Kinematics and star formation histories of brightest cluster galaxies

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Abstract

We present a study on the kinematics and star formation histories of brightest cluster galaxies (BCGs) in a sample of clusters over a 3.4 Gyr time period ($0.3 < z < 0.8$). We analyze the spectroscopic data of the BEAMS[1] BCGs observed on the Southern African Large Telescope (SALT). We focus on stacking the spectra to increase the signal-to-noise ratios for more accurate measurements from which stellar populations and star formation histories can be measured as a function of cluster mass and redshift.

Introduction

Brightest cluster galaxies (BCGs) are the most massive and luminous galaxies in the Universe. A typical BCG is located near the centre of its parent cluster and well-aligned with the cluster galaxy distribution suggesting that it lies at the bottom of the cluster's gravitational potential well. A fraction of the BCGs exhibit recent star formation, and therefore evolutionary histories that are in stark contrast with the conventional expectation that giant elliptical galaxies in clusters of galaxies are all quiescent, passively evolving, 'red and dead' systems.

The Cluster Sample

The data in this study utilise a large sample of BEAMS Optical selected clusters. The subset of this cluster sample, consists of 150 clusters and are within the redshift interval $0.3 < z < 0.8$.

- The data was obtained with the RSS on (PI: M. Hilton) SALT.
- Reduction was performed with the RSSMOSPipeline.

Identifying the BCG

- Identification through visual inspection.
- The BCG need not necessarily be photometrically the brightest galaxy.

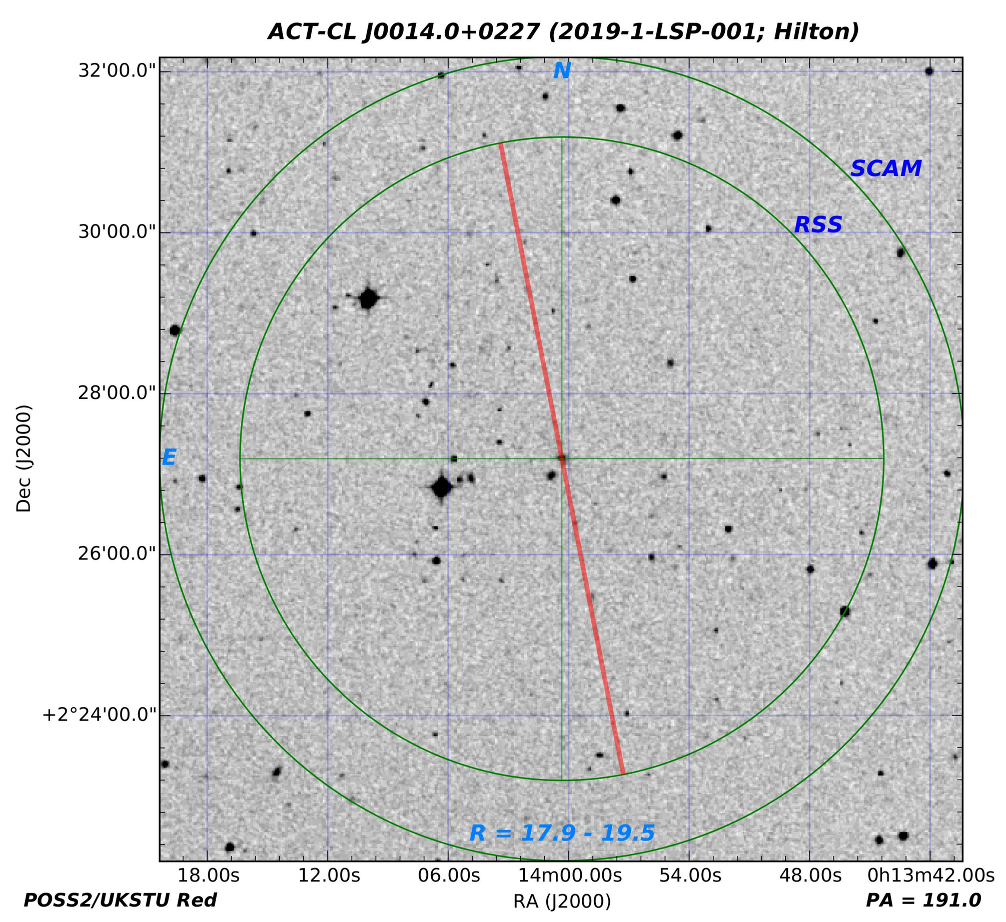

Figure 1: SALT finders' chart of J0014.0+0227, used in the identification process of the BCG.

