Refining the Age of the Universe Using Globular Clusters: Prerequisite Work

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Undergraduate Advising and Research Leave-Term Grant
Spring 2020

INTRODUCTION AND MOTIVATION

The Hubble Tension—a discrepancy in experimental findings for the age of the universe—is a topic of current research is several subfields of astronomy. The value for the age of the universe impacts what we know about cosmology going all the way back to the Big Bang, and is essential to the cosmological standard model.

The purpose of my current project is to estimate the ages of several globular clusters in the Milky Way. These clusters contain the oldest stars in the galaxy, and determining the age of them puts a strict lower limit on the overall age of the universe (the universe can't be younger than the stars that exist within it). New Gaia DR3 data allows us to do this with higher precision than ever before. This limit will serve as useful data for continued Hubble Tension research.

METHODS

In order to best determine the age of a given globular cluster, we compare it to isochrone stellar evolution models. However, simply finding a single best-fit model for a given cluster tells us nothing about the error in our fit. In order to do that, we use a Monte Carlo simulation of some 10,000 models. This is done by using a python program to select the parameters for each model based on known distributions for each value

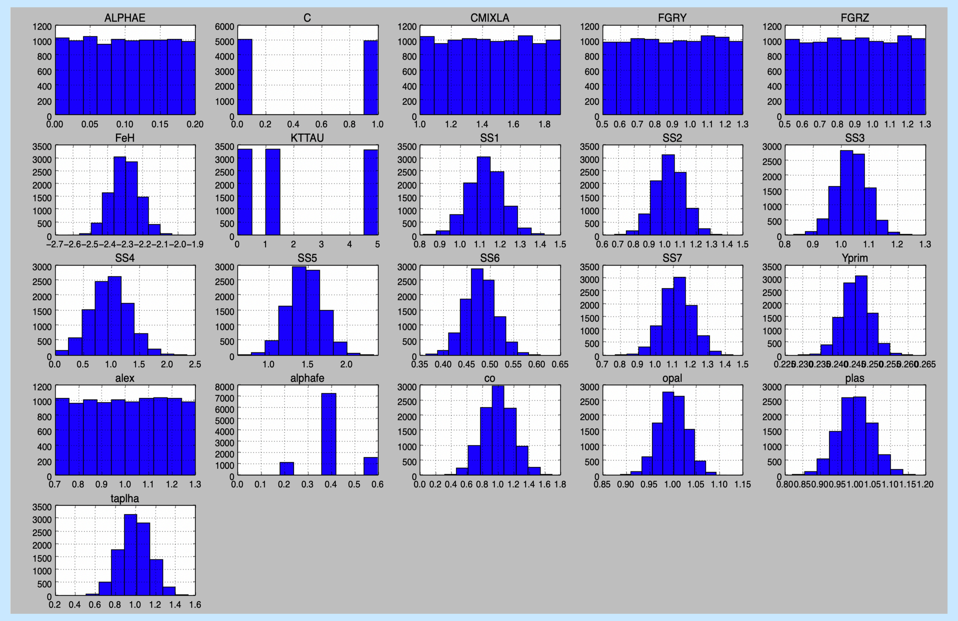

Figure 1: Distributions of selected values for 21 different isochrone parameters for the Monte Carlo simulation.

