Modelling integrated spectrum to study hot stellar components in old stellar populations

Thayse Adineia Pacheco
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October 25^{th}, 2023

Why do we study integrated spectrum of old GC?

- Improve stellar population synthesis models;
- Infer ages in a more reliable way;
- Break the degeneracy between age and HB morphology;
- Extragalactic motivation: unresolved studies.

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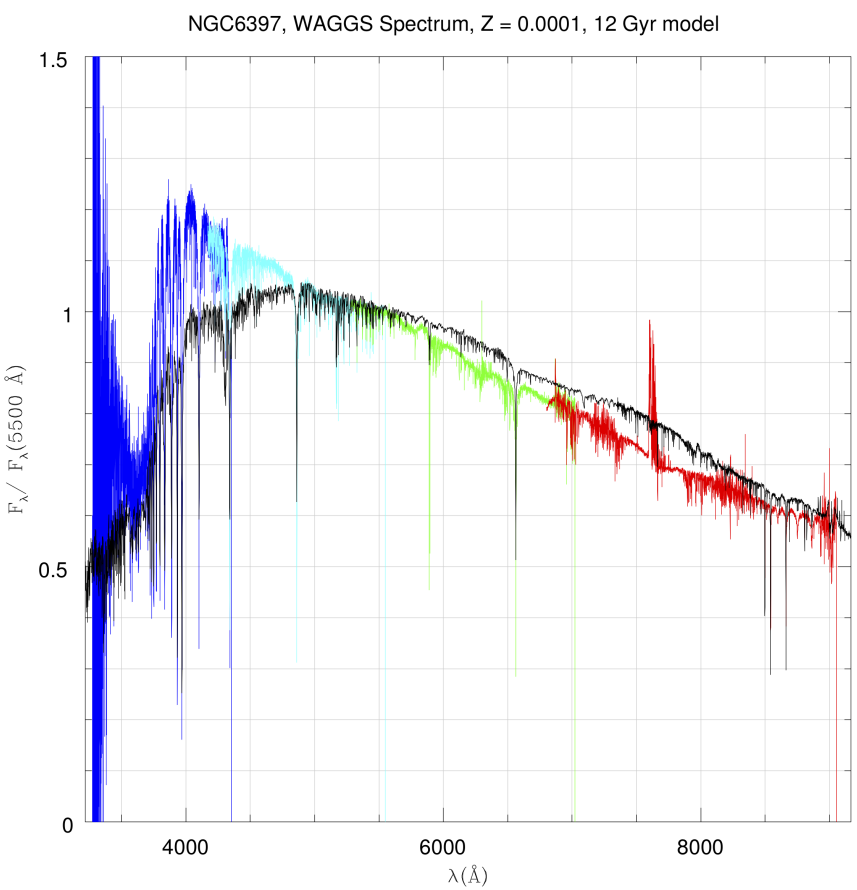
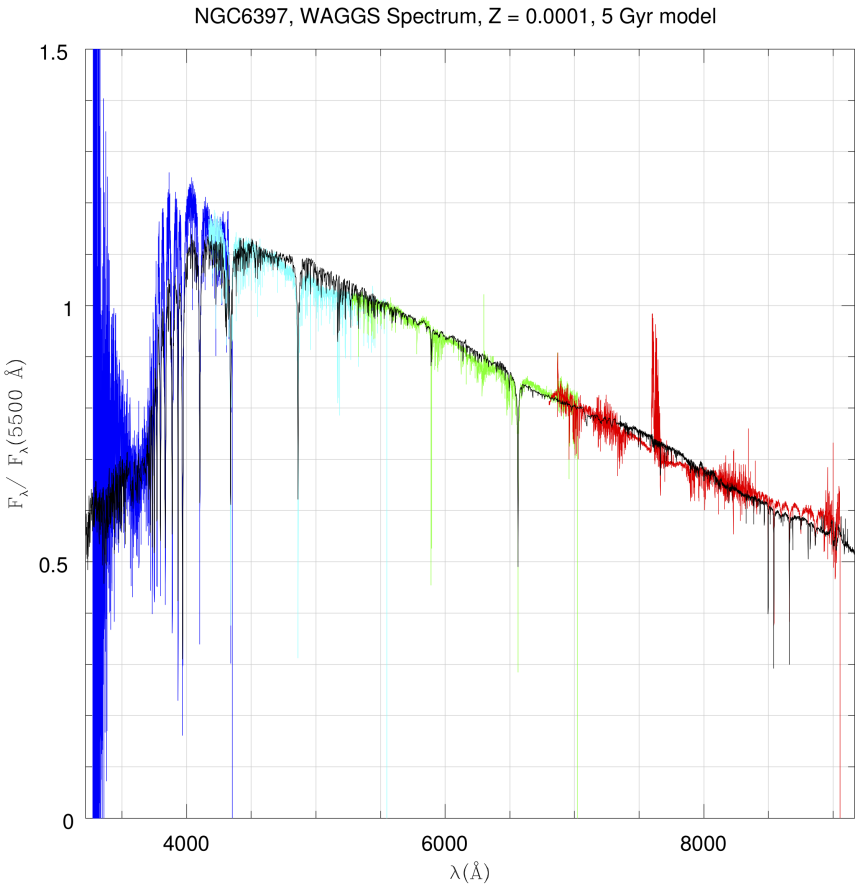
Integrated spectrum (NGC 6397)

