Galaxy Evolution and Feedback across Different Environments
Proceedings IAU Symposium No. 359, 2020
T. Storchi-Bergmann, W. Forman, R. Overzier & R. Riffel, eds.
doi:10.1017/S1743921320002410

Stellar populations and ionised gas in central spheroidal galaxies

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Abstract. We investigate the stellar populations and ionised gas properties of a sample of central spheroidal galaxies in order to better constrain their history of star formation and gas excitation mechanism. We select galaxies from Spheroids Panchromatic Investigation in Different Environmental Regions (SPIDER) catalogue and separate these galaxies in different regimes of halo and galaxy mass. To characterise the stellar population properties of these galaxies we use the stellar population synthesis method with the Starlight code, and the presence of ionised gas is identified by measurements of the Hα equivalent width. We analyse how these properties behave as a function of the galaxy stellar mass and the parent halo mass. A trend is observed in the sense of increased ionised gas emission for low-mass centrals in high-mass halos. We interpret this trend in a scenario of intracluster medium (ICM) cooling versus active galactic nuclei (AGN) feedback in a Bondi accretion context.

Keywords. galaxies: clusters: general – galaxies: clusters: intracluster medium – galaxies: active

1. Introduction

Central galaxies of dark matter massive halos, usually of spheroidal morphology, have distinct physical properties relative to non-central spheroidal galaxies with comparable mass. Several studies suggest that, because they are in a privileged halo location, such objects are subject to evolutionary processes distinct from those that operate in non-central galaxies. Such mechanisms, however, are poorly understood, in particular regarding their effects on the barionic content evolution (Von Der Linden *et al.* 2007).

2. Methods

We use Spheroids Panchromatic Investigation in Different Environmental Regions (SPIDER, La Barbera *et al.* 2010) sample of early-type galaxies ($0.05 < z < 0.095$), selected from the sixth data release (DR6) of the Sloan Digital Sky Survey (SDSS). We characterise the environment where these galaxies are located using the Yang group catalogue (Yang *et al.* 2007), being 15,572 central galaxies. The stellar population parameters were derived from SDSS DR12 optical spectra (Alam *et al.* 2015). In order to increase the spectral signal-to-noise ratio, we stack the galaxy spectra in a grid of stellar velocity dispersion and parent halo mass by median-combining the flux-normalised individual spectra. Stellar population synthesis was performed with the Starlight code (Cid Fernandes *et al.* 2005) using simple stellar populations (SSPs) drawn from the BC03 (Bruzual & Charlot 2003) and Vazdekis (Vazdekis *et al.* 2015) evolutionary models.

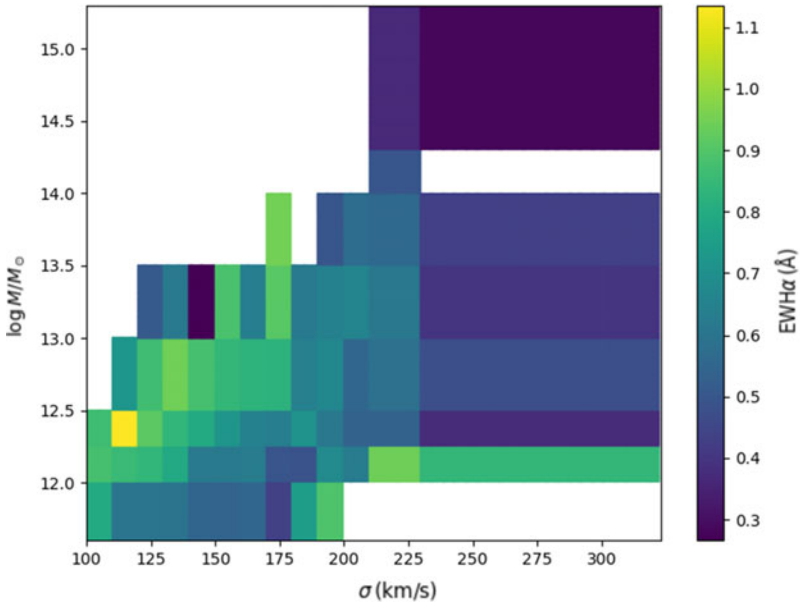

Figure 1. EWHα as a function of the galaxy velocity dispersion and halo mass.

The synthesis include a contribution of a power law ($F_\lambda = \lambda^{-1.5}$) in order to characterise a possible active galactic nuclei (AGN) signature.

We construct a model for the ionised gas content, explicitly in terms of galaxy stellar mass (σ) and halo mass (M_h), since these are the parameters that we use in the creation of our stacks and both are directly related to the AGN feedback and the intracluster medium (ICM) thermal energy (Stott *et al.* 2012). Using the Bondi accretion model (Bondi 1952) to describe the AGN feeding, we model the ratio between the AGN power and the internal energy of the ICM. We find the following relation for equivalent width of Hα (EWHα):

$$\log EW_{H\alpha} \propto \gamma(-10.74 \log \sigma + 1.67 \log M_h). \tag{2.1}$$

3. Results

We find that the extinction A_V, the EWHα and the contribution of a power law increases as the halo mass increases and the mass of the central galaxy decreases. The mean stellar ages present the opposite behaviour, while the mean stellar metallicity is higher for higher halo masses and galaxy velocity dispersion. In Figure 1, we present the EWHα as a function of the galaxy velocity dispersion and halo mass. For each observable A, we fit the function $\log(A) = a \log \sigma + b \log M_h + c$ by a least squares method.

We find that with $\gamma \sim 0.073$ the theoretical coefficients become very similar to those observed in our stacks (~ -0.78 and ~ 0.121 for a and b, respectively). This suggests that the ionised gas emission is governed by the ratio of the thermal energy of the ICM to the instantaneous power of the AGN in a Bondi accretion scenario.

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https://doi.org/10.1017/S1743921320002410 Published online by Cambridge University Press

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https://doi.org/10.1017/S1743921320002410 Published online by Cambridge University Press

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