Chemically Self-Consistent Isochrones of the Globular Cluster NGC 2808

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A Multi-wavelength View On Globular Clusters Near and Far From JWST to the ELT

Abstract

The inferred helium mass fraction of multiple populations (MPs) in globular clusters (GCs) can vary significantly from older to younger populations [1]. As the origin of these MPs remains an open question, and one which is sensitive to the compositional variations between populations, the extent of the composition variations is a key parameter when constraining formation channels. Many metal abundances may be directly measured spectroscopically; however, helium abundances are not directly observable in GCs. Instead, helium abundances are inferred from stellar models. It is therefore important to build stellar models which are chemically self-consistent between the structure, atmosphere, and opacities. In this work we present the first chemically self-consistent stellar models of the Milky Way globular cluster NGC 2808. We find that the helium abundance of the second generation of stars is enhanced when compared to the first generation by 9 percent.

Consistency & Modeling

We use the Dartmouth stellar evolution program (DSEP) [2] to evolve a grid of models with a variety of mixing lengths and helium mass fractions. Atmospheric boundary conditions are computed using MARCS [3] and are kept chemically consistent with the structure code from hydrogen to zinc. High-Temperature opacities are pulled from OPLIB and low temperature opacities are pulled from Aesopus, both of these are also kept chemically consistent from hydrogen to zinc.

`FIDANKA`

The software we develop for this work (**`fidanka`**) has been released under a permissive open-source licence and is available on GitHub.

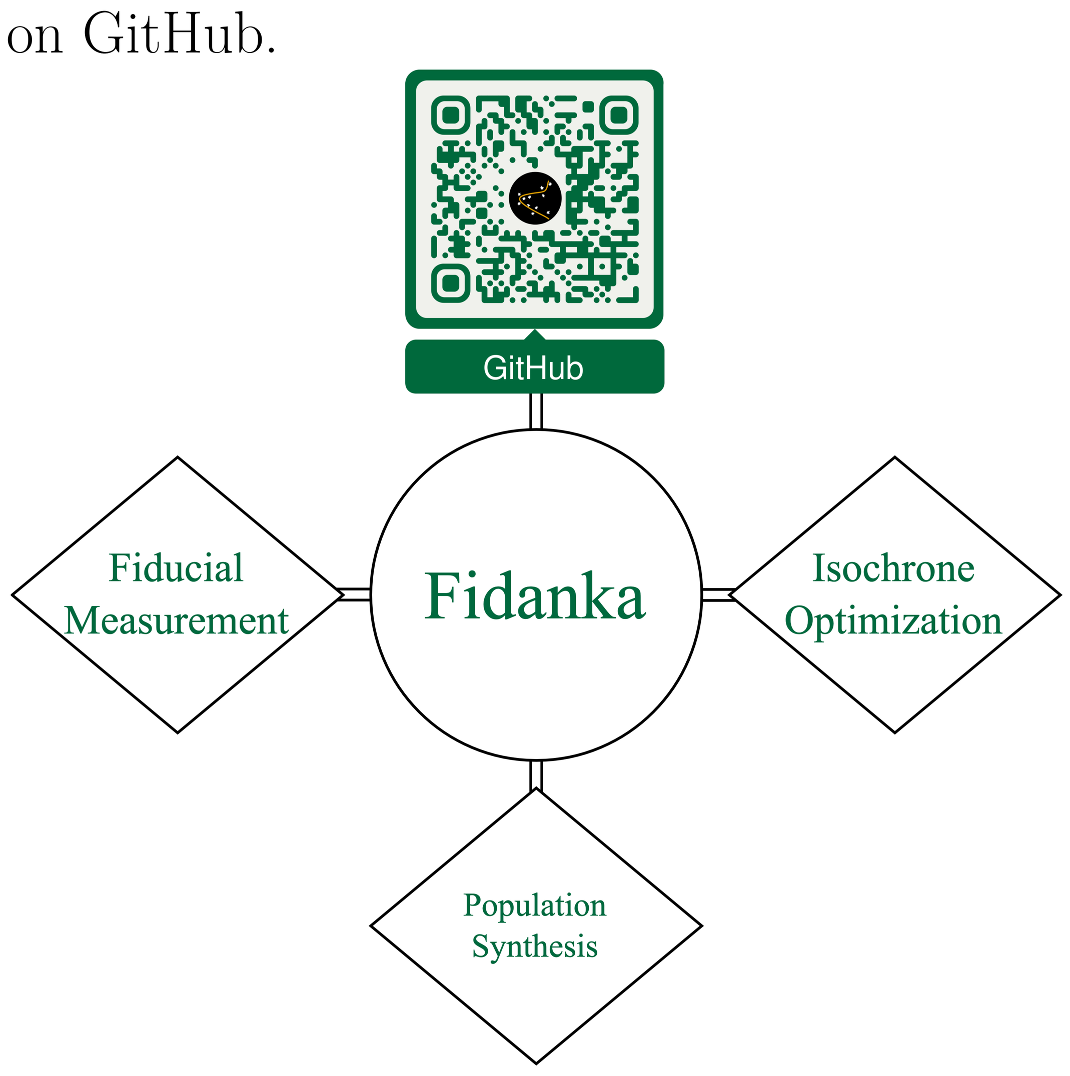

Fig. 1: Concept map of `fidanka`

Fiducial Measurement

In order to measure the subtle number density variations separating populations along the Main Sequence we make use of a novel, convex-hull based, adaptive binning approach. This algorithm keeps the number of stars per bin uniform. An example of the density estimate produced by this algorithm is shown in Figure 2. **Note how the sequences stand out clearly in the density plot.**