12 Gyr

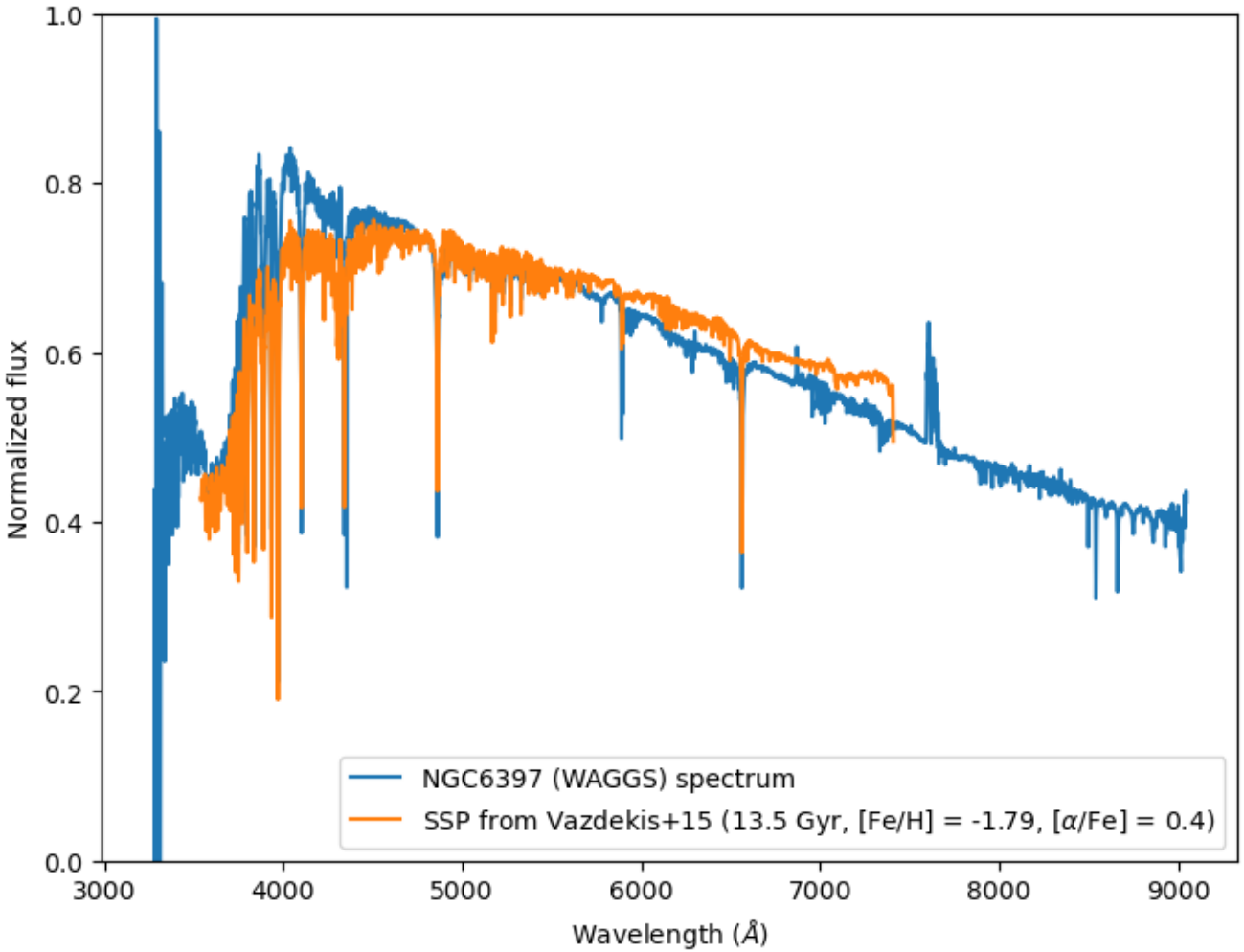


5 Gyr



WAGGS spectra from Usher+17 (colored) compared with SSP of Charlot & Bruzual (black).

