Evolution in Solitude

Field Galaxies from Half the Age of the Universe to the Present

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Abstract

We analyze the stellar populations and evolutionary history of bulge-dominated ($n_{ser} \geq 1.5$) field galaxies at redshifts up to z~1 as part of the Gemini/HST Galaxy Cluster Project (GCP). High signal-to-noise optical spectroscopy from Gemini Observatory and imaging from Hubble Space Telescope is used to analyze a total of 44 field galaxies, focusing on 30 passive (EW[OII]≤5Å) field galaxies . Our results indicate that the size-mass and size-velocity dispersion relations for the passive field galaxies show no significant evolution between z~1 and the present. The passive field galaxies contain younger stellar populations than cluster galaxies at similar redshifts, with a formation redshift z_{form} =1.2-1.4 compared to z_{form} =1.8 for the cluster galaxies. We establish the Fundamental Plane and study the M/L ratios, both indicating that the formation redshift for the passive field galaxies is mass dependent. The zero point differences of the scaling relations for the M/L ratios agree with the formation redshift of z_{form} =1.2-1.4 found from the line indices and are consistent with the passive evolution model.

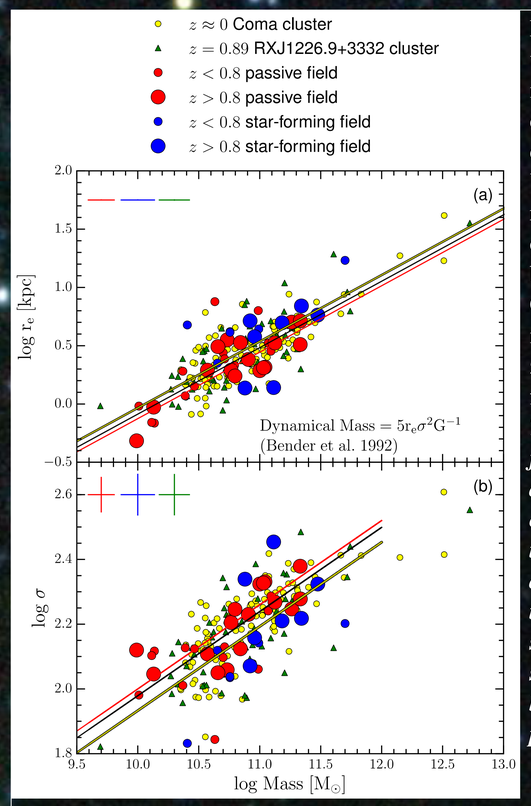

Fig 1: a)Effective radius versus dynamical galaxy mass. b) Velocity dispersion versus dynamical galaxy mass. Yellow line: best-fit relation for the Coma cluster; black and red lines: best-fit relation for the Coma cluster offset to the median zero points of the z<0.8 and z>0.8 passive field galaxies, respectively. ***The passive field galaxies follow the same relations as found for the Coma cluster sample. We therefore conclude that at a given dynamical mass, the field galaxies show no significant evolution of size or velocity dispersion between z~1 and the present.***

