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QUANTITATIVE MORPHOLOGICAL ANALYSIS OF GALAXIES AT INTERMEDIATE RED SHIFT: CLUES TO GALAXY EVOLUTION

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RESUMEN

Introducimos un código desarrollado para realizar análisis morfológicos cuantitativos de galaxias desde bajo a alto desplazamiento al rojo. El programa está diseñado para extraer información cuantitativa sobre la morfología de las diferentes componentes de las galaxias (bulbos y discos) tanto para observaciones obtenidas desde tierra como con el HST. Presentamos varias posibles aplicaciones para el estudio de la evolución morfológica de galaxias con el GTC hasta $z \sim 0.5$.

ABSTRACT

We have developed morphological analysis software for studying galaxies from low to high redshifts. This code is designed to extract quantitative information about the morphology of the different components of galaxies (bulges and disks) imaged with both HST and ground-based observations. We present here some of its possible applications to the GTC in order to follow galaxy morphological evolution up to $z \sim 0.5$.

Key Words: **GALAXIES: FUNDAMENTAL PARAMETERS — GALAXIES: DISTANCES AND REDSHIFTS — GALAXIES: EVOLUTION — GALAXIES: PHOTOMETRY**

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1. INTRODUCTION

The ability to visually classify galaxies by Hubble type becomes increasingly difficult for faint and/or high redshift galaxies; it is therefore necessary to use an objective and quantitative profile decomposition method to retrieve their physical properties. Quantitative classification has two major advantages over visual classification: 1) it is reproducible, and 2) biases can be understood and carefully characterized through simulations. Moreover, the use of quantitative morphology can enable the recovery of reliable information about galaxy structural parameters (shape, size, axial ratios, etc.). The information contained in these parameters plays a fundamental role in understanding the evolution and origin of galaxies. The software program we have designed fits a two-dimensional bulge + disk model to both the surface brightness and the ellipticity profiles of the galaxies; i.e., we do not simply use the outer isophote –which can be affected by seeing for small high red-shift galaxies– to determine the intrinsic galaxy ellipticity, but compute the ellipticity in an iterative procedure that fully corrects for seeing. We assume that the disks have an exponential profile and that the bulges follow the $r^{1/n}$ law (Sersic 1968). We have paid special attention to the convolutions of the model profiles and the point spread function (PSF) of the images. Considerable effort has been made to accurately treat both narrow- (HST) and broad-winged (ground-based) PSFs (Trujillo et al. 2001a,c).

2. STRUCTURAL PARAMETER CORRELATION WITH LOCAL DENSITY

We have applied our algorithm to the intermediate redshift cluster Abell 2443 ($z \sim 0.1$). We imaged this cluster with HiRAC at the Nordic Optical Telescope (NOT). Expanding on the work of Dressler (1980), who found a morphological segregation (elliptical versus spirals) according to environment, we find a further dependency within the elliptical class itself: more centrally concentrated ellipticals appear in denser regions (Trujillo et al. 2001b). We argued that mergers are a possible explanation of this observation. We are developing an extensive campaign in order to confirm whether this result holds in other clusters. To date, we have imaged six nearby clusters using the Wide Field Camera on the Isaac Newton telescope (INT) and for more clusters at $z \sim 0.1$ using ALFOSC on the NOT. We have also studied the Coma Cluster, obtaining a similar result (Trujillo et al. 2002a). This sample will provide the $z = 0$ standard for comparisons at high z.

3. GALAXY COMOVING DENSITY EVOLUTION

Putting observational constraints on theoretical models is absolutely essential to our understanding of how galaxies form and evolve. We have also used

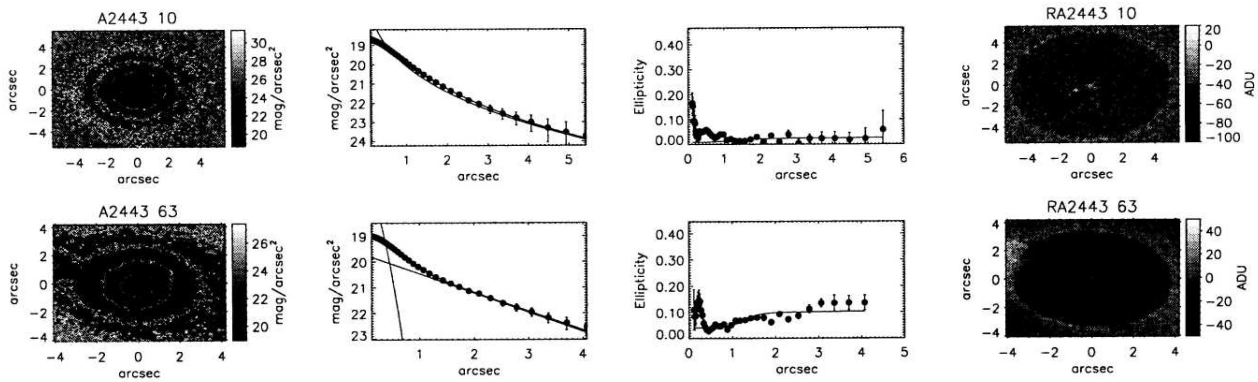

Fig. 1. Example of our code applied to ground-based images of one elliptical and one spiral galaxy in the $z = 0.1$ cluster Abell 2443. From left to right: a gray-scale image of the I band data (surface brightness isocontours are shown to μ_I = 23 mag arcsec^{-2} with intervals of 1 mag); the surface brightness profile; the ellipticity profile, and the residuals of the fit. Superimposed on the surface brightness profile data are the model profile (dashed line) and the convolution of this model profile (solid line) to match the data. The solid lines in the ellipticity plots show the fit to the ellipticities using our algorithm. Intrinsic ellipticities (i.e., not seeing-convolved) of the galaxies can be obtained by extrapolating the solid lines to infinity.

our quantitative morphological algorithm to analyze HST images of the Hawaiian Deep Fields SSA13 and SSA22. By using the bulge-to-total ratio (B/T) we have classified a complete sample of galaxies down to $M_B =$ -18 in a redshift range $0 < z < 0.8$. We have evaluated the comoving density of both E/S0s and spiral galaxies for different models of the Universe. For a universe with $\Omega_m = 0.3$ and $\Omega_\Lambda = 0.7$, the number density of E/S0 galaxies does not evolve, or only slightly decreases, at $z = 0.8$, while that of spiral galaxies remains constant (Aguerri & Trujillo 2002). Our results are in good agreement with predictions resulting from hierarchical clustering scenarios (e.g., Baugh, Cole & Frenk 1996).

4. APPLICATIONS TO THE GTC

From our simulations we expect that the quantitative morphological analysis of galaxies using the GTC facilities can be extended to $z \sim 0.5$. This will provide an intermediate redshift sample of clusters of galaxies. Using this sample we will probe whether the relations found between galaxy structure and local density holds at higher redshift. On the other hand, a bigger volume sample is necessary in order to diminish the uncertainties associated with the cosmic variance in galaxy comoving density evolution studies. This source of uncertainty will be greatly reduced with OSIRIS + GTC by increasing the number of fields with deep (broad band filter) exposures. A subsequent exhaustive campaign in order to determine galaxy distance by measuring redshift will be performed using OSIRIS multislit spectroscopy and/or tunable filters.

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