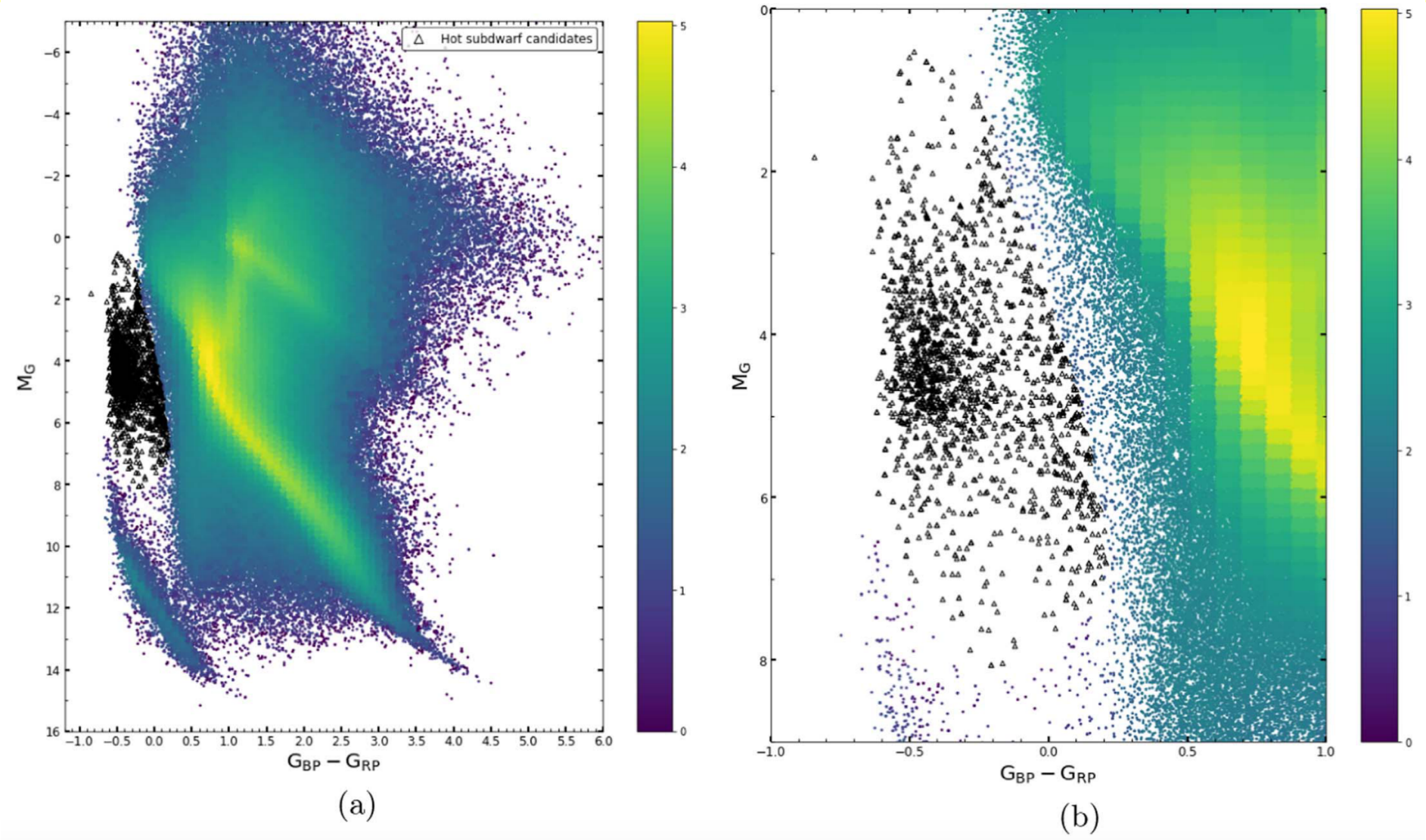
Integrated spectrum (NGC 6397) - 13.5 Gyr



- Horizontal branches;
- Subdwarfs;
- White dwarfs.

WAGGS spectra from Usher+17 (blue) compared with SSP of Vazdekis+15 (orange).
Private communication with Geraldo Gonçalves.

Hot low-luminosity and low-mass components



Cross-matching Gaia DR2 database with LAMOST DR5 database.
2,074 hot subdwarf candidates. Figure 1 from Lei+19.

Subdwarf atmosphere models and synthetic spectra

The Astrophysical Journal Supplement Series, 256:41 (10pp), 2021 October https://doi.org/10.3847/1538-4365/ac2508

A Grid of Synthetic Spectra for Subdwarfs: Non-LTE Line-blanketed Atmosphere Models

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Abstract

A new grid of detailed atmosphere model spectra for hot and moderately cool subdwarf stars is presented. High-resolution spectra and synthetic photometry are calculated in the range from 1000–10,000 Å using non-LTE fully line-blanketed atmosphere structures. Our grid covers eight temperatures within $10{,}000 \leqslant T_{\rm eff}\,[{\rm K}] \leqslant 65{,}000$, three surface gravities in the range $4.5 \leqslant \log g\,[{\rm cgs}] \leqslant 6.5$, two helium abundances matching two extreme helium-rich and helium-poor scenarios, and two limiting metallicity boundaries regarding both solar ($[{\rm Fe/H}] = 0$) and Galactic halos ($[{\rm Fe/H}] = -1.5$ and $[\alpha/{\rm Fe}] = +0.4$). Besides its application in the determination of fundamental parameters of subdwarfs in isolation and in binaries, the resulting database is also of interest for population synthesis procedures in a wide variety of stellar systems.

