at higher redshifts as well. This is likely to give us significant clues to the evolution of galaxy populations as a function of redshift. We also have plans of using spectroscopic observations of our galaxy sample being obtained by our collaborators using the VLT to estimate the underlying galaxy properties such as the SFR, metallicities etc using stellar population synthesis models at a later date.

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