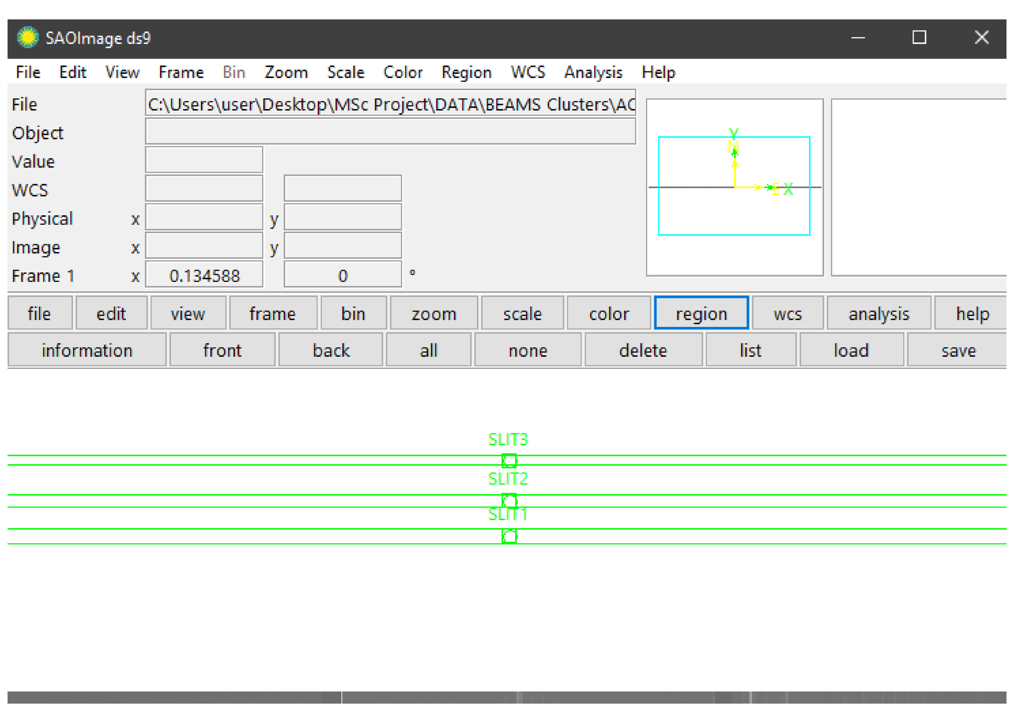

Figure 2: Region file of J0014.0+0227, used in the identification process of the BCG.

