Kinematics of superdense galaxies in clusters

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& the WINGS team

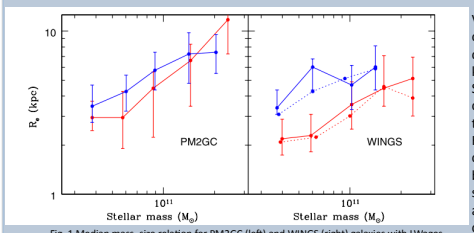

Fig. 1 Median mass–size relation for PM2GC (left) and WINGS (right) galaxies with LWages >8 Gyr (red solid lines) and LWages <4 Gyr (blue solid lines). Upper and lower quartiles are shown as error bars. For WINGS, dotted lines refer to LWages <6Gyr(blue) and >10 Gyr

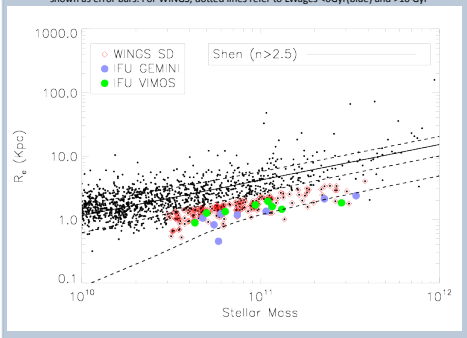

Fig. 3 Mass-size relation for WINGS galaxies (only cluster members). Black lines are the local relations in SDSS (Shen et al., 2003) for n>2.5 galaxies.
Red dots are WINGS SDGs. Green and purple symbols are IFU candidates.

Valentinuzzi et al., 2010 found in WINGS sample of local cluster of galaxies (0.04<z<0.07) a significant number of massive and compact galaxies ($3x10^{10}$ $M_\odot$< M <$4x10^{11}$ $M_\odot$, Σ_{50}>$3x10^9$ $M_\odot$/ kpc^2), that have not been found in other local surveys (e.g. SDSS). This poses a challenge, since it can be used to put a constraint on the quantity of early-type galaxies that increase theirs size by merging moving from high to low redshift. However, in doing so, it must be taken into account the so-called progenitor bias, i.e. the fact that these galaxies appear to be older with respect to galaxies with the same mass but larger sizes. When analyzing local groups (PM2GC data) Poggianti et al., 2013 found that both in the field and in clusters, as one considers galaxies with older LW ages, the median mass–size relation shifts to smaller sizes, but this effect is more pronounced in clusters than in the field (Fig.1).
Our results show that selecting already passive galaxies at high z means selecting the most compact ones. Assuming they do not resume the star formation activity at later times, the high-z sizes should be compared with the sizes of the oldest (in terms of their LWage) low-z galaxies, to avoid a significant progenitor bias.
Taking into account this progenitor bias Poggianti et al., 2013b found that for compact galaxies in low density environments a significant size evolution for these compact objects is not needed.

In order to validate our stellar masses, derived using fiber spectroscopy and our spectrophotometric tool SINOPSYS (Fritz et al., 2007, 2011) we obtained two sets of IFU observations for a subsample of 17 WINGS SDGs. 9 of them have been observed with G-MOS @GEMINI (purple dots in Fig. 3) and 8 of them with VIMOS (green dots in Fig. 3). Table 1 show the characteristics of the GEMINI subsample that we have currently been investigating, while Fig.2 shows the main characteristics of the whole SDG sample. IFU candidates are representative of the global sample of SDG.

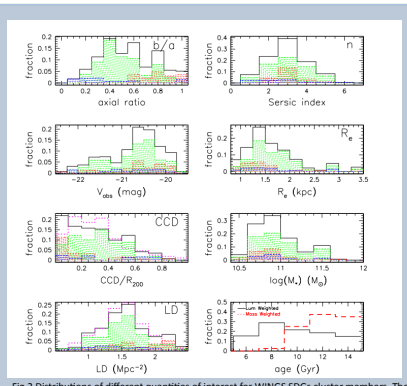

Fig.2 Distributions of different quantities of interest for WINGS SDGs cluster members. The color shades correspond to morphologies—red: ellipticals, green:SOs, and blue: late-type galaxies.M* is the total stellar mass (Fritz et al. 2007), CCD is the cluster centric distance in units of R200 (Carlberg et al. 1997), while LD is the local density (Dressler 1980). The magenta dashed histograms are the distribution of non-compact galaxies in the same mass range of SDGs.

