Better (?) ingredients → better Pizza !?

All models are different (if not wrong) !?!

Uncertainties of Age Estimation of Spiral Galaxies Using Optical and Near-Infrared Photometry (Tuesday)

alpha-Enhanced (at given [Fe/H]) Integrated Lick/IDS Spectral Indices + SBF (Thursday)

Support for this work was provided by the NSF through grant AST-0307487, the New Standard Stellar Population Model (NSSPM) project.

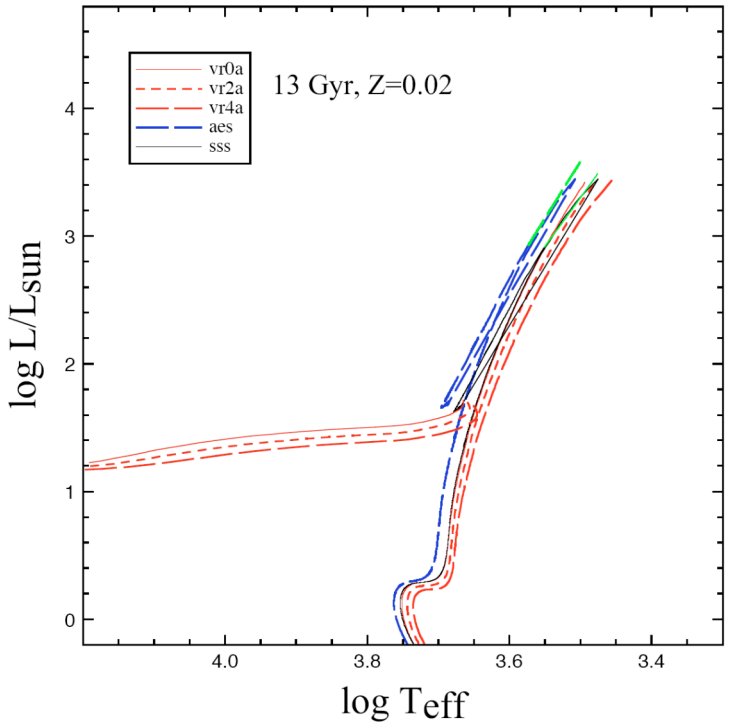
Project Summary

New Standard Stellar Population Models

Intellectual Merit: The proposed set of stellar population models (isochrones plus stellar colors and spectra) will set a new standard of completeness and excellence. The most novel feature of the models is that they will incorporate flexible chemistry so that almost any interesting chemical mixture can be interpolated. Abundance will be described by parameters for He/H, C, N, O, three choices for "alpha" element mixture, and an overall scaling factor for heavy element abundance. The proposed models will be generated from PHOENIX model atmospheres for stellar fluxes and low-temperature opacities, OPAL interior opacities, and a state-of-the-art stellar evolution code, DSEP, which incorporates accurate equations of state, helium diffusion, heavy element diffusion, and convective overshooting. Known flaws and omissions (temperature issues, mass-loss, late-stage evolution, binarism) of current models will be eliminated or minimized.

Our goals are to demonstrate 10% absolute mean ages derived from a single integrated light spectrum, to derive ages for a sample of local galaxies, to discover the origin of the scatter in 1500-V among elliptical galaxies, to measure He, O, Cr, and Ni abundances from integrated light (high risk), and to measure C, N, Ca, Si, Sc, V, Ti, Fe, and Mg abundances from integrated light (low risk). This new level of detail will open a whole new set of constraints for nucleosynthetic enrichment in clusters and galaxies. As a byproduct, homogeneous data for a series of star clusters of widely varying age and abundance will be collected and made available.

What alpha-enhancement?



Teramo Isochrones: alpha-enhanced

at fixed Z (total metallicity)

from Pietrinferni et al. 2006, ApJ, 642, 797

VR Isochrones: alpha-enhanced

At fixed [Fe/H]

vr0a: [a/Fe] = 0.0
vr2a: [a/Fe] = 0.3
vr4a: [a/Fe] = 0.6
from Vandenberg et al. 2006, ApJS, 162, 375
(Victoria-Regina models)

Models are available at http://astro.wsu.edu/hclee

THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 160:176–198, 2005 September

α-ENHANCED INTEGRATED LICK/IDS SPECTRAL INDICES AND MILKY WAY AND M31 GLOBULAR CLUSTERS AND EARLY-TYPE GALAXIES

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Received 2005 April 22; accepted 2005 May 25