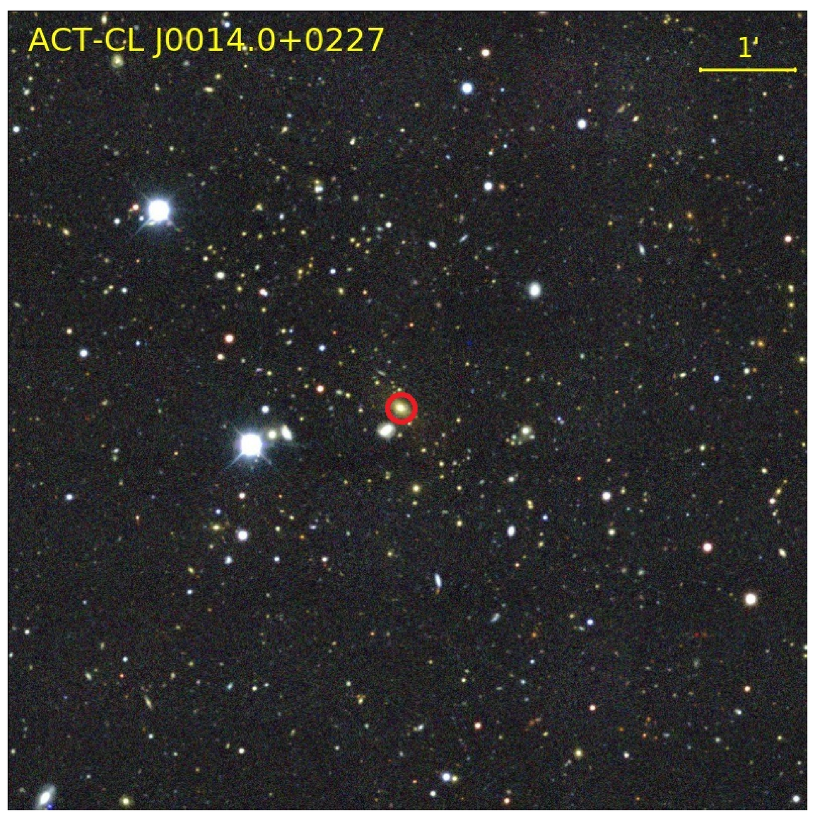

Figure 3: Dark Energy Survey (DES) image of the BCG of ACT-CL J0014.0+0227 (z = 0.337). The BCG is circled in red.

PPXF and specstack

- PPXF (Cappellari, 2017; Vazdekis et al., 2010) used to find the velocity dispersion and measure any emission lines present.

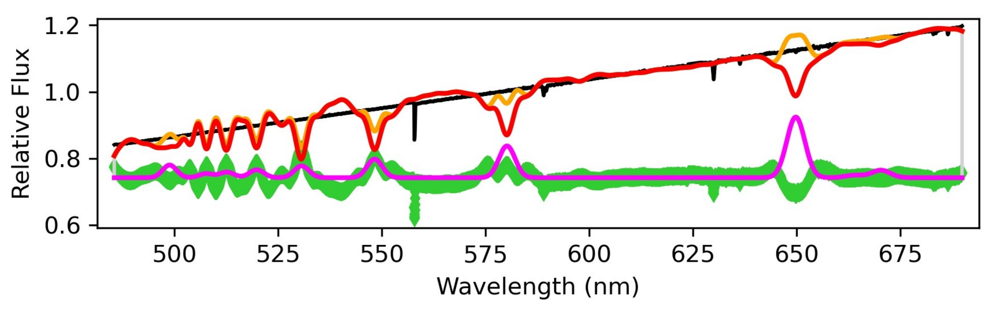

Figure 4: Spectra of ACT-CL J0014.0+0227 at z = 0.337, before stacking. The S/N of a single BCG is too low to fit with stellar templates.

- Spectra stacked using specstack.

