COSMOLOGICAL SIMULATIONS AND GALAXY FORMATION: PROSPECTS FOR HST/WFC3

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Abstract. The star formation history of nearby early-type galaxies is investigated via numerical modelling. Idealized hydrodynamical N-body simulations with a star formation prescription are used to study the minor merger process between a giant galaxy (host) and a less massive spiral galaxy (satellite). We find that the evolution of the star formation rate is extended over several dynamical times and shows peaks which correspond to pericentre passages of the satellite. The newly formed stars are mainly located in the central part of the satellite remnant while the older stars of the initial disc are deposited at larger radii in shell-like structures. Synthetic 2D images in J, H, NUV, Hβ and V bands, using the characteristic filters of the Wide Field Camera 3 (WFC3) on the Hubble Space Telescope, reveal that residual star formation induced by gas-rich minor mergers can be clearly observed during and after the final plunge, especially in the near-ultraviolet band, for interacting systems at ($z \leq 0.023$) over moderate numbers of orbits (for more details see Peirani et al. 2010).

Keywords: formation, galaxies: interactions, galaxies: structure, galaxies: kinematics and dynamics, galaxies: photometry, methods: N-body simulations

1 Introduction

Understanding the formation of early-type galaxies (ETGs), and in particular their star formation history, is of crucial importance for setting strong constraints on models of galaxy formation. It is now well known that ETGs have considerable substructure (e.g. from SAURON and GALEX) which is interpreted as a result of mergers in the past several gigayears. To study this plausible process, we have compared the ultra-violet (UV) colours of nearby ($0.05 \leq z \leq 0.06$) early-type galaxies with synthetic photometry derived from numerical simulations of minor mergers, with reasonable assumption for the ages, metallicities and dust properties of the merger progenitors (Kaviraj et al. 2009). We found that the large scatter in the ultra-violet colours of intermediate mass early-type galaxies in the local universe and the inferred low-level recent star formation in this objects can be reproduced by minor mergers in the standard ΛCDM cosmology. In the present work, our aim is to study the evolution of the internal structure of these objects using the same methodology but with higher mass resolution, in order to help understand in more detail the observational signatures of satellite minor merger events with different mass ratios, gas-fractions and orbital configurations. This work is also motivated by the recent installation on the Hubble Space Telescope (HST) of NASA's Wide Field Camera 3 (WFC3*) whose optical design provides a large field of view and high sensitivity over a broad wavelength range, excellent spatial resolution and a stable and accurate photometric performance. It features two independent imaging cameras, a UV/optical channel (UVIS) and a near-infrared channel (IR).

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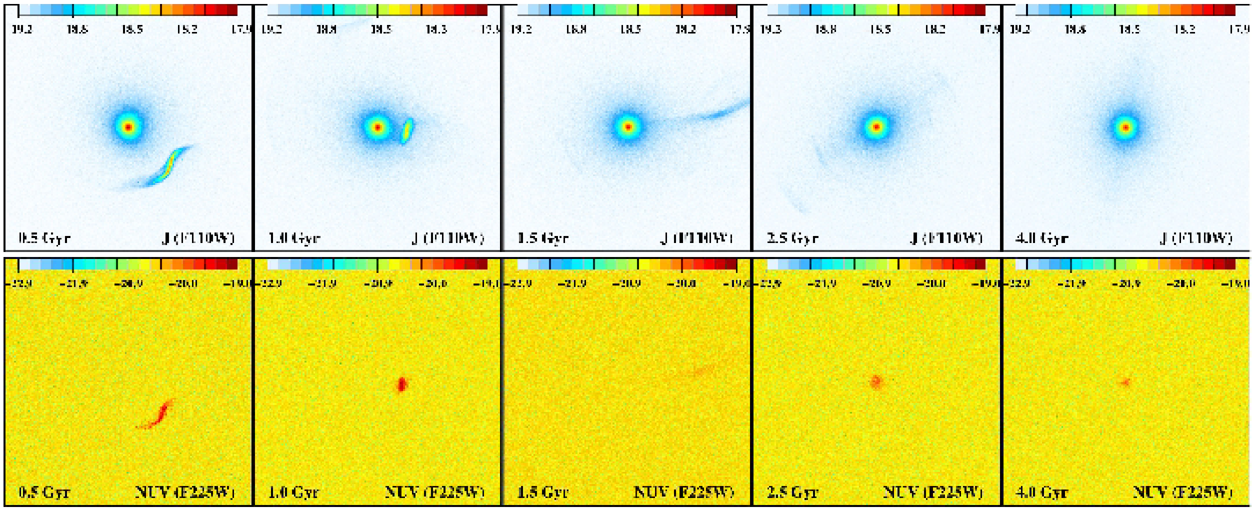

Fig. 1. The evolution of synthetic images through J (first line) and NUV (second line) assuming the observed system at $z \sim 0.023$. the magnitude units given as measures of spectral flux are $W\,m^{-2}$, and in all synthetic images, we use a logarithmic scale.

2 Evolution of WFC3 bands

In order to produce synthetic images, we have assumed our galaxy system to be in the local universe. The galaxy pair is supposed to be at a redshift $z \sim 0.023$ (or equivalently at a luminosity distance of $D = 100$ Mpc) in order to facilitate comparisons with future observational data. In Fig.1, we present the grid map derived by our numerical modelling through the J and NUV bands. From the J band, it appears that it is possible to resolve the host elliptical galaxy and the satellite remnant, in particular the shell structure which is mainly composed of old stars. However, this latter tends to disappear at $t = 4.0$ Gyr. From the NUV band, the ongoing star formation regions can be clearly followed. In particular, after the final plunge, ongoing star formation located at the center of the galaxy can be clearly observed.

Thus, the combination of IR and UVIS images allows us to separate different stellar populations and then distinguish the most bound part of the satellite remnant, composed of young stars, from the host galaxy, composed of older stars. This combination also gives useful clues on the formation of ETGs: while the shell structure revealed in IR images support a past merger scenario, evidence or not of the presence of young stars in UVIS images bring additional constraints on the wetness/dryness of the merger.

3 Conclusions

The present work shows that minor mergers induce amounts of star formation in ETGs which can be measured through UV bands. WFC3 represents the best instrument to study these minor merger events because it has a matching UV and optical FOV and gives the resolution to see young substructures (which would not be possible with GALEX for instance). The previous ACS/HRC UV detectors had a tiny FOV so it was not possible to study a galaxy up to 1 effective radius because one would get the whole galaxy in the optical image and only a fraction of its core using the UV. With WFC3, it is now possible to map the entire galaxy in both the UV and optical making it possible for the first time to perform spatially resolved star formation histories in ETGs at low redshift using the UV. Moreover the ability to see the young substructures is important because it rules out UV flux from old sources such as horizontal branch stars (which would follow the optical light profile).

References

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