STUDYING THE COLOUR-MAGNITUDE RELATION OF SIMULATED EARLY-TYPE GALAXIES

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In this work we present preliminary results of the study of the colour-magnitude relation (CMR) of early-type galaxies at different redshifts (z) in cosmological numerical simulations. Our analysis explores the evolution of that relation from z = 2 to z = 0, selecting a sample of simulated objects that display properties observed in early-type galaxies of the Local Universe. These results represent the starting point of a project aimed at identifying the processes that originated the CMR at z = 0, performing a comprehensive comparison between simulated and observed early-type galaxies.

INTRODUCTION

In the colour-magnitude diagram (CMD), early-type (ET) galaxies trace a well-defined sequence from dwarfs to giant, where brighter galaxies tend to be redder. This colour-magnitude relation (CMR) is considered as universal, in the sense that it is observed in both groups and clusters of galaxies, and it has been interpreted as a relation between stellar mass and stellar metallicity, with brighter and redder galaxies tending to be more massive and more metal-enriched. Nevertheless, processes that establish and define it are not yet totally known for certain.

In this work, we present a preliminary study that extends a previous analysis of the CMD for early-type galaxies extracted from cosmological numerical simulations, studying the behaviour of the diagram as function of redshift. Our main goal is to provide clues in order to explain the origin of the CMR, studying its evolution since the formation times of elliptical galaxies until today.

THE EAGLE SIMULATIONS

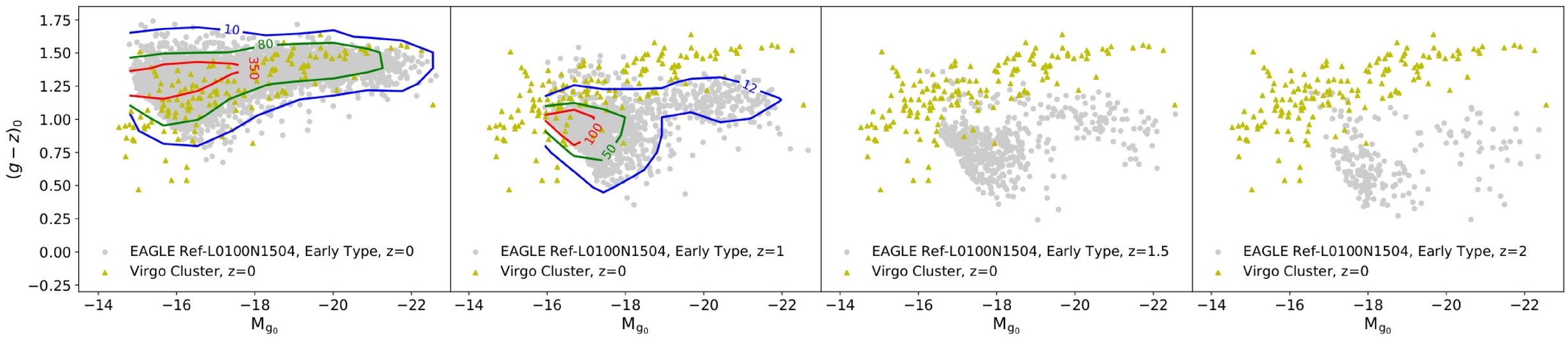
In this work, we use simulations of the EAGLE (Evolution and Assembly of GaLaxies and their Environments) project (Schaye et al., 2015), a suite of cosmological, hydrodynamical simulations of a standard ΛCDM universe. The cosmological parameters used for the EAGLE simulations are those of the Planck Collaboration (2015): Ω_Λ=0.693, Ω_m=0.307, Ω_b=0.048 and h=0.6777.

We started working with the reference, intermediate-resolution simulation (Ref-L0100N1504), which has a box size lenght of 100 cMpc, with an initial baryonic particle mass of 1.81 x 10^6 $M_\odot$ and a maximum proper softening length of 0.70 pkpc. Due to its volume, with this simulation we are able to obtain a significant number of galaxies (in particular, galaxies of intermediate and high masses) at redshifts we analyse.