RESULTS

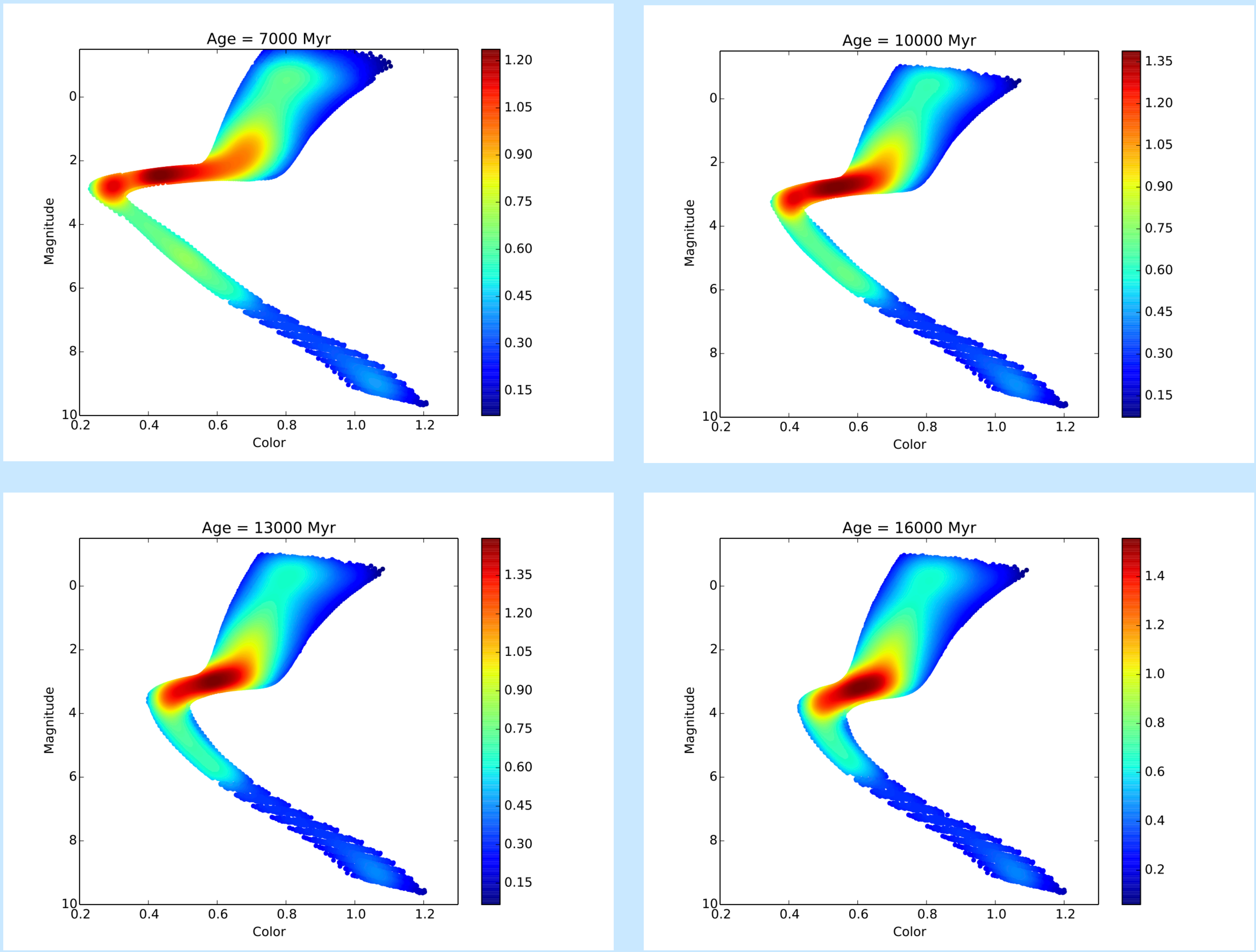

Figure 2: Four example Monte Carlo simulation models ranging in age from 7-16 Gyr, each containing 400 isochrones. X axis is color in F606W-F814W filters, Y axis is magnitude in the F606W filter, and color is an indication of point density

We have managed to create several hundred isochrone models with different parameters and ages ranging from 5Gyr-20 Gyr and are in the process of creating several thousand more for comparison purposes.