Unified Astronomy Thesaurus concepts: Stellar atmospheres (1584); Spectral energy distribution (2129); Stellar spectral lines (1630); Subdwarf stars (2054)

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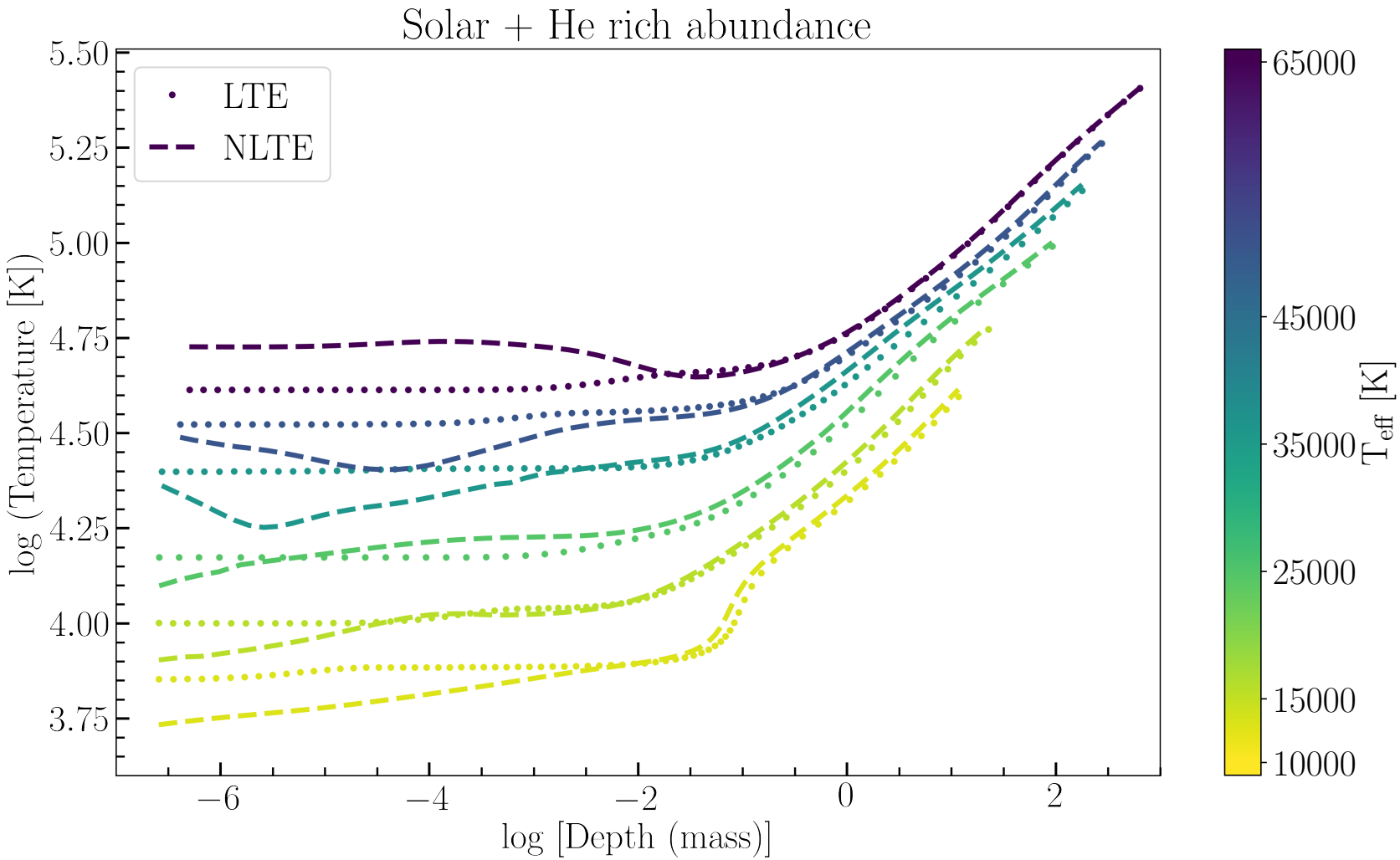
Proceedings of sdOB 10*th* conference

(Pacheco+23, Bulletin de la Société Royale des Sciences de Liège)