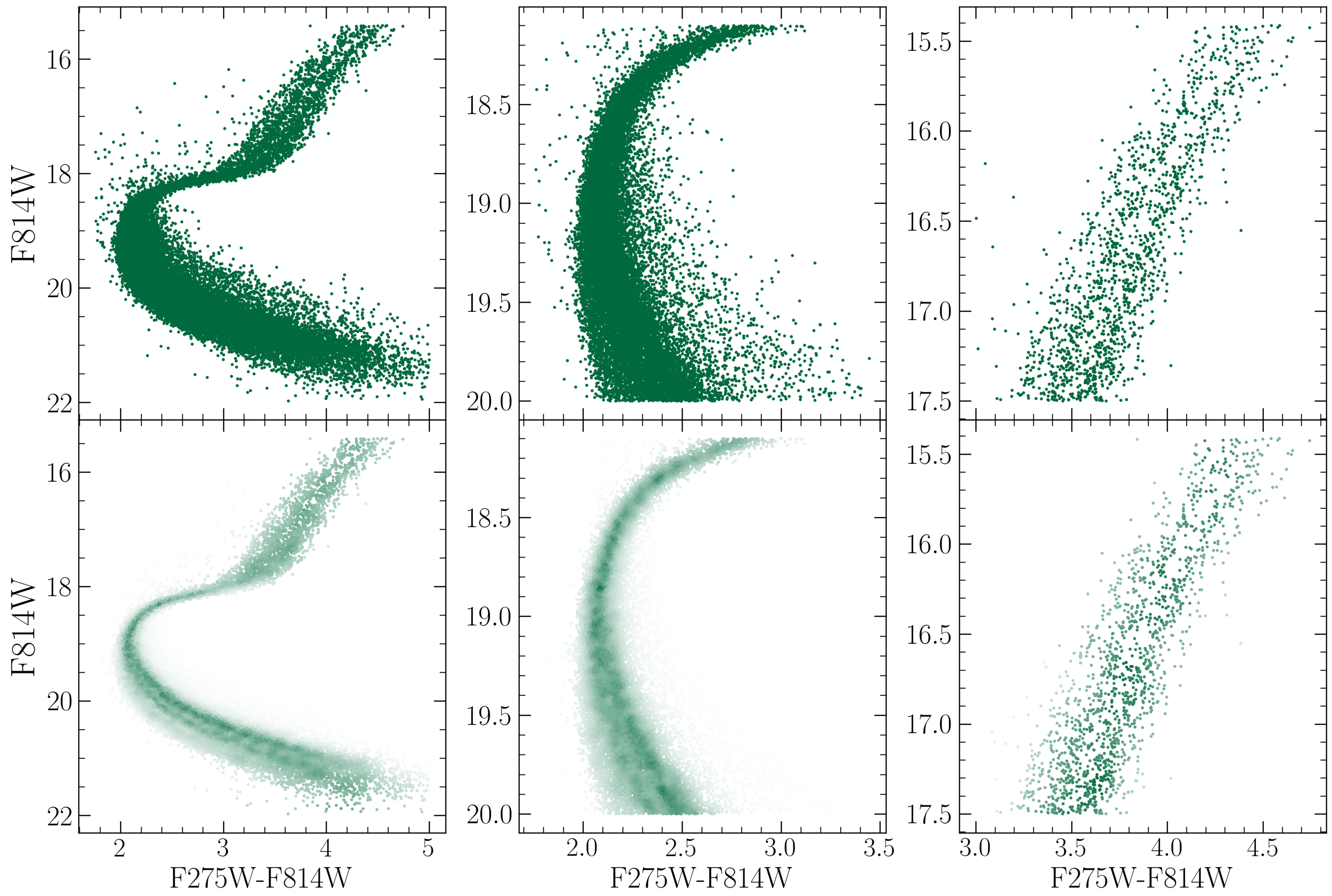

Fig. 2: NGC 2808 CMD from the HUGS survey after data quality cuts have been applied (top). Number density of stars in the CMD of NGC 2808 (bottom).

We use Bayesian Gaussian Mixture Modeling and the Diecrelt Process to trace median ridge lines over a series of magnitude bins. This eliminates the need for a prior on the exact number of populations. Traced fiducial lines for the two most extreme populations (A&E in [4]) in NGC 2808 are shown in in Figure 3.