NEXT STEPS

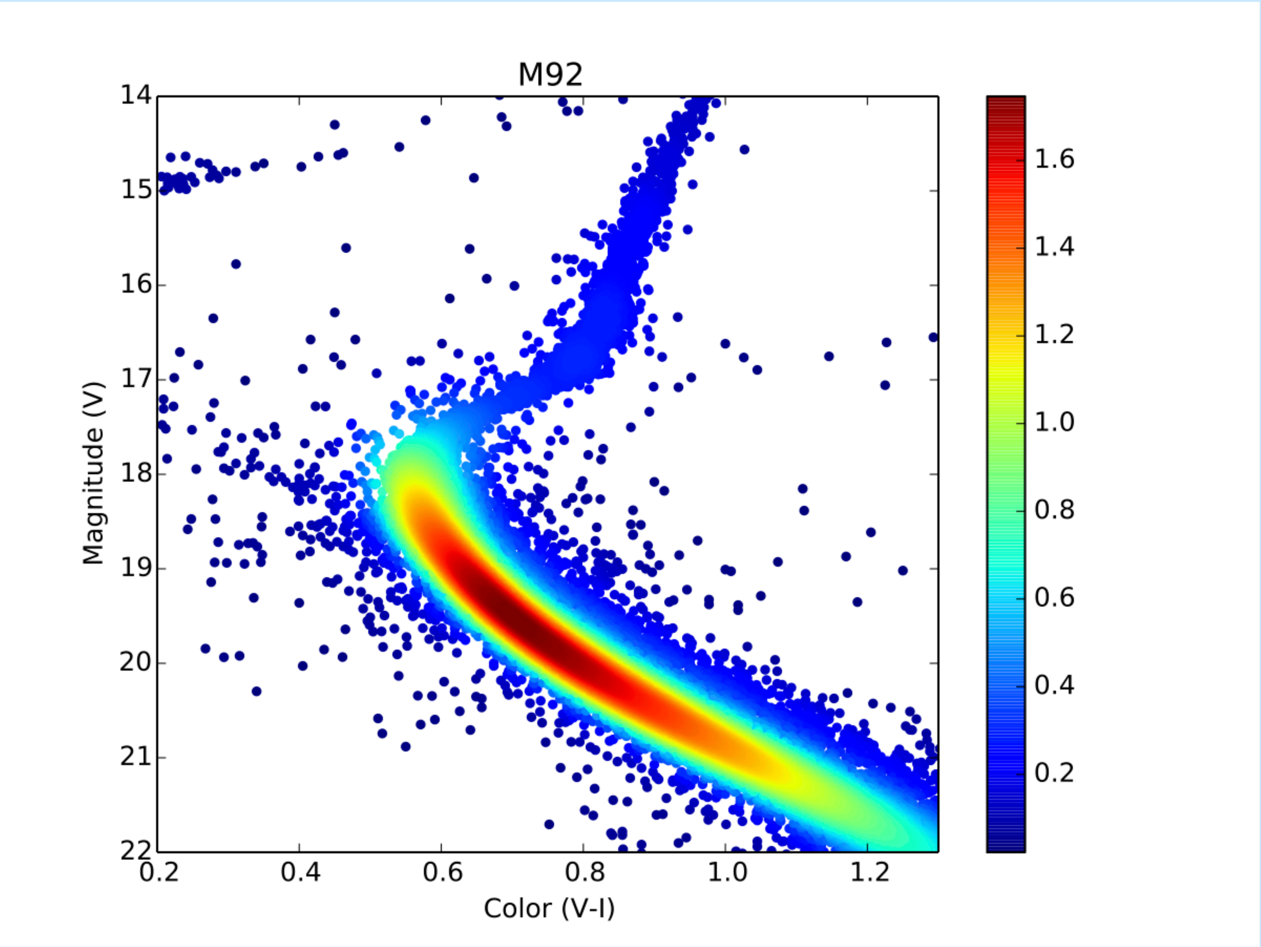

Figure 3: Data from the M92 cluster (Fe/H ~-2.32)

- Finish creating the rest of the isochrone models for the Monte Carlo simulation
- Generate luminosity functions for isochrones
- Compare models to four known Globular Clusters (M92, NGC 6397, NGC 362 and 47 Tuc), as done in O'Malley et al. 2017 in order to find cluster age estimates
- Use numerical methods assessing number density along the main sequence turn off, like Dolphin 2001

REFERENCES

A.E. Dolphin. Numerical Methods of Star Formation History Measurement and Applications to Seven Dwarf Spheroids

A. G. Riess, S. Casertano, W. Yuan, L. M. Macri, and D. Scolnic. Large Magellanic CloudCepheid Standards Provide a 1% Foundation for the Determination of the Hubble Constantand Stronger Evidence for Physics beyond ΛCDM. , 876(1):85, May 2019.