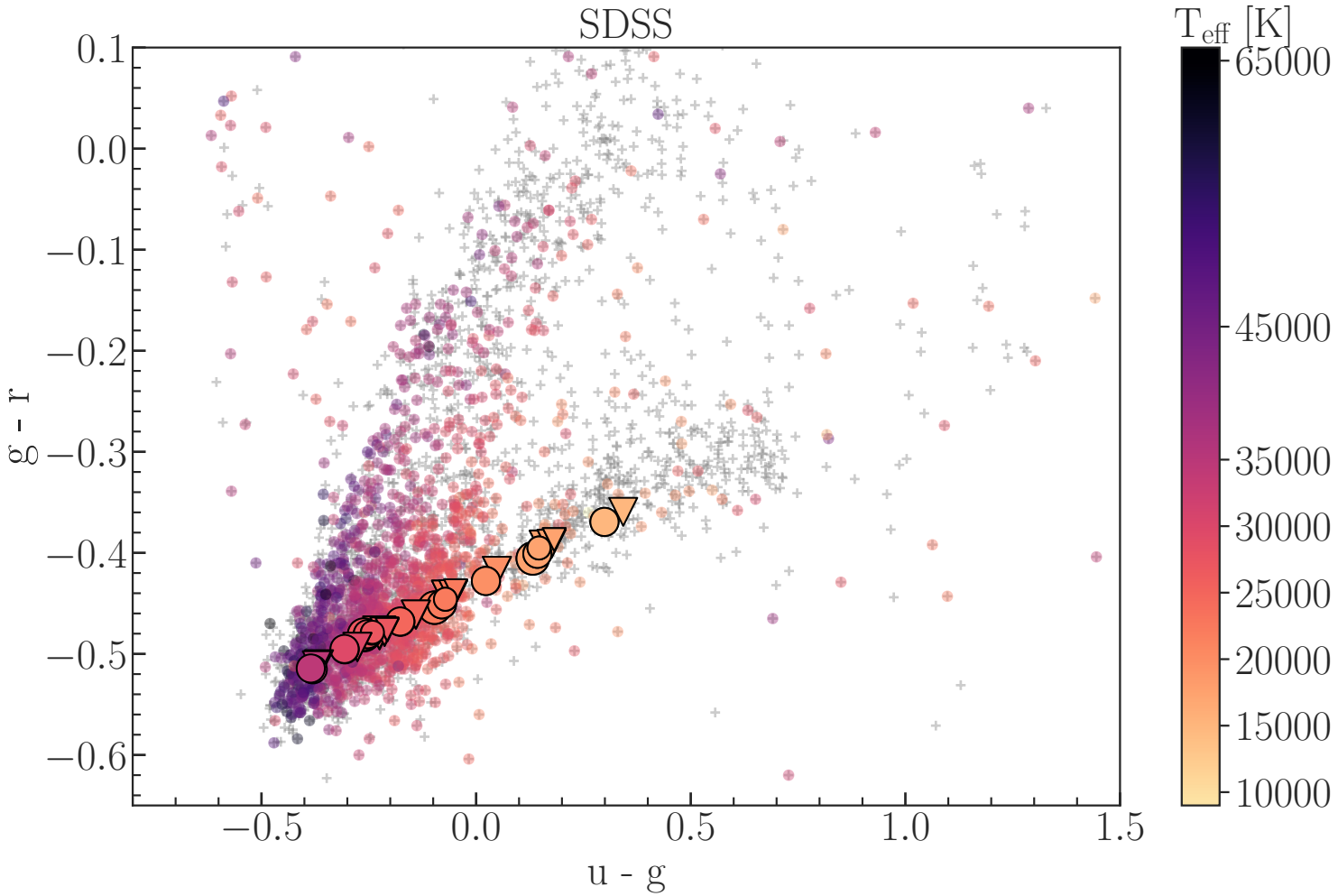
Atmosphere structure models (Fig. 1a from Pacheco+21)



Temperature as function of mass depth in logarithm scale.
These models have solar and He-rich abundance and $\log g$ [cgs] = 4.5.

Synthetic magnitudes and SDSS data

Fig. 10 from Pacheco+21 updated.
Fig. 1 from Pacheco+23.



Color-color diagram composed by observational data on subdwarfs from SDSS (Geier20).

Download (Pacheco+21, arXiv:2110.02229) (Pacheco+23, arXiv:2307.08362)

- Spectral models of stars and stellar populations: http://specmodels.iag.usp.br/
- VizieR: vizier.cds.unistra.fr/viz-bin/VizieR?-source=J/ApJS/256/41
- Spanish Virtual Observatory (SVO): svo2.cab.inta-csic.es/theory/newov2/index.php?models=pacheco

How much do hot low-mass stellar components contribute to the old stellar population?

Method to model integrated spectrum;

Based on the CMD method by Martins+19 (Pacheco+ a, *in prep*).