GALAXY SELECTION

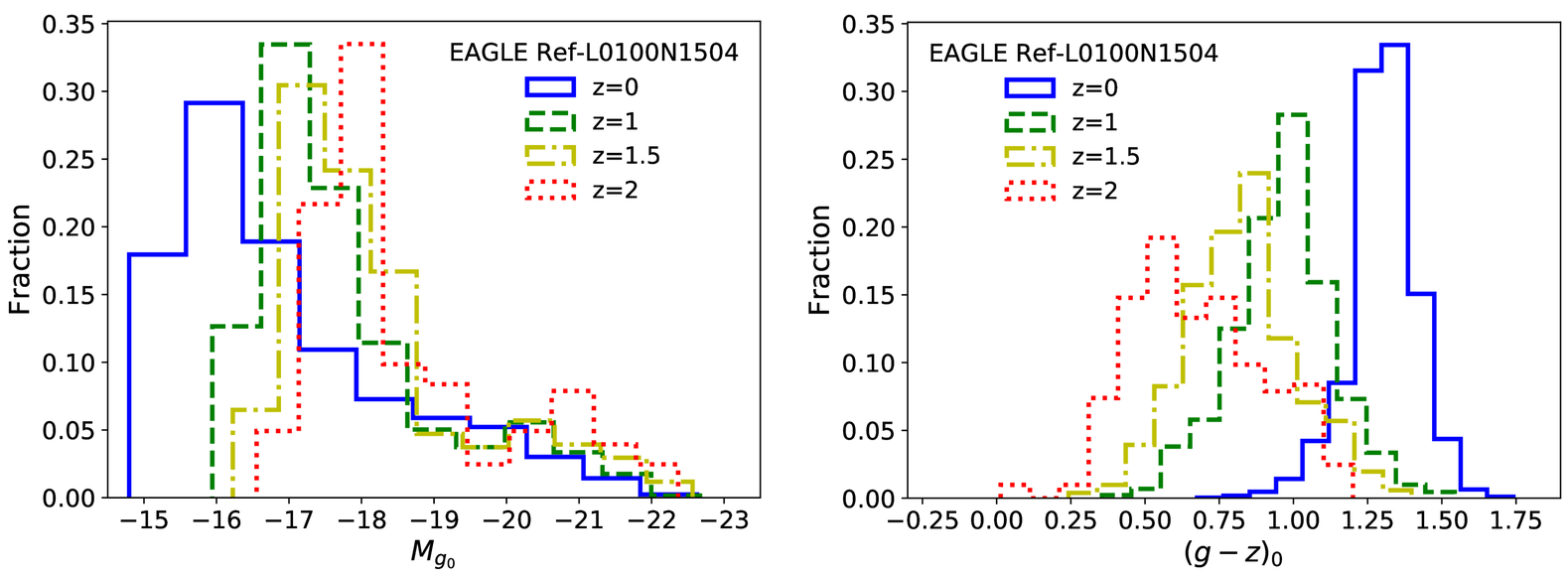
From the Ref-L0100N1504 EAGLE simulation, we extracted a sample of galaxies at redshifts from z=0 to z=2, with $M_\star \geqslant 10^9$ $M_\odot$, $\log(SFR/M_\star) \leqslant -11$ yr^{-1} and star forming gas fraction (with respect to star forming mass + stellar mass) lower than 0.1 (Zenocratti et al., 2018). Galaxies fulfilling these conditions are defined as our simulated sample of early-type galaxies. In order to check our selection criteria, we compared the CMD of the z=0 sample of simulated galaxies with that of the early-type galaxies in the Virgo Cluster (Chen et al., 2010; Sánchez-Janssen et al., 2018). The CMD of the simulated galaxies agrees with the observed one.

COLOUR-MAGNITUDE DIAGRAMS AT DIFFERENT REDSHIFTS



Panels show the simulated $(g-z)_0$ vs M_{g_0} CMD at z=0 to z=2. For comparison, galaxies of the Virgo Cluster (which are at z=0) are shown in every panel. Some contours of constant number of galaxies are plotted in the first two panels. As can be seen, at higher z the simulated early-type galaxies are brighter and bluer, and the number of such galaxies decreases. Also, most of the simulated galaxies are located in the redder-less bright (-less massive) region of the CMD.

DISTRIBUTION OF MAGNITUDES AND COLOURS



In these two panels, the distributions of magnitude M_{g_0} and colour $(g-z)_0$ are shown for redshifts from z=0 to z=2. With respect to the distribution in magnitude, the low-magnitude peak moves towards less luminous magnitudes at lower z, which means that from z=2 to z=0, ET galaxies tend to have less brightness; also, at z=2 and z=1.5, a bimodality in the distribution can be seen, hence there are two population of simulated ET galaxies at those times. The brightest systems might be ET galaxies still in development.

The distribution of colour $(g-z)_0$ shows that at lower z, galaxies are redder, with the maximum of the distribution more pronounced, i.e., the scatter in colour seems to decrease towards lower z.

SUMMARY

- We started studying the evolution with redshfit of the CMR for simulated ET galaxies, extracted from the EAGLE Ref-L0100N1504 simulation. Our selection criteria give us a sample at z=0 consistent with the observed CMD for ET galaxies in the Virgo Cluster.
- In the CMD, the distribution of ET galaxies moves towards redder and less luminous regions with decreasing z. At lower z, more low-luminosity systems appear.
- At lower z, ET galaxies tend to be redder, with a decreasing scatter in the colour distribution.
- In a future work, other EAGLE simulations with variations in the subgrid physics will be analyzed, in order to determine how variations in parameters affect the CMR. Also, evolution of galaxies in the CMD will be studied, and a detailed comparison with observations will be performed.

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