ID	V	(B-V)[5kpc]	M	R_e	R_e[kpc]	μ_e	n_e	Redshift
WINGSJ032953.81-523502.9	15.67	1.16	11.454	2.55	2.958	19.091	1.661	0.062
WINGSJ033004.70-521616.9	17.47	1.06	10.8414	0.87	1.009	17.341	4.136	0.060
WINGSJ034255.49-533735.2	16.77	1.17	10.9201	1.10	1.262	18.804	2.665	0.061
WINGSJ043150.25-613046.3	16.22	1.11	11.2375	2.35	2.696	18.989	2.917	0.057
WINGSJ055940.68-394620.9	16.79	1.10	10.8024	1.27	1.150	18.851	3.555	0.051
WINGSJ043755.42-215724.3	16.50	1.09	11.1866	1.59	2.065	18.646	2.520	0.071
WINGSJ101721.85-104310.9	17.35	1.19	10.7676	0.99	1.132	19.156	2.924	0.060
WINGSJ101722.48-103947.8	15.77	1.25	11.6055	2.20	2.516	19.467	2.929	0.065
WINGSJ101757.67-103345.7	17.22	1.11	10.8985	1.82	2.082	19.320	1.975	0.0547

Tab. 1 SDGs characteristics of GEMINI data

WINGS SDGs have been observed with GEMINI G-MOS with an exposure time of ~2700 s, using the B600 grism in the 1-slit mode. The FoV is ~3.5" x 5". The wavelength coverage goes from ~4000 to ~6900 Å.
Fig. 5 shows the maps of our SDGs sample with superimposed the IFU FoV, the effective radius (in red) and the fiber dimension over which we performed our spectrophotometric analysis (in blu)

We derived the stellar kinematics by using the pPXF algorithm by Cappellari & Emsellem (2004), that works in regions where S/N=10 (defined by a Voronoi tessellation). In our case we used as templates a set of MILES SSPs with 16 values of ages and 6 metallicities. Fig. 6 and Fig 7 show the velocity and the velocity dispersion maps. Number above the maps in Fig. 7 are the mean velocity dispersion and the V_{rms} ranges, where Vrms=sqrt(V^2+σ^2), while the number above maps in Fig. 6 is the Δv/2.
A first look at the V/σ relation shows that most SDGs are fast rotators (Fig. 4).

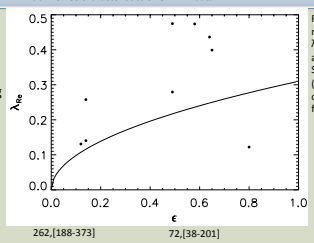

Fig.4 : Luminosity weighted angular momentum within R_e vs ellipticity. λ_{Re} has been defined following Emsellem et al., 2007. The line divides fast rotators (8 SDGs) from slow rotators (WINGSJ101722.48-103947.8). The fraction of SR resembles the one found in clusters for normal ETGs by Fogarty et al., 2014.

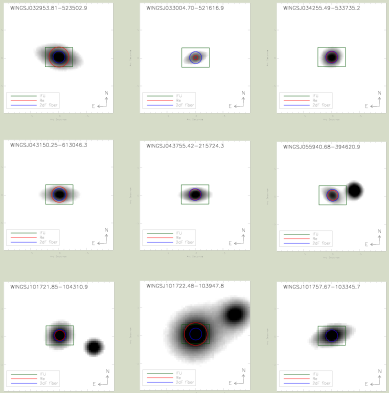

Fig. 5 Maps of GEMINI SDGs

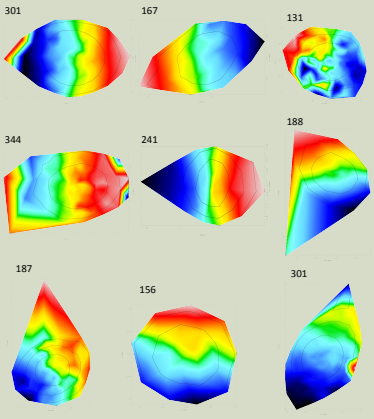

Fig. 6 SDG velocity maps. All galaxies but two show a clear rotation.

