Extragalactic globular cluster near-infrared spectroscopy

I. Integrated near-infrared spectra of Centaurus A/NGC 5128

L. G. Dahmer-Hahn[1], A. L. Chies-Santos[2], E. Eftekhari[3,4], E. Zanatta[5], R. Riffel[2,3], A. Vazdekis[3,4], A. Villaume[6,7], M. A. Beasley[3,4,8], and A. E. Lassen[2,9]

ABSTRACT

Context. One way to constrain the evolutionary histories of galaxies is to analyse their stellar populations. In the local Universe, our understanding of the stellar population properties of galaxies has traditionally relied on the study of optical absorption and emission-line features.

Aims. In order to overcome limitations intrinsic to this wavelength range, such as the age-metallicity degeneracy and the high sensitivity to dust reddening, we must use wavelength ranges beyond the optical. The near-infrared (NIR) offers a possibility to extract information on spectral signatures that are not as obvious in traditional optical bands. Moreover, with the current and forthcoming generation of instrumentation focusing on the NIR, it is mandatory to explore possibilities within this wavelength range for nearby-Universe galaxies. However, although the NIR shows great potential, we are only beginning to understand it. Widely used techniques such as a full spectral fitting and line strength indices need to be tested on systems that are as close to simple stellar populations as possible, and the result from the techniques need to be compared to the yields from a traditional optical analysis.

Methods. We present a NIR spectral survey of extragalactic globular clusters (GCs). The set was composed of 21 GCs from the Centaurus A galaxy that were obtained with SOAR/TripleSpec4, which covered the ~1.0-2.4 μm range with a spectral resolution ($R = \lambda/\Delta\lambda$) of 3500. These spectra cover Hβ equivalent widths between 0.98 Å and 4.32 Å, and [MgFe]' between 0.24 Å and 3.76 Å.

Results. This set was ideal for performing absorption band measurements and a full spectral fitting, and it can be used for kinematic studies and age and abundance measurements. With this library, we expect to be able to probe the capabilities of NIR models, as well as to further improve stellar population estimates for the GCs around the Centaurus A galaxy.

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(first paper of a series of 5 papers)

How reliable are NIR stellar population models?

- Understanding a galaxy's evolution requires determining its stellar population properties.
- Optical wavelengths have been commonly used for the analysis, but have limitations like age-metallicity degeneracy.
- NIR would mitigate some issues found in the optical studies.
  - NIR light is dominated first by RSG, then by RGB, RC, and AGB.
  - These populations are weakly dependent on age → metallicities and abundances can be measured without age uncertainty.
  - CO and OH (3.3μm) molecular lines are useful to measure the O abundance.
- However, the current NIR models are not mature (reliable) due to such as how to account for the influence of TP-AGB stage.
- Model spectra have been studies with galaxy spectra (i.e., CSP) → should be done with SSP.
- → Spectroscopy of globular clusters in NGC5128 with TripleSpec4 on SOAR 4.1m.
  - R~3500 0.9-2.4 simultaneous spectroscopy with a long slit.
  - Sample from the public optical spectral catalog (Beasley+08)
    - **[MgFe]'**: proxy for metallicity, **Hβ** for age.

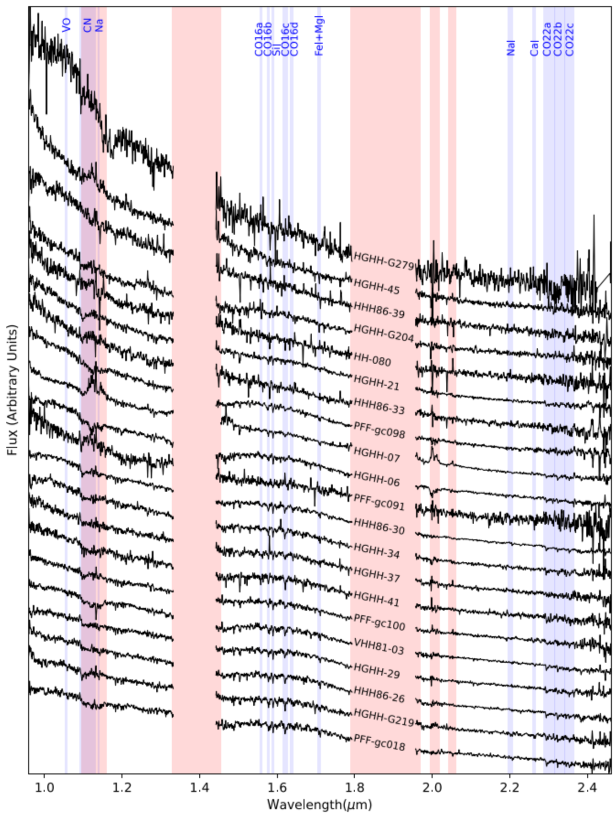


Fig. 2. NIR spectra of our sample, normalized at the H band plus a constant, and sorted by J-K colour. Regions with high telluric absorption are masked in red. We also highlight in blue the main stellar absorptions from Riffel et al. (2019) with a sufficient S/N and without an optical counterpart.