E. M. O'Malley, C. Gilligan, and B. Chaboyer. Absolute Ages and Distances of 22 GCs Using Monte Carlo Main-sequence Fitting. , 838(2):162, Apr 2017.

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METHODS

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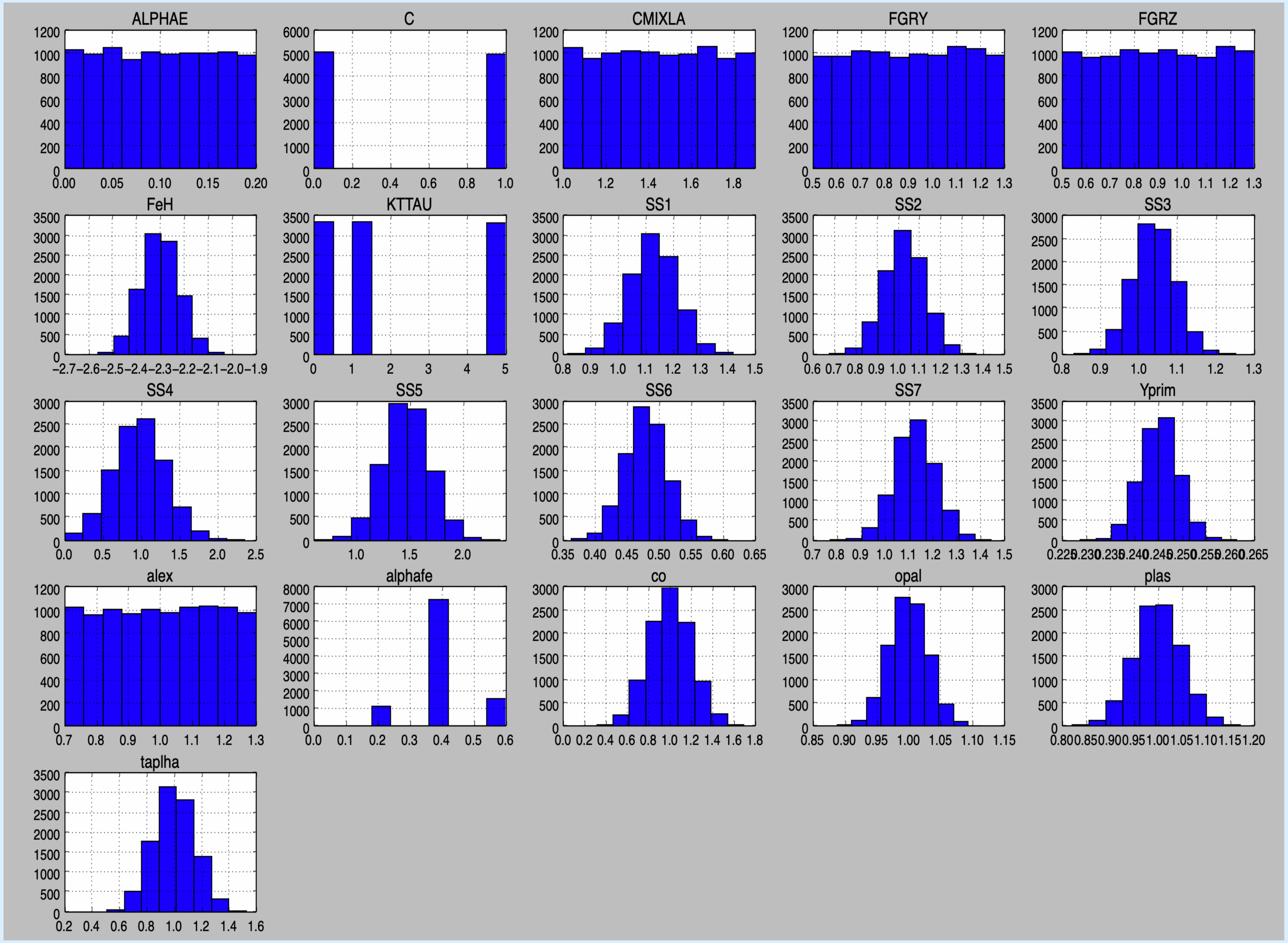