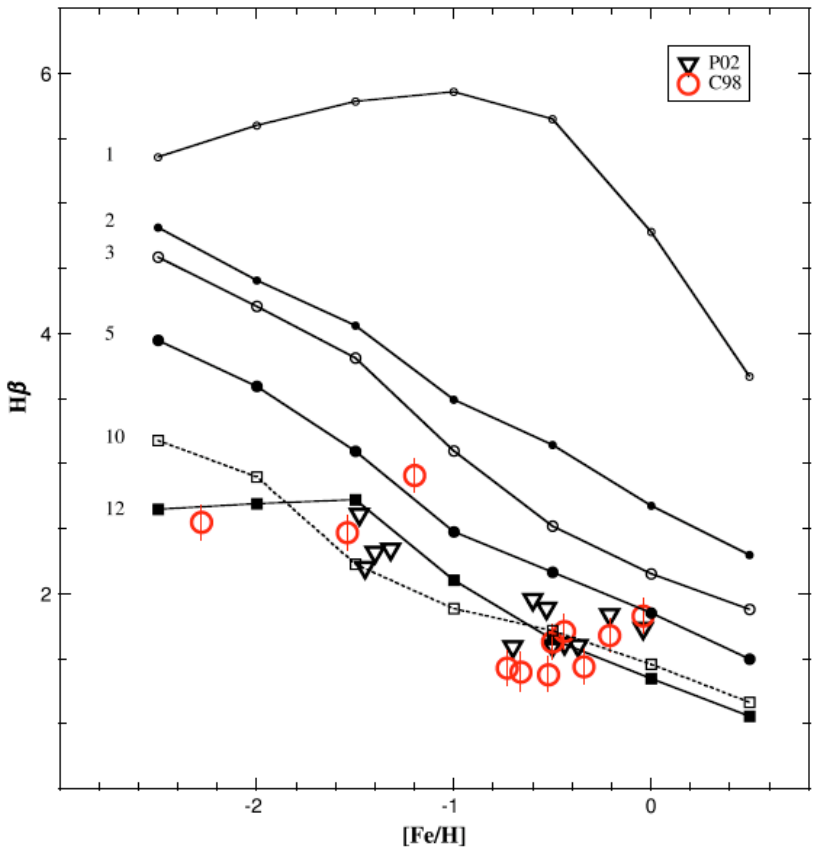
ABSTRACT

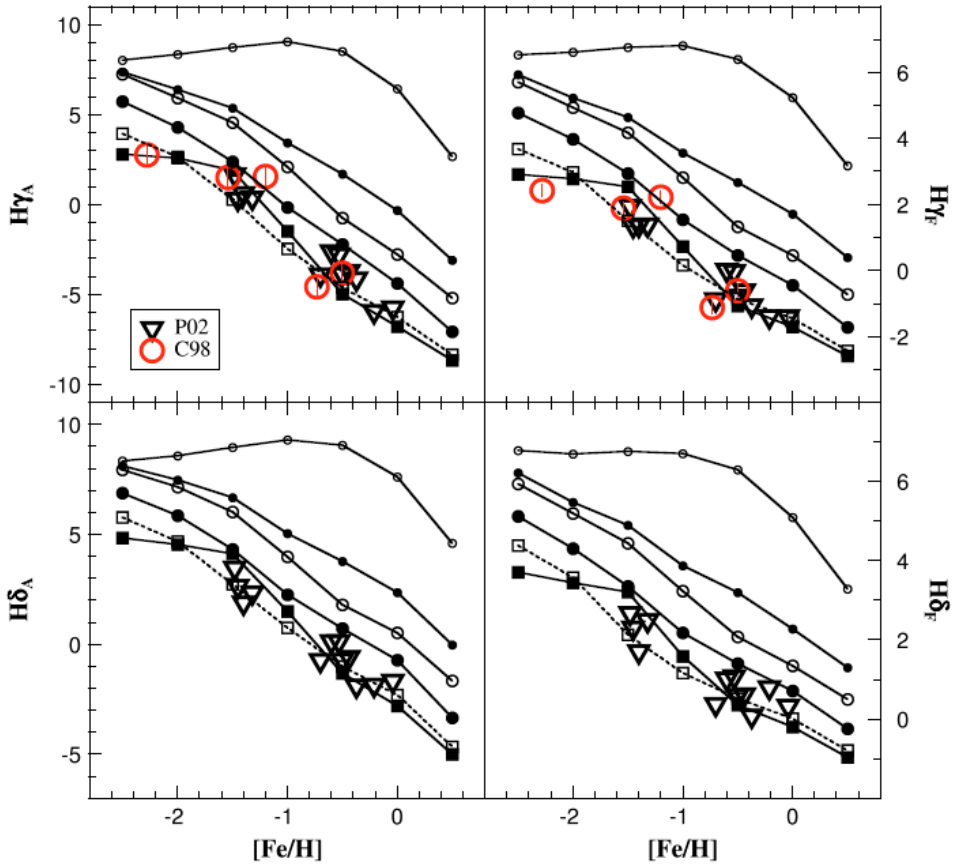
We present new simple stellar population models
at the fixed [Fe/H]
based on the alpha-enhanced and the solar-scaled Y^2 isochrones.

We have computed all 25 Lick/IDS spectral indices
with effects from horizontal-branch stars fully implemented.

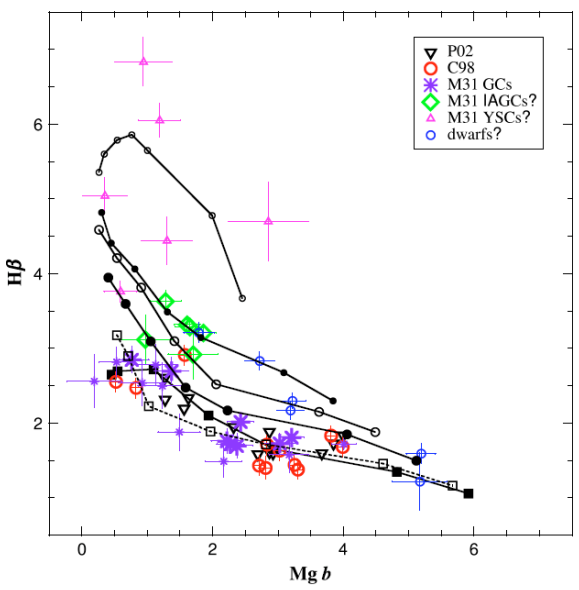
We compare our models with recent Keck observations of Milky Way and M31 globular clusters and Lick observations of early-type galaxies.