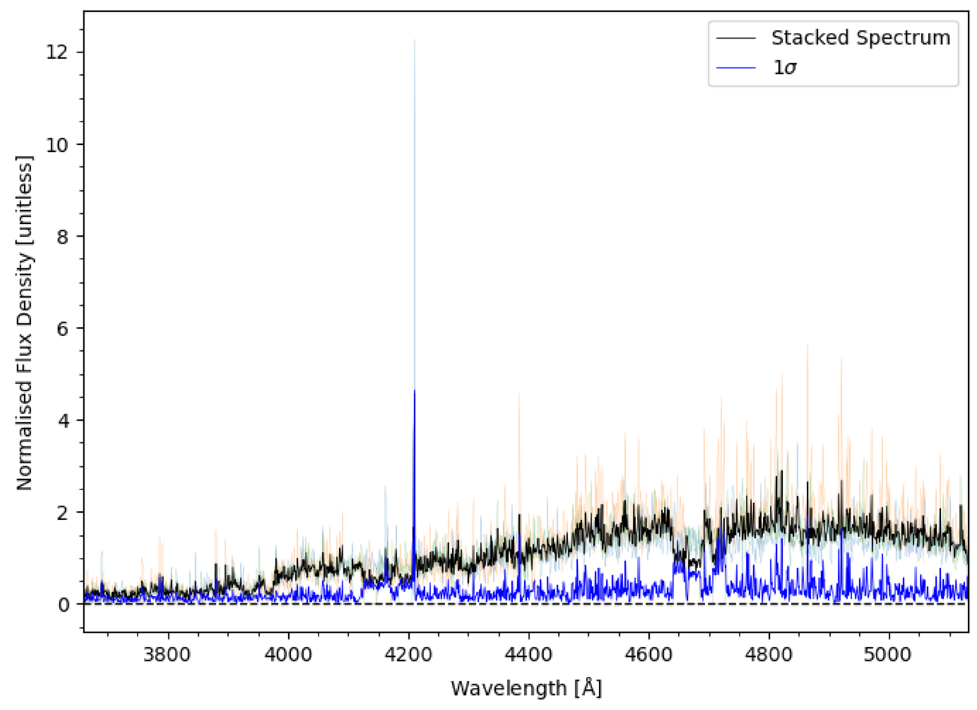

Figure 5: Stacked spectra of ACT-CL J0405.9-4915, J0014.0+0227 and J2031-4037 at z = 0.325, 0.337 and 0.344 produced by specstack.

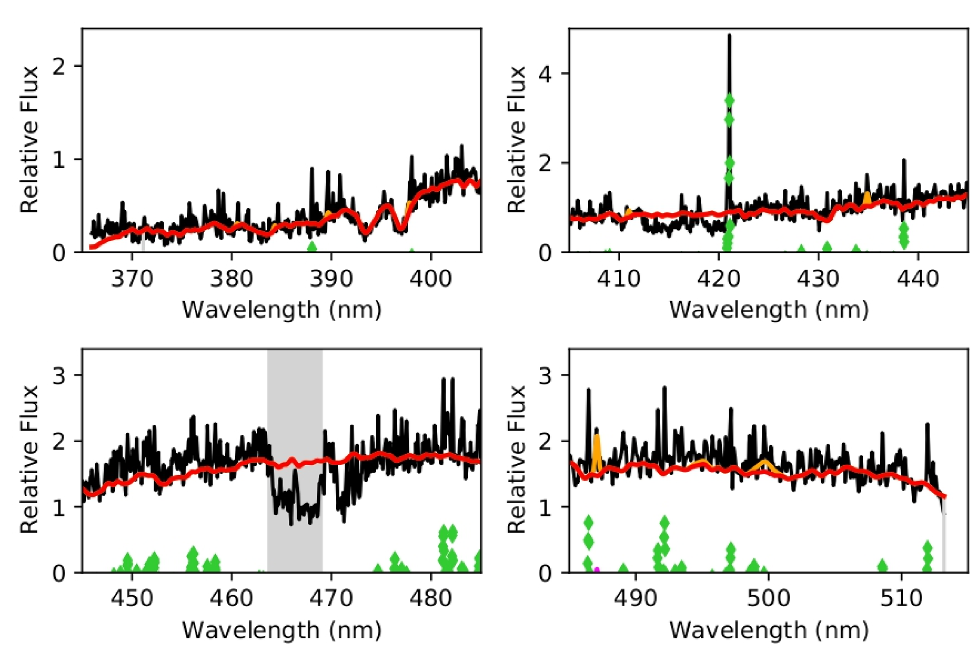

Figure 6: Stacked spectra of ACT-CL J0405.9-4915, J0014.0+0227 and J2031-4037 at z = 0.325, 0.337 and 0.344.

FIREFLY

- We use FIREFLY (Wilkinson et al., 2017) to fit the stacked spectra to derive stellar population ages and metallicities.