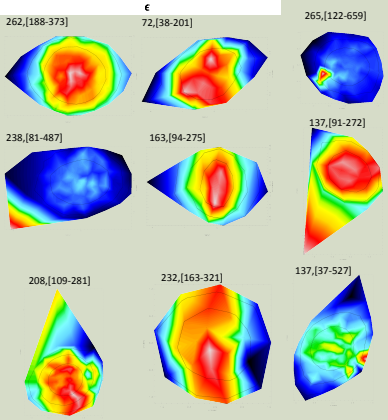

Fig. 7 velocity dispersion maps

We evaluate the dynamical mass using the Jeans Anysotropic MGE models by Cappellari 2008, that require only the first two velocity moments (namely V and σ) to extract the galaxy dynamical mass.. The starting point of these models is an accurate Multi-gaussian modelization (MGE) of the galaxy light, that we performed on the V band wide-field images of our clusters. Fig. 8 shows an example of the data and model comparison for one of our SDG. Particular care has been taken in the evaluation of the sky background, as well as in the choice of the flattest gaussian that enter in the fit (since it can bias the galaxy deprojection without having a real physical meaning). We then used a "self-consistent JAM model" (see Cappellari et al., 2013, Paper XV), where the underlying assumption is that the mass distribution follows the light one derived from the MGE fit, to evaluate the M/L ratio. This model has two non linear parameters (the vertical anisotropy $\beta=1-\sigma^2_z/\sigma^2_R$ and the galaxy inclination *i*). The M/L ratio is then derived imposing the match with the observed V_{rms}. The derived M/L is the total one, and not only the stellar one. Fig. 9 shows, for one of our galaxies, the data and model (left and right, respectively) for the velocity and the velocity dispersion (upper and lower panels). We are currently deriving the M/L_{JAM} for our galaxies with the aim of estimating the dark matter fraction inside R_e (by comparing it with the stellar M/L derived from spectrophotometry) and the possible influence of the adopted IMF. Fig. 10 shows the relation between the galaxies stellar mass and the velocity dispersion for a sample of PM2GC galaxies for which the velocity dispersion was available from SDSS. Black points are "normal" ETG, while red dots are what we defined as superdense galaxies. On average they show clearly a higher velocity dispersion. Black squares are our SDG in clusters, with the velocity dispersion derived from IFU data. Most of them show the same behaviour. We are currently analyzing in detail the lower σ galaxies, and improving the sample by analizing VIMOS data as well.

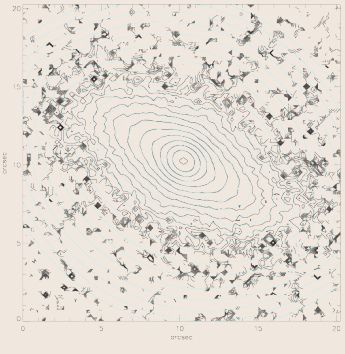

Fig. 8 Data and MGE model for WINGSJ055940.68-394620.9

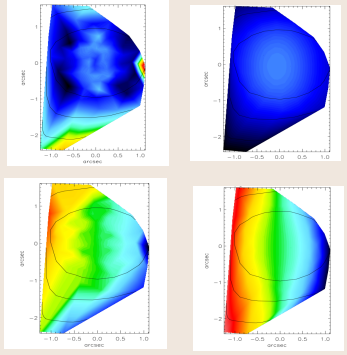

Fig. 9 Data and JAM best model for the velocity and the velocity dispersion map for WINGSJ055940.68-394620.9

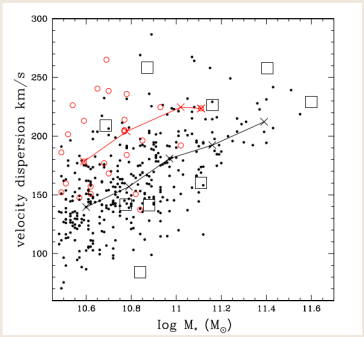

Fig. 10 Stellar mass vs velocity dispersion for PM2GC data (in black and red dots normal and SDG galaxies with velocity dispersion derived from SDSS).
Black squares are our SDG in clusters observed with GEMINI.