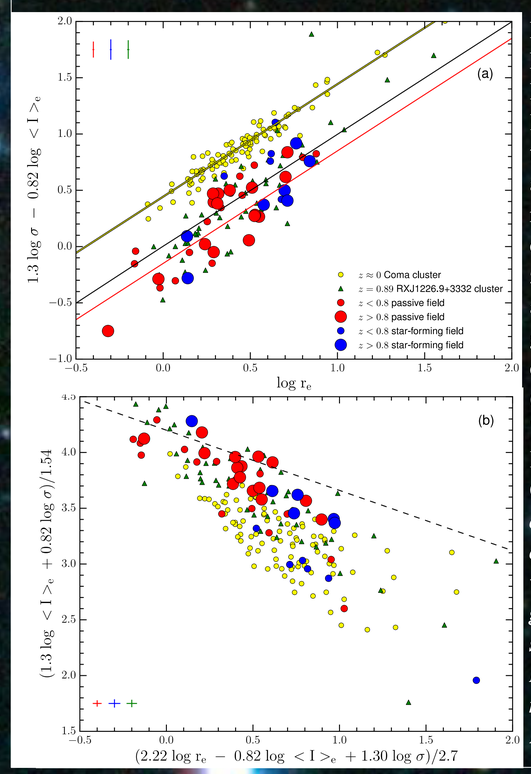

Fig 2: (a) Edge-on and (b) Face-on Fundamental Plane. Panel (a) yellow line: best-fit relation for the Coma cluster; black and red lines: best-fit relation for the Coma cluster offset to the median zero points of the z<0.8 and z>0.8 passive field galaxies, respectively. The dashed black line in panel (b), y=0:54x+4:2, is the "exclusion zone" noted by Bender et al. (1992) for the Coma cluster. ***The Coma cluster galaxies are well-constrained to the plane, while the passive field galaxies display more scatter. The Fundamental Plane is shown as the M/L ratio vs. log Mass in Figure 3.***

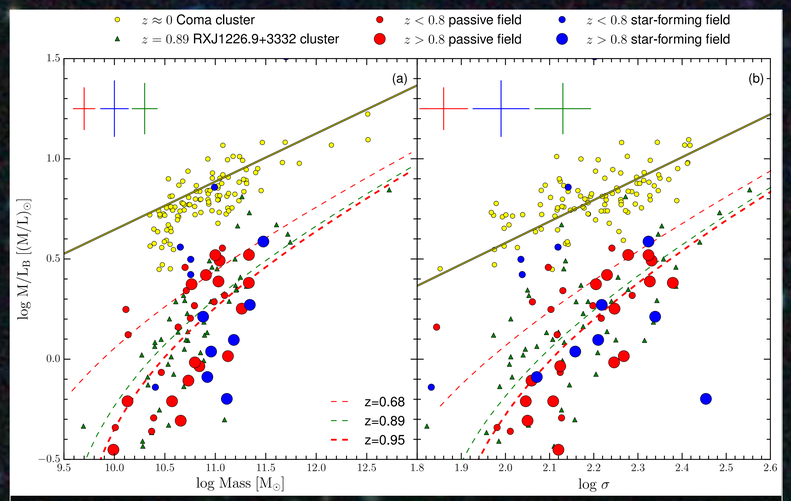

Fig 3: M/L ratios vs. log Mass and log σ. Models from Thomas et al. (2005) are plotted to show the predicted locations for the median redshifts of the samples. These models display the mass dependence of formation redshift for galaxies. ***The passive field galaxies roughly follow the models, inferring that the low-mass galaxies formed their stars more recently while the high-mass galaxies formed their stars at higher redshifts. The passive field galaxies show more evolution in the M/L ratios than the models.***