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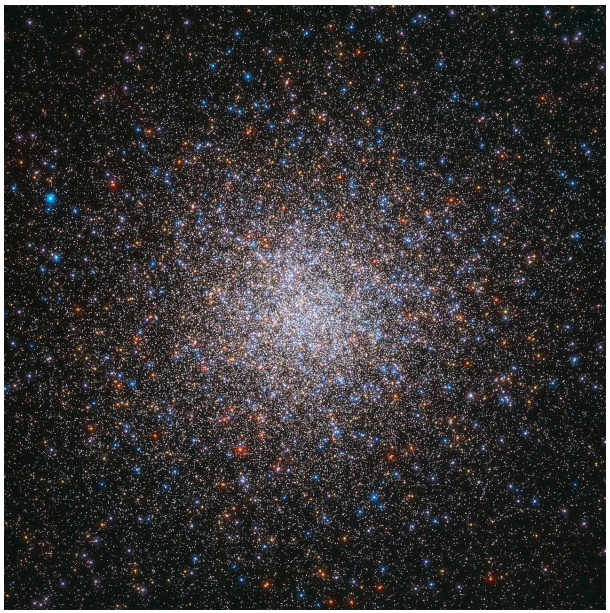
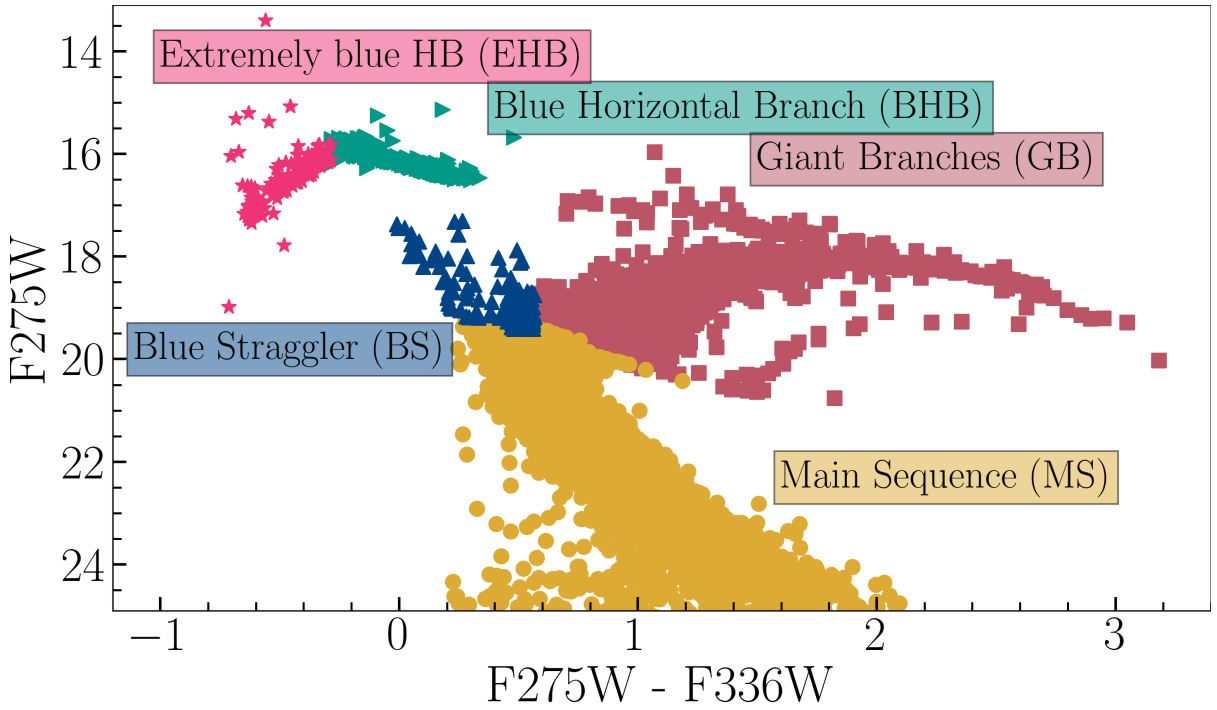
NGC 7089 (M2): evolutionary phases in Galactic GC