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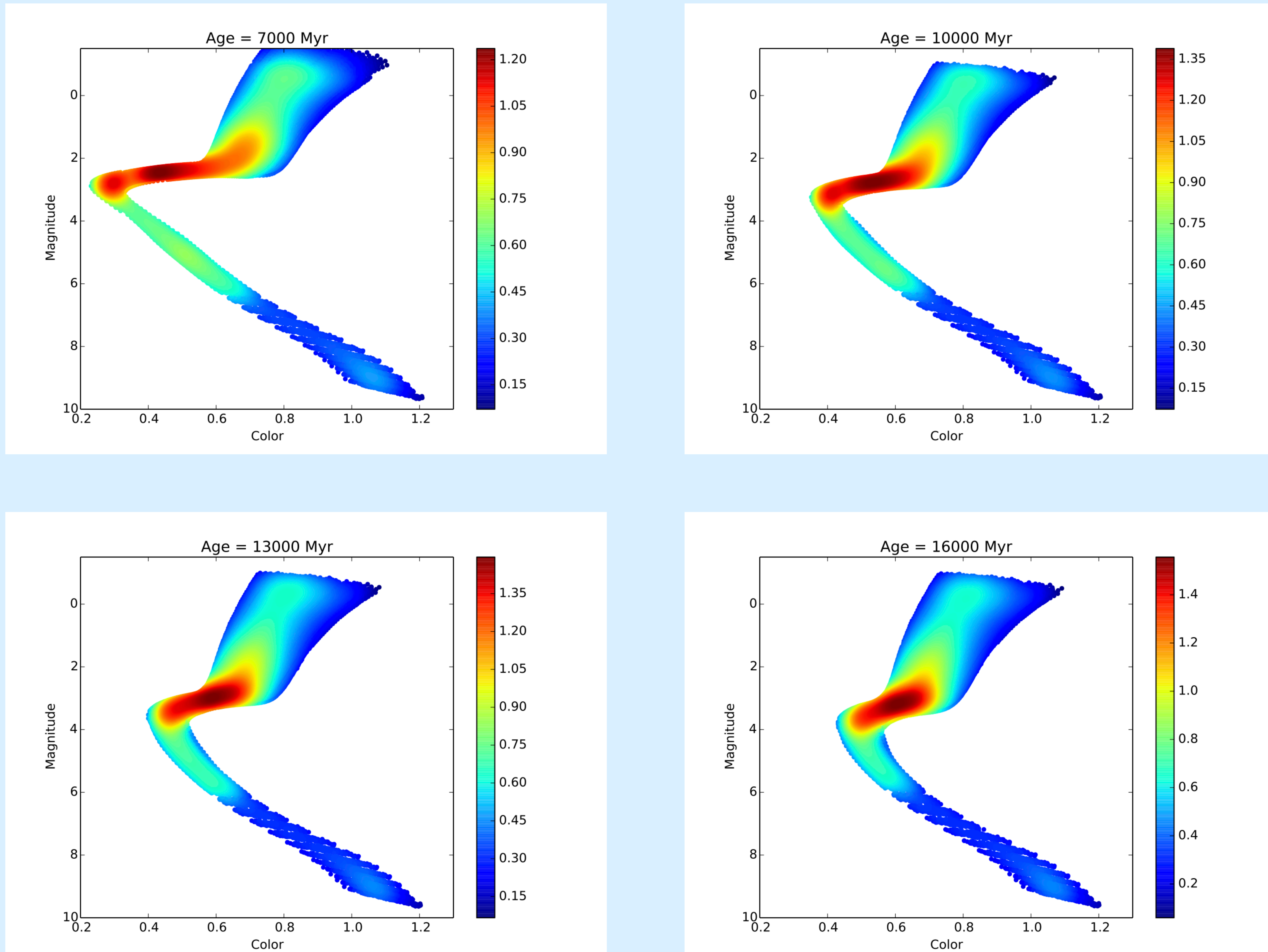