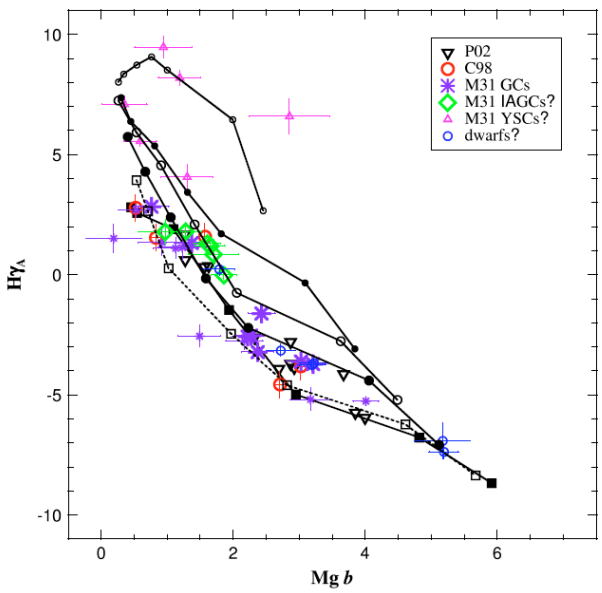
Online material: color figures, machine-readable table

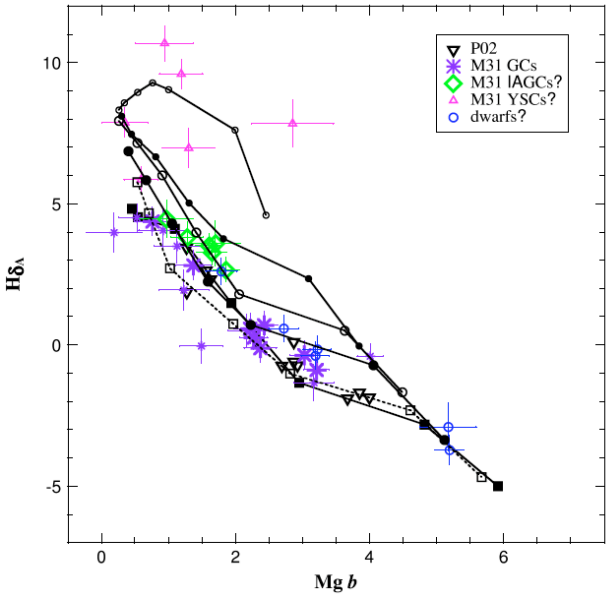




Our stellar population models at 1, **2, 3, 5, 10, 12** Gyr are compared with MWGCs. At given ages, [Fe/H] = -2.5, -2.0, -1.5, -1.0, -0.5, 0.0, and +0.5 from left to right. P02: Puzia et al. (2002 A&A, 395, 45), C98: Cohen et al. (1998 ApJ, 496, 808).



