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VELOCITY DISPERSIONS AND STELLAR POPULATIONS OF THE MOST COMPACT AND MASSIVE EARLY-TYPE GALAXIES AT REDSHIFT ∼1

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RESUMEN

Presentamos espectros ópticos obtenidos con Gran-Telescopio-Canarias/OSIRIS de 4 de las galaxias de tipo temprano más compactas y masivas en el Groth Strip Survey a redshift $z \sim 1$, con radios efectivos $R_e = 0.5 - 2.4$ kpc y masas estelares fotométricas $M_\star = 1.2 - 4 \times 10^{11}\ M_\odot$. Encontramos que estas galaxias tienen dispersiones de velocidad $\sigma = 156 - 236$ km s^{-1}. Los espectros se ajustan bien con modelos de una única población de aproximadamente 1 Gyr de edad y metalicidad solar. Concluimos que: (i) las masas dinámicas de estas galaxias son sistemáticamente menores por un factor ∼6 que las masas estelares publicadas; (ii) cuando estimamos las masas estelares como $0.7 \times M_{\rm dyn}$, una combinación de reducción pasiva de luminosidad y crecimiento en masa/tamaño por fusiones galácticas menores resulta en un modelo de evolución plausible para que nuestra muestra de objetos se asemeje a la población local de galaxias de tipo temprano.

ABSTRACT

We present Gran-Telescopio-Canarias/OSIRIS optical spectra of 4 of the most compact and massive early-type galaxies in the Groth Strip Survey at redshift $z \sim 1$, with effective radii $R_e = 0.5 - 2.4$ kpc and photometric stellar masses $M_\star = 1.2 - 4 \times 10^{11}\ M_\odot$. We find these galaxies have velocity dispersions $\sigma = 156 - 236$ km s^{-1}. The spectra are well fitted by single stellar population models with approximately 1 Gyr of age and solar metallicity. We find that: (i) the dynamical masses of these galaxies are systematically smaller by a factor of ∼6 than the published stellar masses; (ii) when estimating stellar masses as $0.7 \times M_{\rm dyn}$, a combination of passive luminosity fading with mass/size growth due to minor mergers can plausibly evolve our objects to match the properties of the local population of early-type galaxies.

Key Words: galaxies: evolution — galaxies: formation — galaxies: kinematics and dynamics — galaxies: structure

1. DISCUSSION

We obtained optical spectra of 4 super-dense galaxies ($R_e < 1$ kpc, $M_\star \geq 10^{11}\ M_\odot$) at $z \sim 1$ from the morphological galaxy catalog presented in (Trujillo et al. 2007). Our aim is to derive dynamical masses and study the stellar populations and evolution of our sample of galaxies. Dynamical masses are calculated under the assumption of homology as $M_{\rm dyn} = 5\ R_e \sigma^2/G$ (see Table 1), following studies of local ETGs (Cappellari et al. 2006). Our galaxies have values that are systematically smaller than the originally published stellar masses by an average factor of ∼6 (see Figure 1). Following local lensing studies (Gavazzi et al. 2007), we apply a fiducial dark matter fraction $f_{\rm DM} = 0.3$ and recalculate the stellar masses as $0.7 \times M_{\rm dyn}$.

In order to understand how our galaxies relate to low redshift ETGs, we investigate the simple evolutionary scenario based on passive luminosity fading of the stellar populations and growth via minor mergers that has been proposed for the general population of ETGs at $z \sim 1$ (Naab et al. 2009). To derive the amount of fading for our sample, we use Bruzual & Charlot (2003) models with Chabrier IMF and the redshift, ages and metallicities from Table 1. According to the simulations by Naab et al. (2009), an ETG with $M_\star = 10^{11}\ M_\odot$ and $R_e = 1.5$ kpc

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TABLE 1

PHYSICAL PARAMETERS OF THE OBSERVED TARGETS[a]

ID	Redshift	I(ABmag)	R_e (kpc)	log $M_\star$ ($M_\odot$)	σ (km s^{-1})	log $M_{\rm dyn}$ ($M_\odot$)	Age (Gyr)	[Fe/H]
12024790	0.9656	21.89	0.514	11.07	156±10	10.16±0.08	0.8	0.0
12024321	0.9159	21.34	2.462	11.10	166±12	10.90±0.08	1.0	0.0
12019899	0.9325	21.71	0.469	11.34	236±17	10.48±0.08	1.6	0.2
12024453	0.9056	20.91	1.601	11.60	186±10	10.80±0.07	1.3	0.2