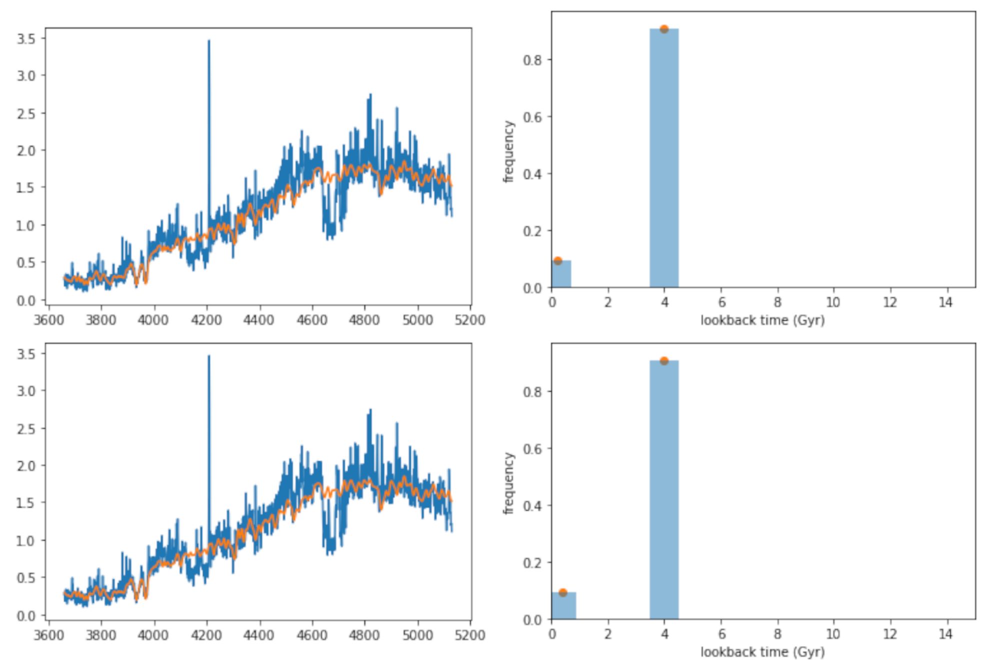

Figure 7: Top : E-MaStar model for the Kroupa Initial mass function (IMF) shown is the fitted spectra (left) and lookback time (right). Bottom: E-MaStar model for the Salpeter IMF.

