Compact passive and Ultra compact massive galaxies: A systematic comparison of KiDs with EAGLE and C-EAGLE

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Within the hierarchical assembly massive galaxies are seen to increase their size (from red nuggets to the large galaxies in the local universe), but due to the stochastic nature of mergers, some red nuggets can be seen also in the present universe, these are actually the relic galaxies. Observations find some discrepancies in the numerical abundances at low-z, but its difficult to quantify the evolution from an in-homogeneous sample of galaxies from different surveys . Thus, to study these discrepancies and analyze the evolution with redshift of the abundance of such objects we have studied the evolution of the most compact and massive and passive galaxies using EAGLE and C-EAGLE. Our main aim is to study the evolution with redshift and the role of the environment. EAGLE suite of hydro-simulations are the state-of-the-art numerical reproduction of the cosmic history of the Universe. C-EAGLE on the other hand is an independent hydro-simulation, based on EAGLE, concentrating on exploring the clusters and their environment. We use EAGLE and C-EAGLE to predict the number of the most compact among the most massive galaxies particularly the so called Ultra-compact massive galaxies (UCMGs) with effective radius $R_e < 1.5$ kpc and stellar mass $> 8 \times 10^{10}\ M_\odot$ (accordingly to Trujillo et al. 2009 and Tortora et al. 2018). These predictions are compared with abundances of UCMGs in galaxies and clusters in KiDS. We show the results for 333 sq. deg. of the survey, and investigate the trend of abundances with redshift (at $z < 0.5$). We have cross-matched with the catalogues of UCMGs to find the abundances of UCMGs in clusters. We compared: (1) abundances derived in the whole 333 sq. deg. of KiDS with abundances in EAGLE reference simulation (100 cMpc); and (2) abundances in KiDS clusters with abundances in C-EAGLE (29 clusters in Bahé et al. 2017). We selected all the UCMGs (using Re calculated with mass particles), counted them in redshift bins, and the number in each redshift bin is divided by the comoving volume of the simulation (i.e. 100 Mpc^3). In KiDS, we counted the galaxies in redshift bins, renormalized to the full sky area and divided by the comoving volume relative to that redshift bin; these number counts are however relative to mixed environments, since no selection has been done in terms of environment. We find that using the r-band effective radii R_{e_r}, the number of compacts is decreasing, the red (superimposed to the blue point) is for passive EAGLE galaxies with this selection. No UCMGs are left in the other bins if r-band Re is used for the selection. We find an excellent agreement using $R_{e_{mass}}$, also in the trend with redshift, while we find differences in abundances if we use R_{e_r}. For comparison with C-EAGLE, at each redshift slice, we count the UCMGs in the 23 simulated clusters (from CE-0 to CE-29 in table A1 of Bahé et al. 2017), and normalize these numbers by the total comoving volume of the clusters. For obtaining the entire volume of the cluster we consider here the volume corresponding to 10 times of r_{200}). We find that in the KiDS clusters, abundances are larger than in the mixed environment case. As expected this can explain the discrepancies at z = 0 among different studies, e.g. Trujillo et al 2008 versus analysis in denser environments in Poggianti et al. 2013). We find an evolution with redshift, consistently with data (Tortora et al. 2019), but there are some issues with the way sizes are defined. And the environment seems to have a role, since these relic galaxies are more abundant in dense environments. We also study the impact of several combinations for the threshold for the selection function, considering the numerical convergence limitations in simulations.