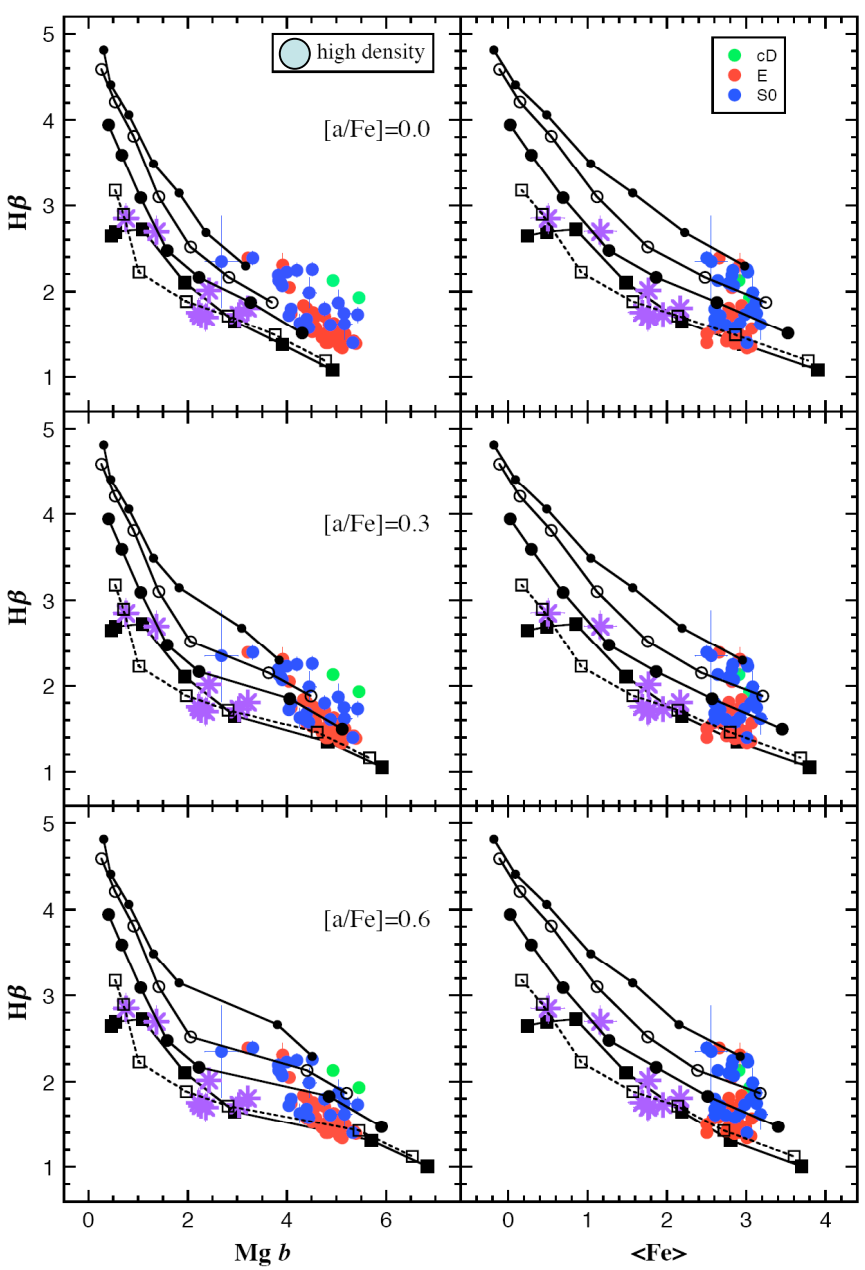


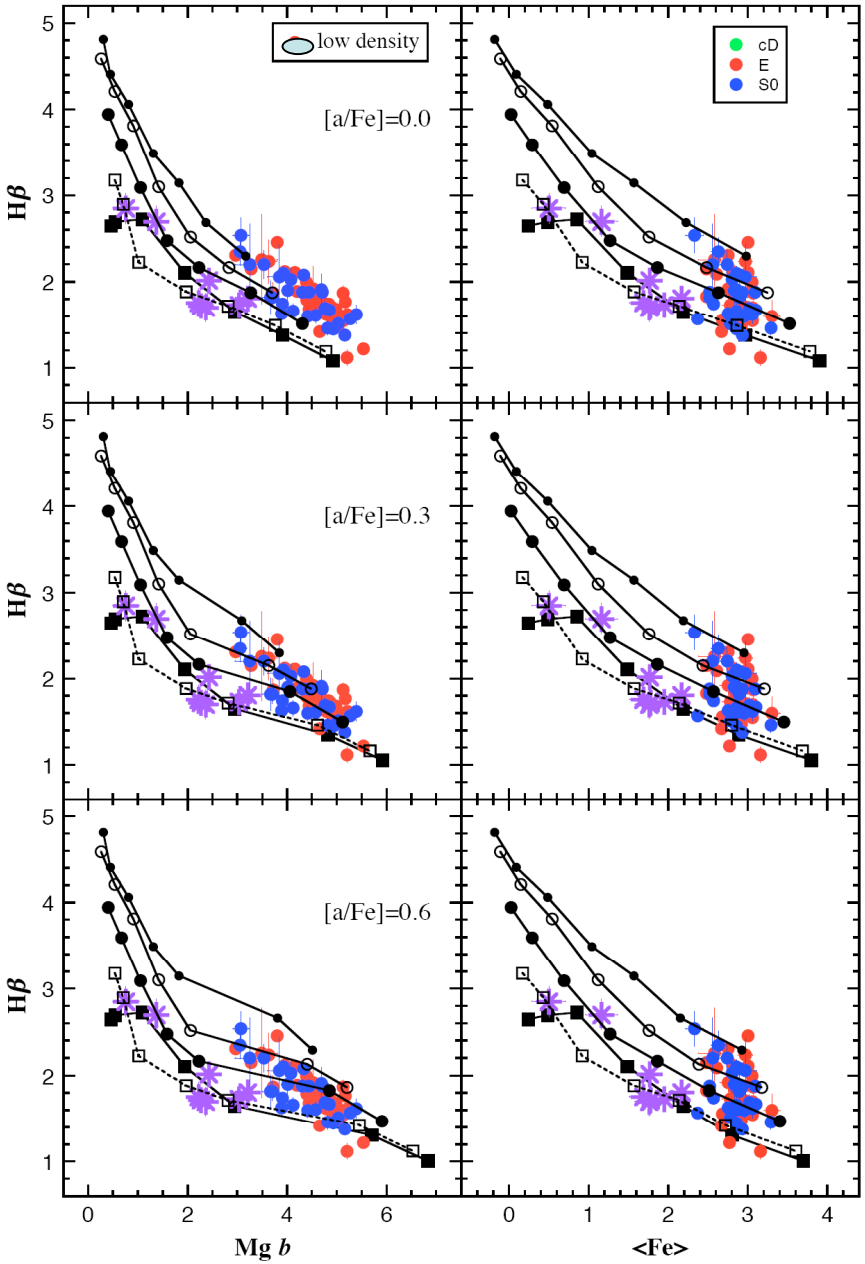


Our models of Balmer lines vs. metallicity trace the MW and M31 GCs at a model age of 12 Gyr