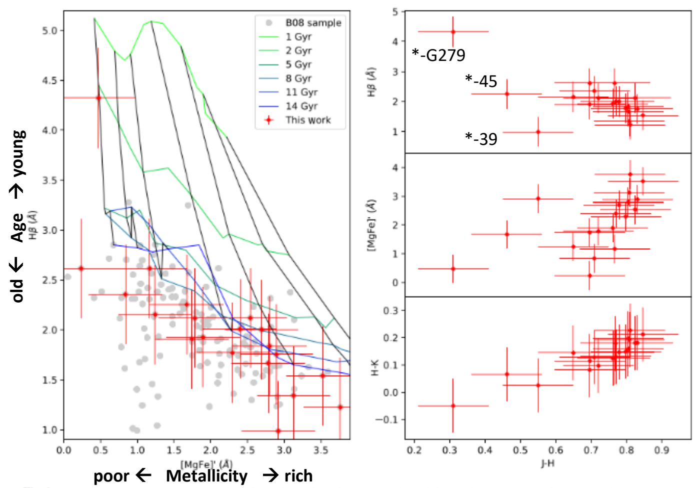


Fig. 1. Main properties for our sample. In the *left* panel, we show that our sample (red diamonds) covers Hβ and [MgFe]' values from B08 (grey circles). For comparison, we overplot the Hβ×[MgFe]' grid measured from the E-MILES model library. Different ages are represented using different colours, and the different metallicities are all represented in black (from left to right, the [M/H] tracks are equal to -2.27, -1.79, -1.26, -0.66, -0.25, +0.15, and +0.40). In the *right* panels, we show the correlations between J-H colours (x-axis) and Hβ (*upper*), [MgFe]' (*middle*), and H-K colours (*bottom panels*). We plot the respective errors in all panels as red crosses over each respective diamond.

↑ Fig.1: Optical/NIR properties of the sample.

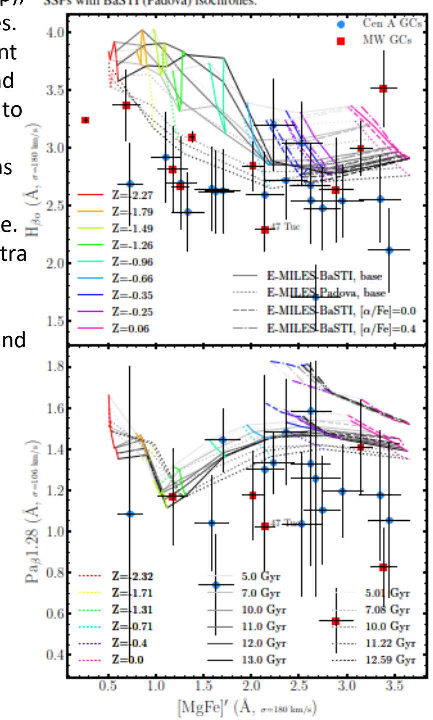
(Left):
- Most of the sample appears to be older than the age of the Universe (age zero-point problem).