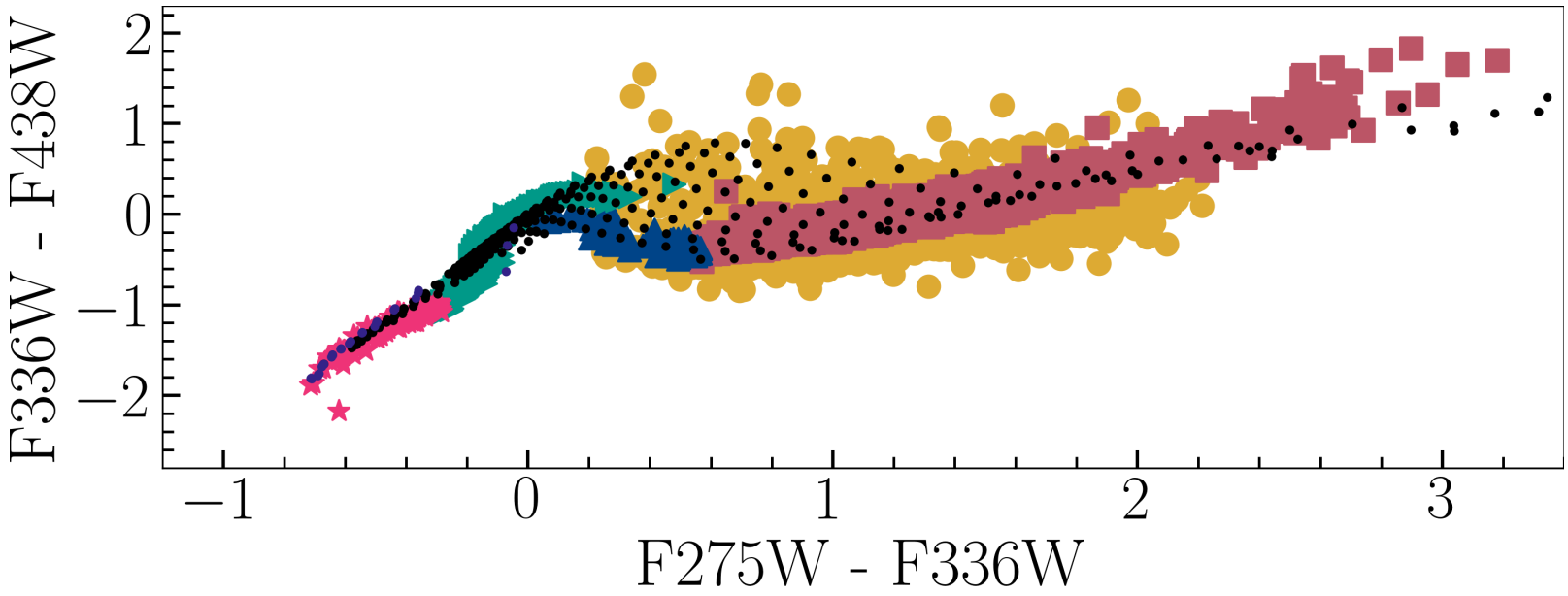


Credit: ESA/Hubble & NASA (Piotto et al. 2002)



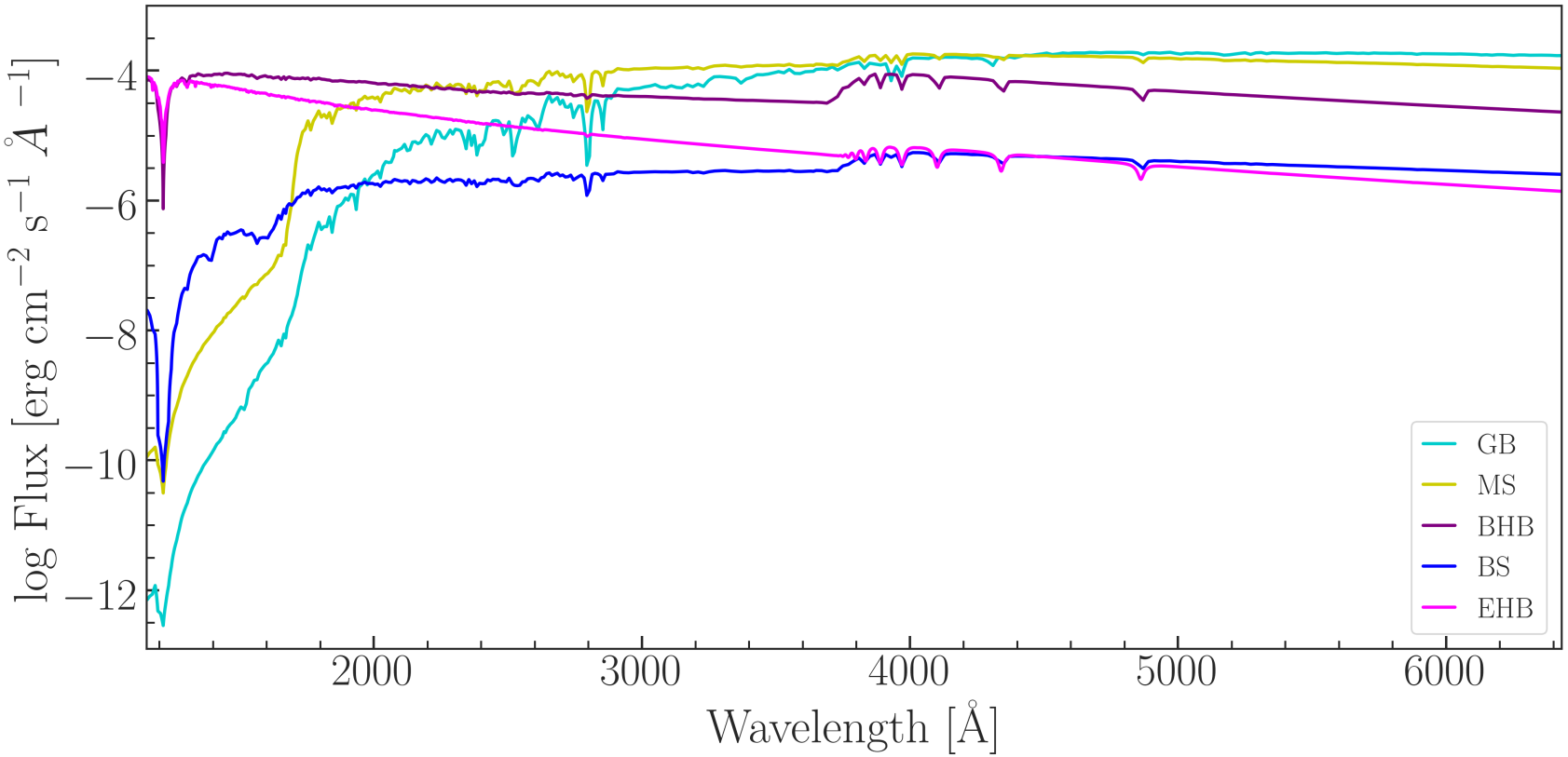
HST photometric data from Nardiello+18 with regions coloured by evolutionary phases (Pacheco+ b, *in prep*).