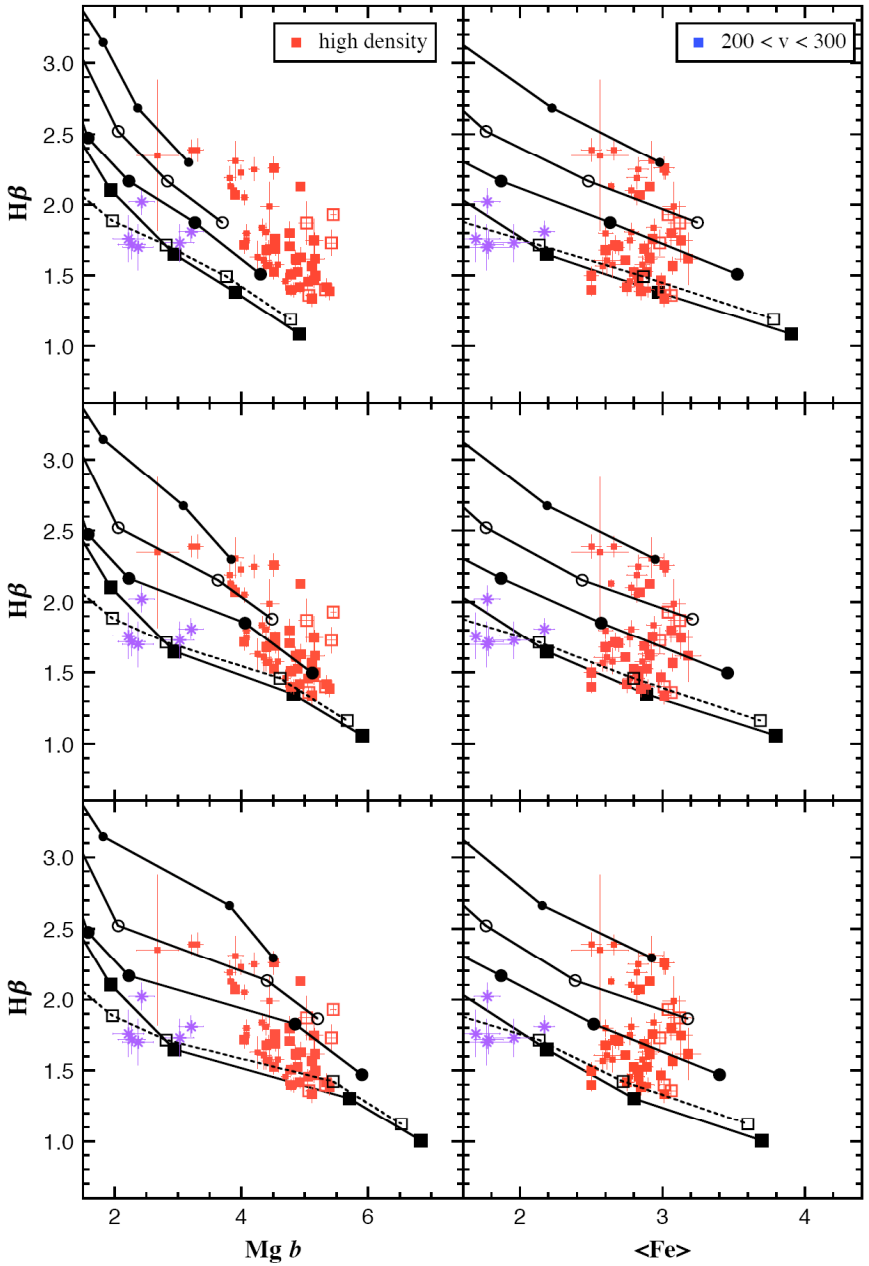
without zero-points offsets.

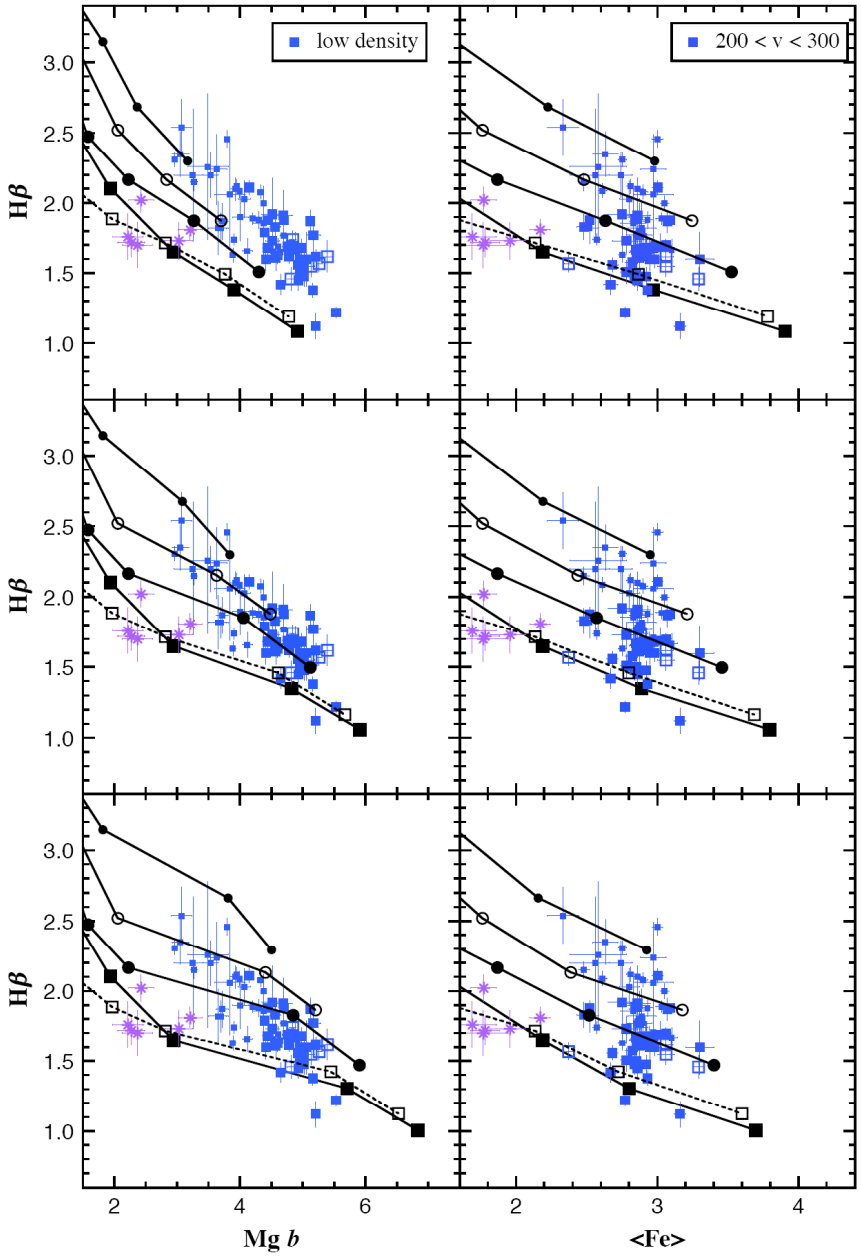
Data are from Beasley et al. (2004 AJ, 128, 1623).