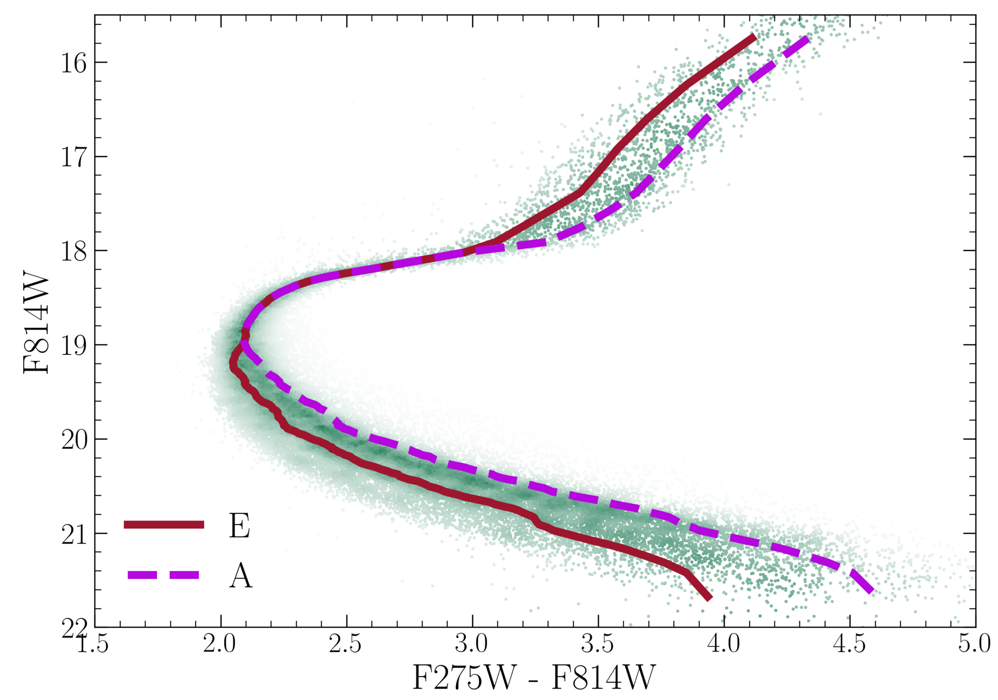

Fig. 3: NGC 2808 populations A & E median ridge lines measured using fidanka.

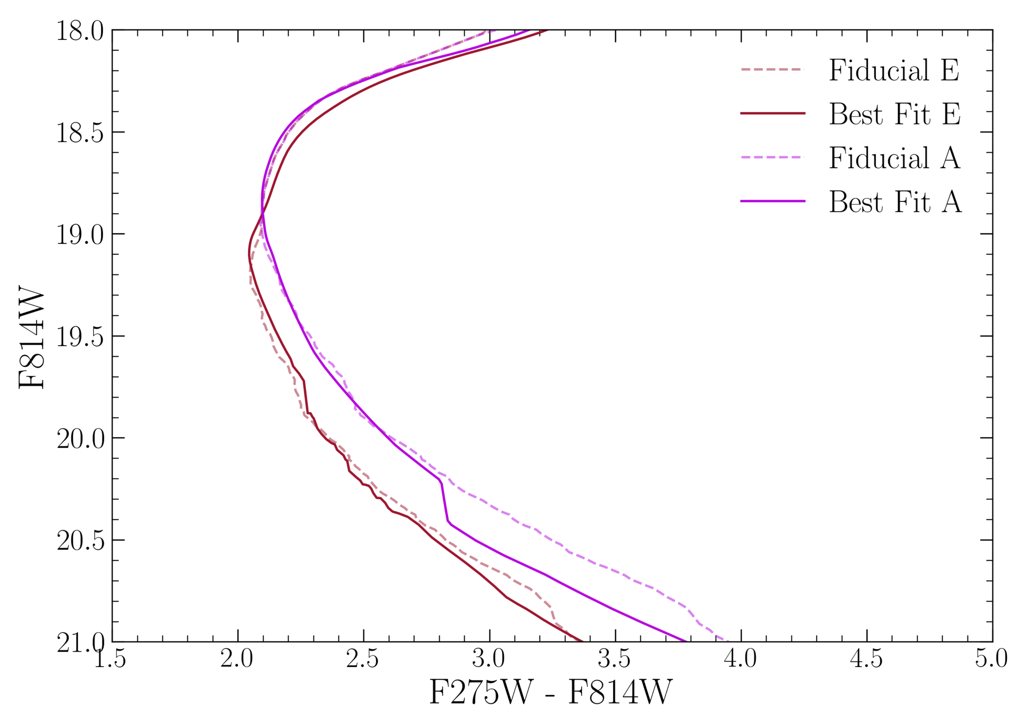

Fig. 4: Preliminary best fitting isochrones. The discontinuity near color=2.9 is due to discrepencies between FreeEOS and an ideal EOS. Work is ongoing to resolve this prior to publication.

Using the path from the fast dynamic time warping algorithm [5] as an objective function we fit the optimal distance modulus, B-V color excess, and age for NGC 2808. Best fitting isochrones are shown in Figure 4. We find $\mu = 15.01$, $E(B-V) = 0.43$, and age=11.81 Gyr ($\chi^2_\nu = 0.067$). **We find preliminary best fit helium mass fractions of Y=0.36 for Population E and Y=0.27 for population A. These are consistent with past results from the literature.**

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