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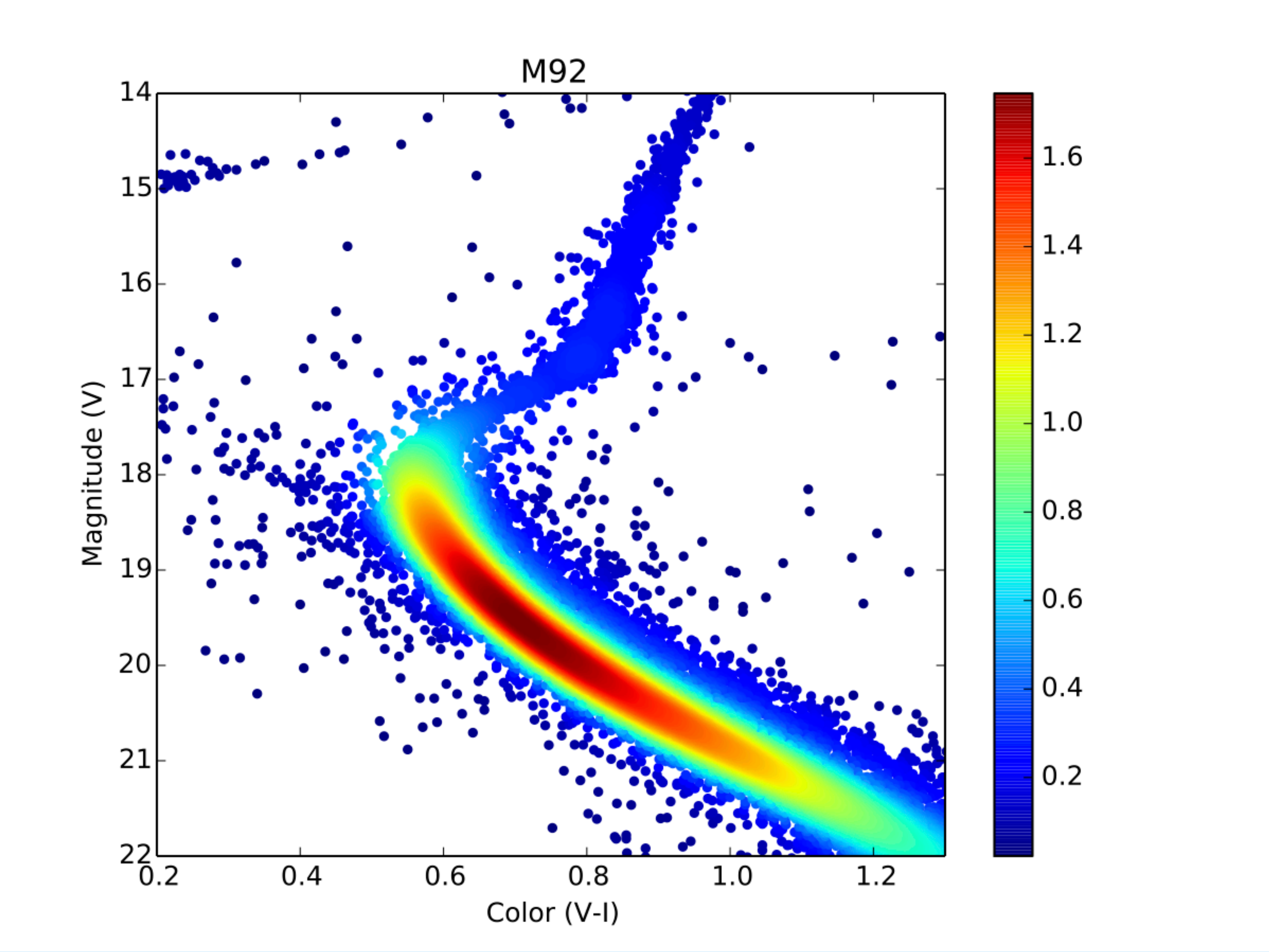

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