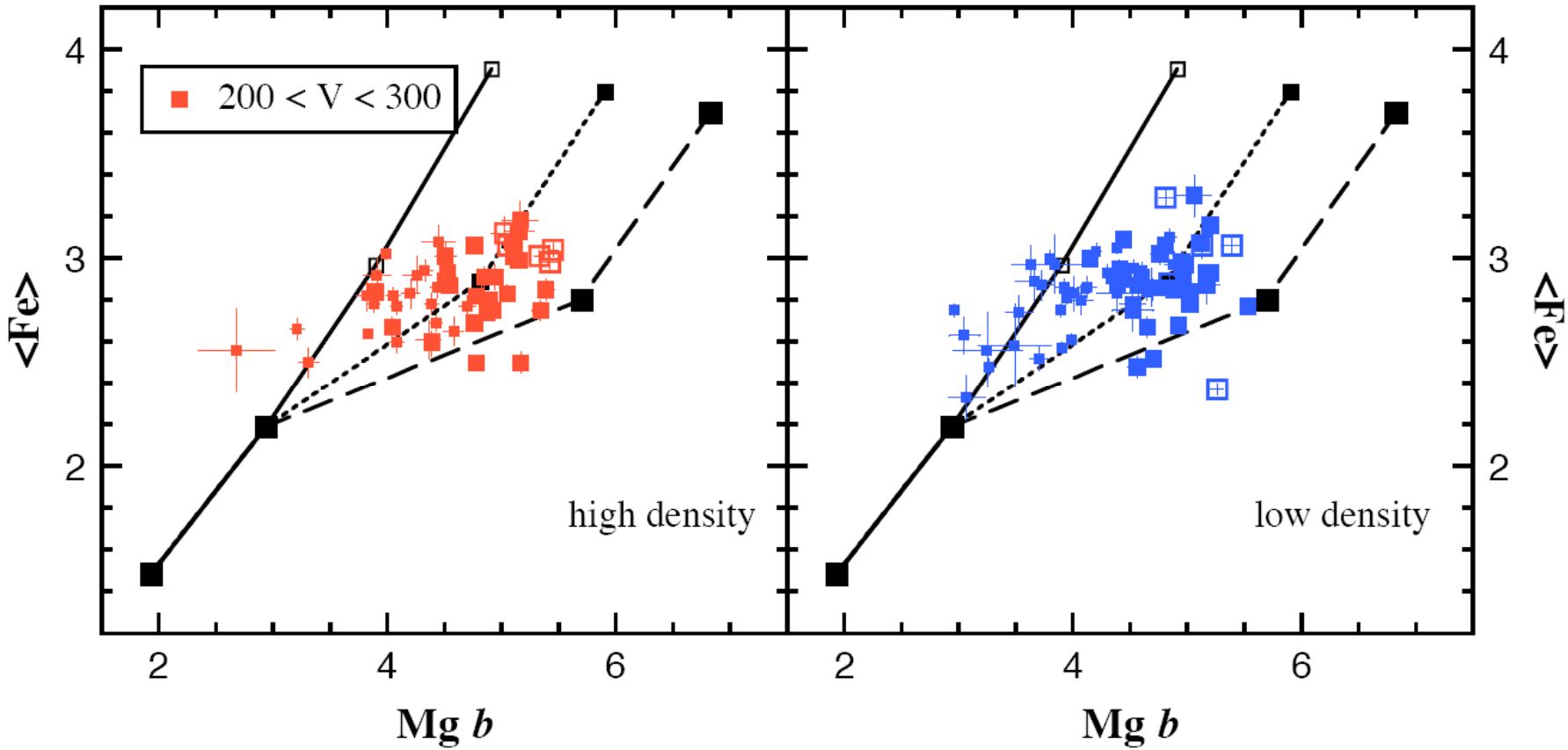


Data from Thomas et al. (2005)