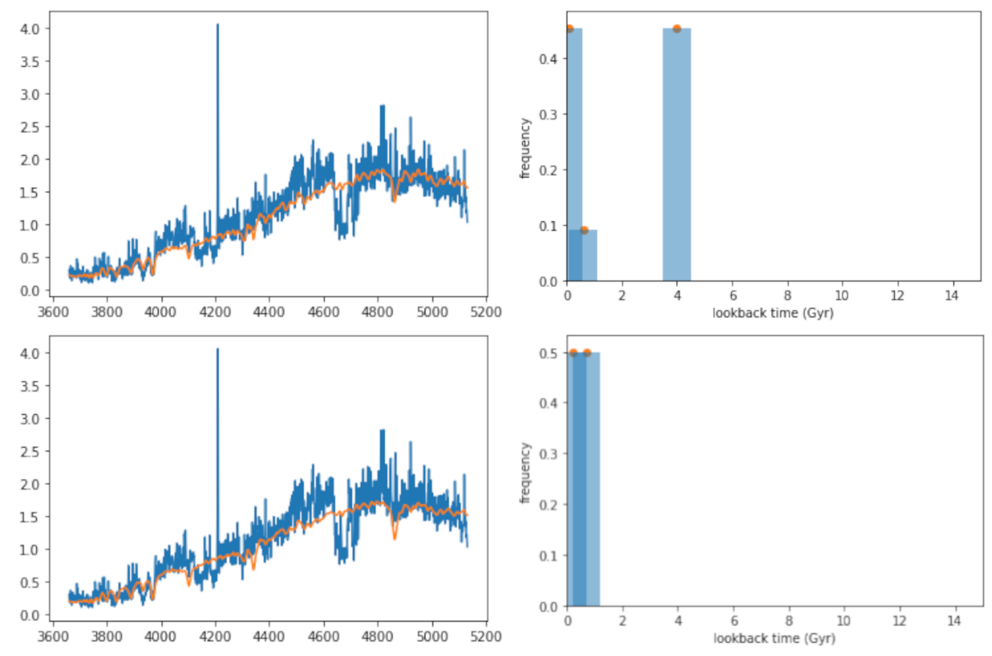

Figure 8: Top: MILES model for the Kroupa IMF shown is the fitted spectra (left) and lookback time (right). Bottom: MILES model for the Salpeter IMF.

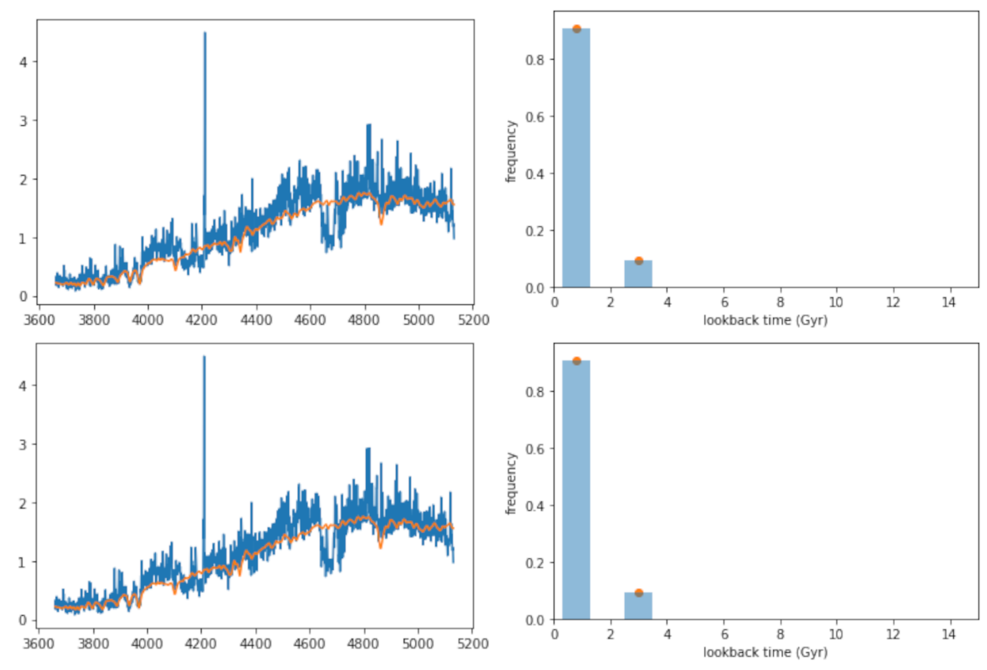

Figure 9: Top: STELIB model for the Kroupa IMF shown is the fitted spectra (left) and lookback time (right). Bottom: STELIB model for the Salpeter IMF.

Conclusions

- Single BCG spectra not enough S/N to fit with spectral fitting software PPXF and FIREFLY.
- We use specstack to stack spectra in redshift bins to achieve enough S/N.
- We measure stellar kinematics with ppxf.
- We measure stellar populations using firefly for different models, stellar libraries and IMFs to determine the ages and metallicies of the stacked spectra (and systematic errors)
- Enables us to investigate BCG evolution with redshift.

Acknowledgements

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References

Cappellari, M. (2017). Improving the full spectrum fitting method: Accurate convolution with gauss–hermite functions. *MNRAS*, 466(1):798–811.

Vazdekis, A. et al. (2010). Evolutionary stellar population synthesis with miles–i. the base models and a new line index system. *MNRAS*, 404(4):1639–1671.

Wilkinson, D. M. et al. (2017). Firefly (fitting iteratively for likelihood analysis): a full spectral fitting code. *MNRAS*, 472(4):4297–4326.

[1] BEAMS - https://acru.ukzn.ac.za/~beams/