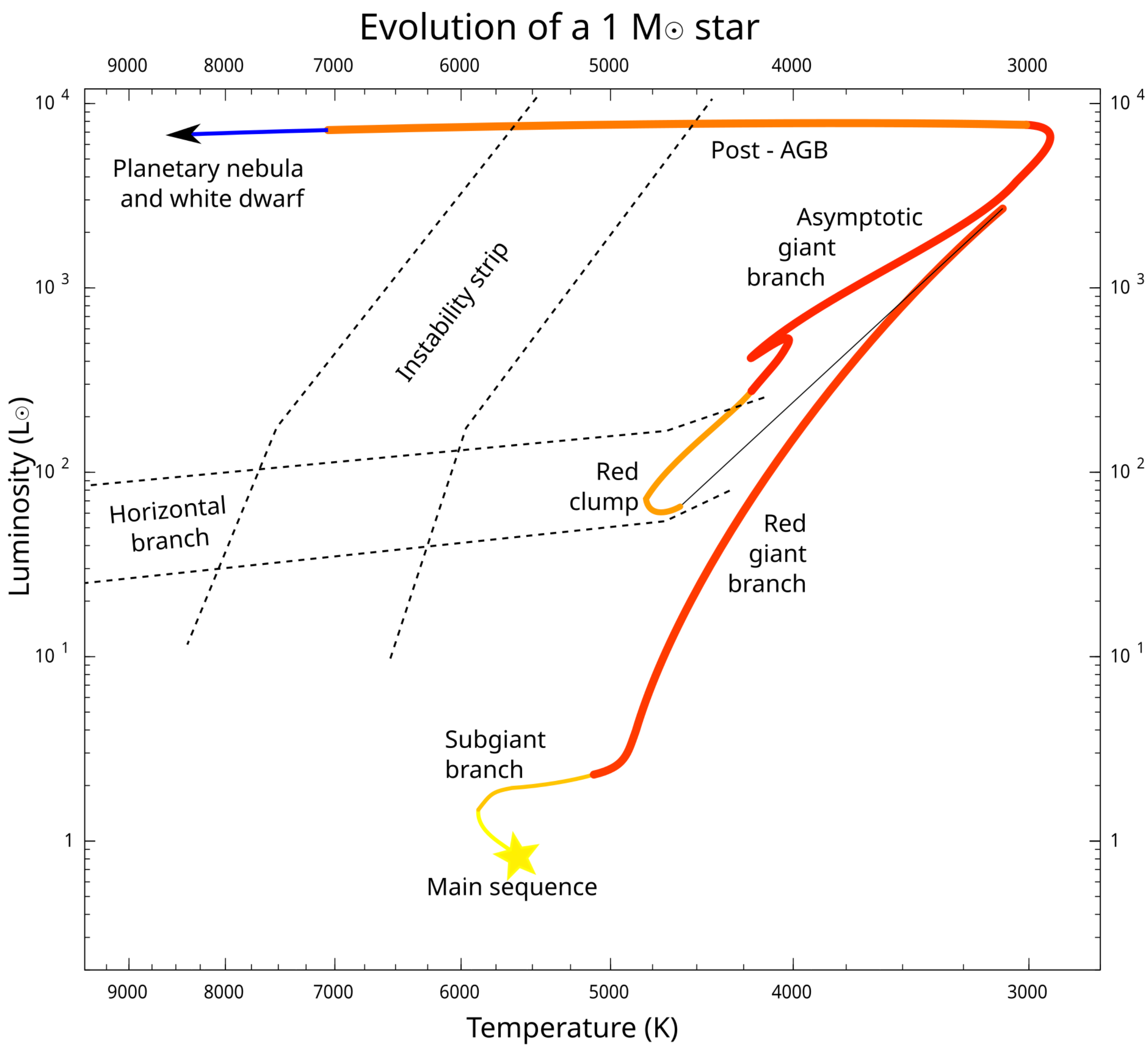
(Right)
- #G279 has larger Hβ EW and bluer in J-H.
  - Identified as a young (1.7 Gyr) cluster by optical spectroscopy.
  - Deeper NIR data are needed for further analysis.
- #45 and #39 have bluer in J-H.
  - They may contain hot horizontal branch stars (T~1e4K) → bluer in NIR.
  - Index analysis or spectral fitting would provide more details and constrain models.

Fig2 in Paper II →

- For the first time, the age zero-point problem has also been identified in NIR (Paβ), independent of isochrones.
- Enhancement of α-element (affecting temperature and luminosity of stars) failed to resolve the age problem.
- Inclusion of binary systems could have an impact.
  - Can cause younger age.
- Note that NIR model spectra used in BPASS have uncertainties in the treatment of cool giants and molecular bands.

Fig. 2. Line strengths of two hydrogen line indices, Hβo in the optical (upper panel) and Pa$_\beta$1.28 in the NIR (lower panel), plotted against the total metallicity indicator [MgFe]' for two samples of GCs in the Cen A galaxy (blue points) and MW (red squares). The overlaid grids represent predictions from updated E-MILES SSP models with BaSTI and Padova isochrones (solid and dotted lines), as well as E-MILES SSPs with [α/Fe] = 0.0 and +0.4 (dashed and dash-dotted lines). These models span a range of metallicities from Z = -2.27 (-2.32) to solar, as indicated by various colours, and ages ranging from 5 to 13 Gyr (12.59 Gyr) for SSPs with BaSTI (Padova) isochrones.





https://www.wikiwand.com/en/articles/Red-giant_branch