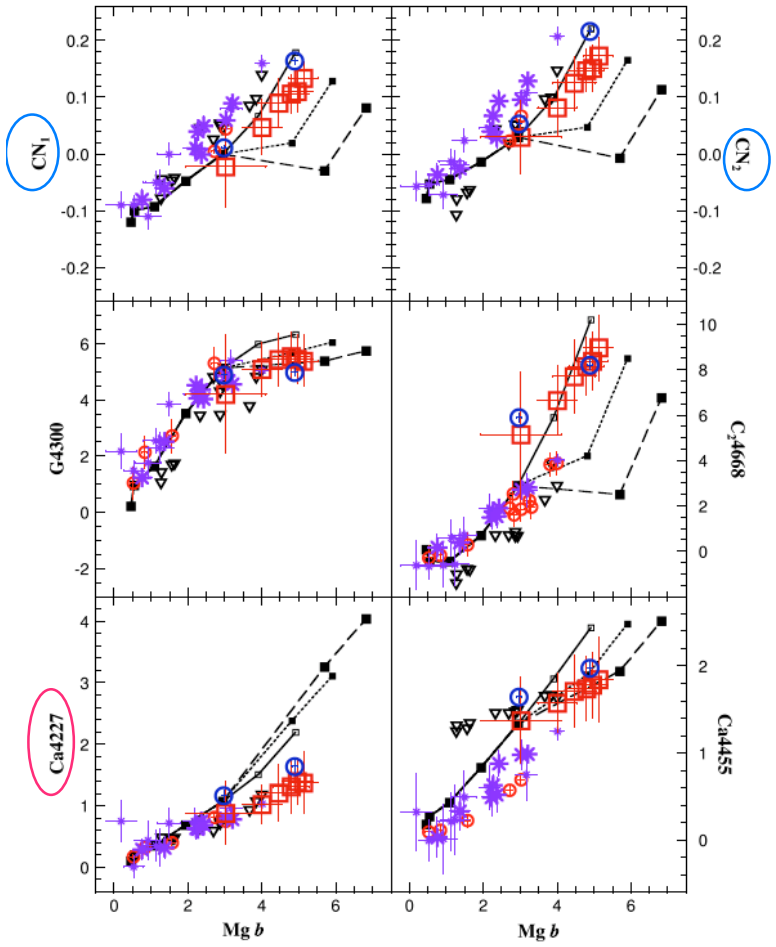




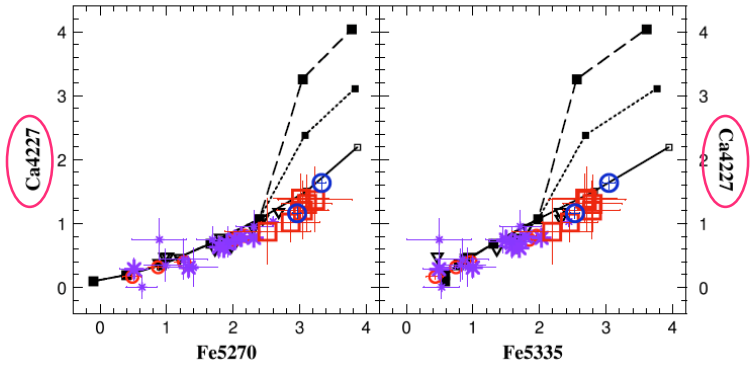
Data from Thomas et al. (2005)



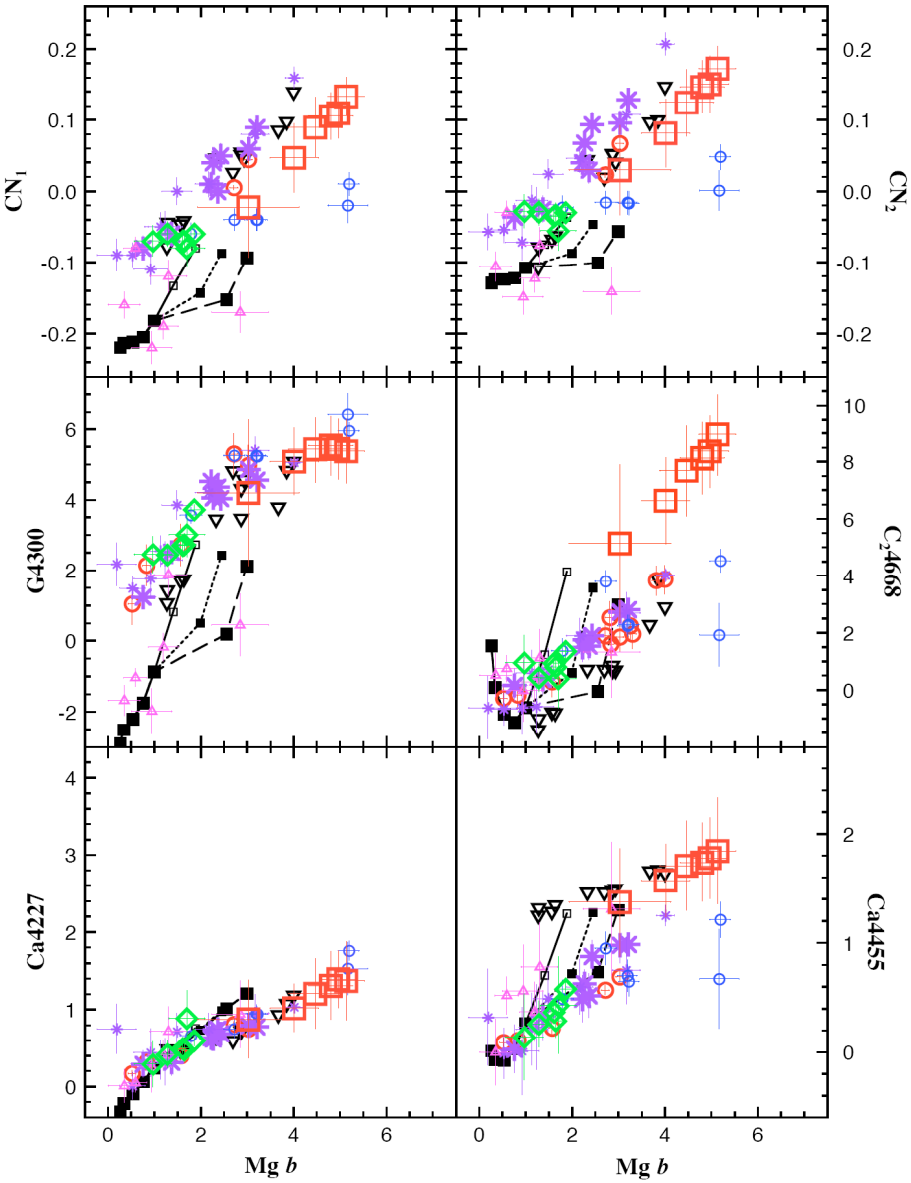
Data from Thomas et al. (2005)