[a]The first five columns are properties from (Trujillo et al. 2007), where the effective radii and stellar masses have uncertainties of 0.06 dex and 0.2 dex, respectively. Age and metallicity are luminosity-weighted by the linear combination of SSP models.

would grow a factor of 1.5 in mass via minor mergers from $z \sim 1$ to $z = 0$. We adopt this factor of mass growth for our galaxies. Following these authors, we model each merger as $\sigma_f^2/\sigma_i^2 = (1+\eta\epsilon)/(1+\eta)$ and $R_{\mathrm{e}f}/R_{\mathrm{e}i} = (1+\eta)^2/(1+\eta\epsilon)$, where the subindexes (i)/(f) denote initial/final values of the host galaxy and $\epsilon = \sigma_a^2/\sigma_i^2$ and the mass ratio $\eta = M_a/M_i$ take into account the accreted system (M_a, σ_a). We assume a history of four mergers with constant $\eta = 0.1$ and $\epsilon = 0.2$ for all galaxies (note that η and the total mass growth set the total number of mergers). We assume a history of four mergers with mass ratio equal to 0.1 for all galaxies. The total change for R_e and σ become factors of 2 and 0.8, respectively.

Figure 1 shows the combined evolution of minor mergers and luminosity fading for our galaxies. Most of them reach positions that are consistent with the local FP and mass-size relations, considering the estimated uncertainties in our measurements. Therefore, this simple evolutionary scenario can plausibly describe the evolution in our sample galaxies to become normal ETGs at $z = 0$.

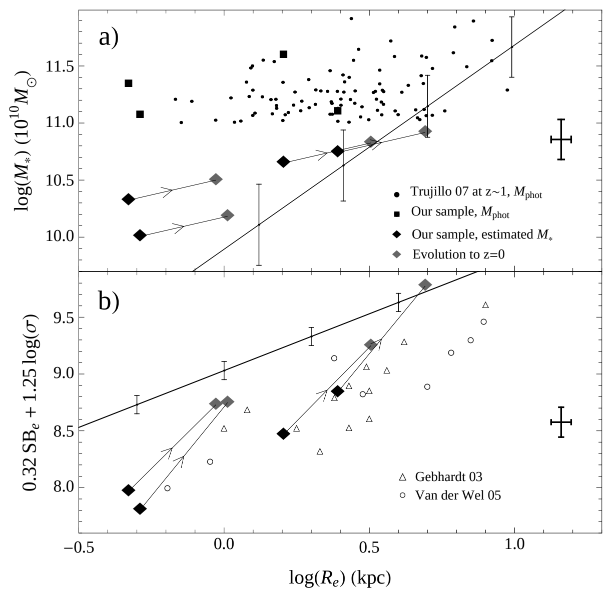

Fig. 1. (a) Stellar mass-size relation at $z \sim 1$. Small circles represent the entire sample from (Trujillo et al. 2007), black squares are our selection among them. The straight line is the local relation from Shen et al. (2003). Black diamonds are our galaxies with stellar masses derived as 0.7 $M_{\rm dyn}$. Gray diamonds are their position when evolved to $z = 0$ via minor merger growth. (b) B-band Fundamental Plane of ETGs. The solid line is the local relation from Jørgensen et al. (1996). Our sample is shown as black diamonds. Gray diamonds are their position when evolved to $z = 0$ via minor merger growth and passive luminosity fading. Samples from Gebhardt et al. (2003) and van der Wel et al. (2005) in the range $z = 0.8 - 1.1$ are shown for comparison.

REFERENCES

Bruzual, G., & Charlot, S. 2003, MNRAS, 344, 1000

Cappellari, M., et al. 2006, MNRAS, 366, 1126

Gavazzi, R., Treu, T., Rhodes, J. D., Koopmans, L. V. E., Bolton, A. S., Burles, S., Massey, R. J., & Moustakas, L. A. 2007, ApJ, 667, 176

Gebhardt, K., et al. 2003, ApJ, 597, 239

Jørgensen, I., Franx, M., & Kjaergaard, P. 1996, MNRAS, 280, 167

Naab, T., Johansson, P. H., & Ostriker, J. P. 2009, ApJ, 699, L178

Shen, S., Mo, H. J., White, S. D. M., Blanton, M. R., Kauffmann, G., Voges, W., Brinkmann, J., & Csabai, I. 2003, MNRAS, 343, 978

Trujillo, I., Conselice, C. J., Bundy, K., Cooper, M. C., Eisenhardt, P., & Ellis, R. S. 2007, MNRAS, 382, 109

van der Wel, A., Franx, M., van Dokkum, P. G., Rix, H.-W., Illingworth, G. D., & Rosati, P. 2005, ApJ, 631, 145