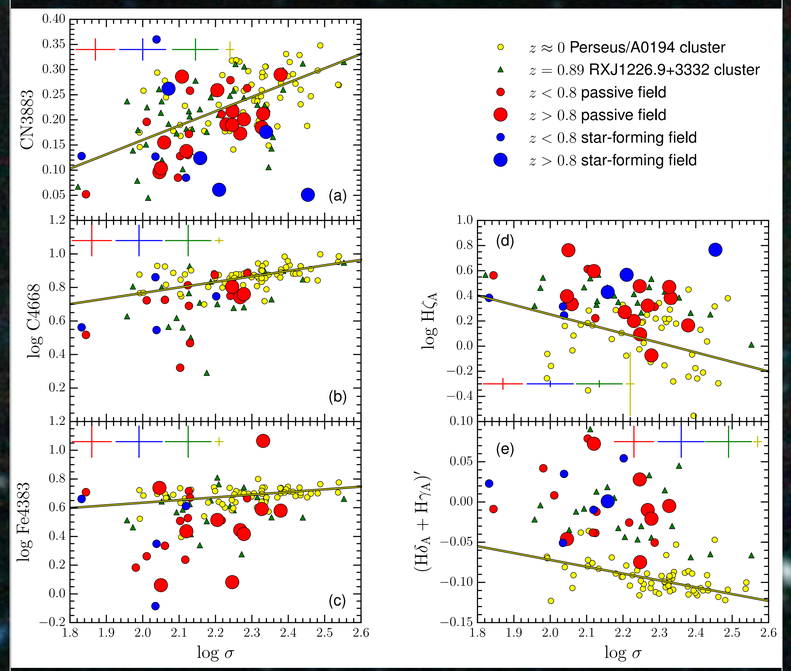

Fig 4: Line indices vs. velocity dispersions shown for the samples of bulge-dominated field galaxies together with our z~0 cluster sample and RXJ1226.9+3332 cluster sample. ***These line indices indicate a formation redshift of z_{form} =1.2-1.4 for the passive field galaxies, based on the models in Figure 5.***

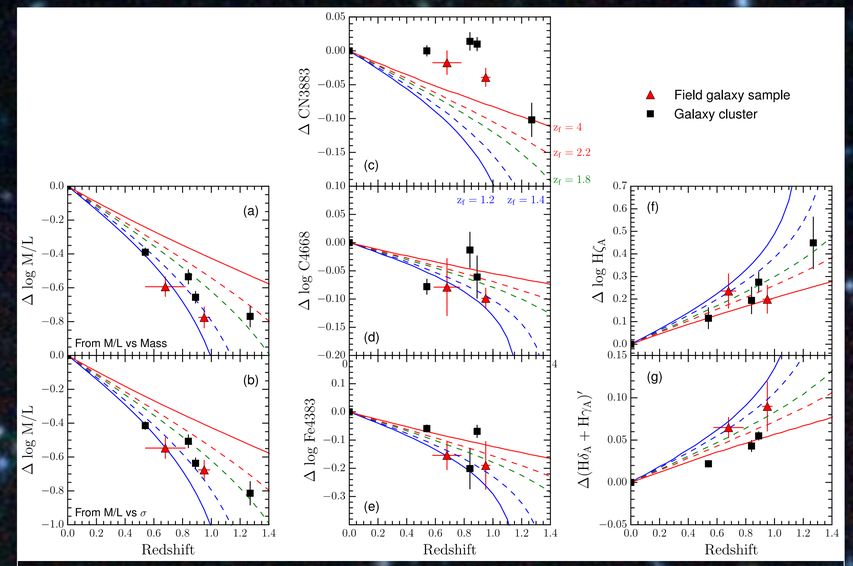

Fig 5: Zero point differences of the scaling relations vs. redshift. The zero point differences are derived as zp = zp_{FG} – $zp_{low\text{-}z}$. The lines overplotted show passive evolution models for z_{form} as labeled based on SSP models from Maraston et al. (2005), Maraston & Strömbäck (2011), and Thomas et al. (2011). The results for massive clusters are from the GCP (Jørgensen & Chiboucas 2013, Jørgensen et al. 2014) ***These figures show that the passive field galaxies are consistent with the passive evolution model. The passive field galaxies contain younger stellar populations than the cluster galaxies at similar redshifts with a formation redshift z_{form} =1.2-1.4 compared to z_{form} =1.8 for the cluster galaxies. The models are not consistent with our data for CN3883.***

Conclusions

- At a given dynamical mass, the passive field galaxies show no significant evolution in size or velocity dispersion
- The Fundamental Plane and M/L ratios vs. log Mass and log σ show that the passive field galaxies have a steeper slope than the Coma cluster relation, confirming that the formation redshift is mass dependent
- The passive field galaxies are consistent with the passive evolution model and contain younger stellar populations than the cluster galaxies at similar redshifts with a formation redshift z_{form} =1.2-1.4 compared to z_{form} =1.8 for the cluster galaxies

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