Matching each star to a model by K-nearest neighbors in 10-dimensional color space (Pacheco+ a,b, *in prep*)



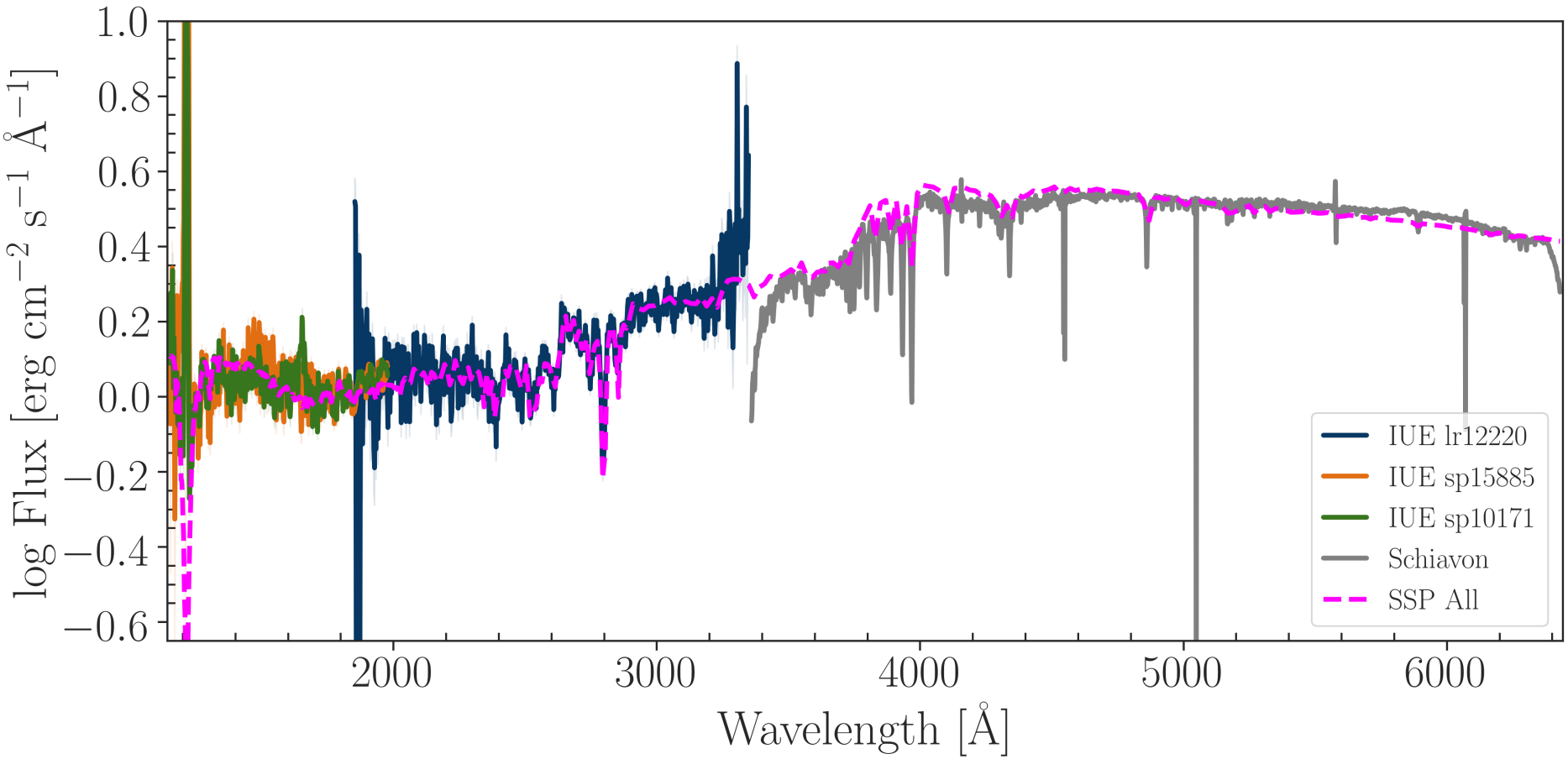
Colour-colour diagram (HST photometric data from Nardiello+18). The small points represent the synthetic colours from Castelli&Kurucz03 and Pacheco+21,23 spectral libraries.

Simple stellar population synthesis of NGC 7089 (M2) (Pacheco+ b, *in prep*)



Flux in logarithmic scale to quantify the light contribution from each stellar evolutionary stage.

Modeling integrated spectrum of NGC 7089 (M2) (Pacheco+ b, *in prep*)



SED comparing the synthetic SSP to observed spectra from UV to IR.

Summary
(Pacheco a *in prep*; Pacheco b *in prep*)

- A grid of synthetic spectra for subdwarfs: NLTE line-blanketed atmosphere models (Pacheco+21,23; arXiv: 2110.02229, 2307.08362);
- High-resolution spectral synthesis performed from the UV to near-IR.
- The hot components (sudbwarfs, blue HB stars, and blue stragglers) contribute with 25% of the light in the near-UV band;
- The HB and EHB dominate the light in the far-UV band;
- The integrated light of a GC was modelled from the UV to the optical.

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