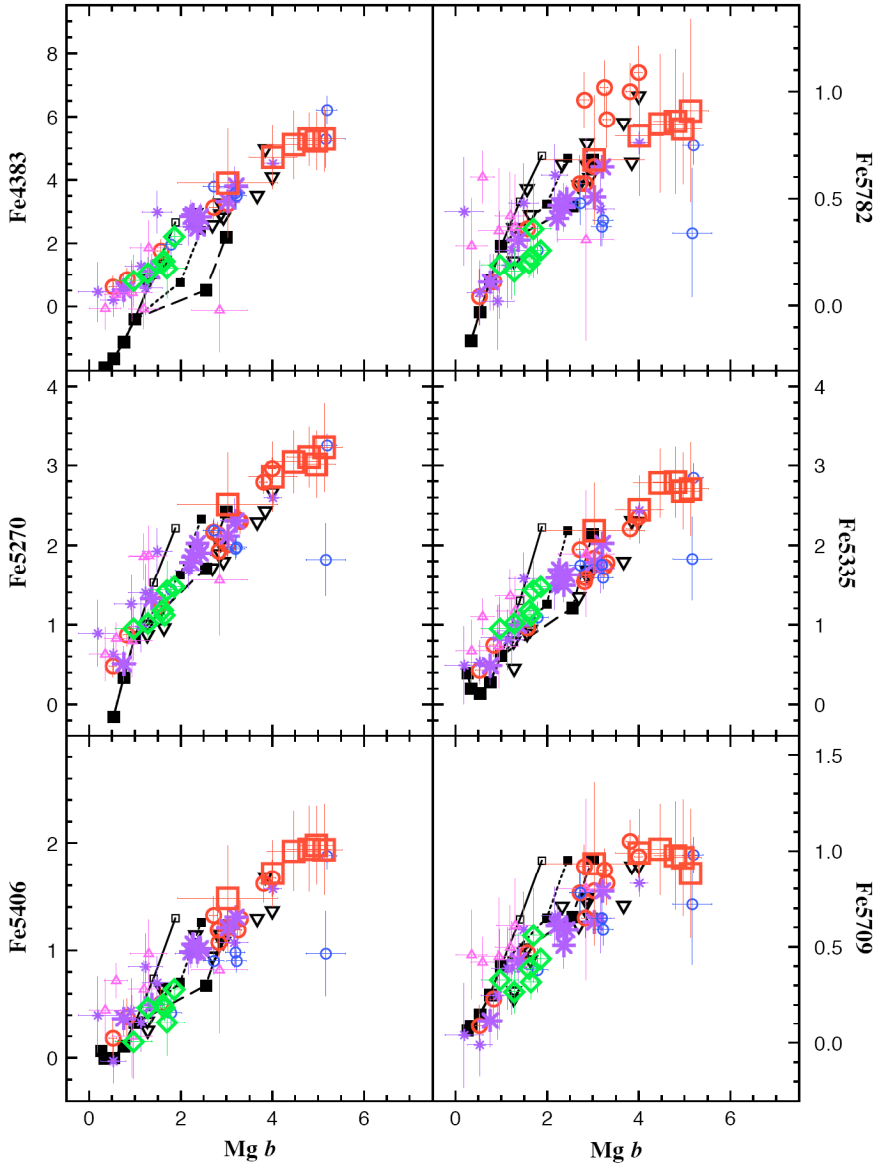


← Lick/IDS early-type galaxies show some systematic shift from MW and M31 GCs. This may be telling us something about N abundance and/or CH-CN bimodality that is generally different in the GC environment as opposed to the elliptical galaxy environment.



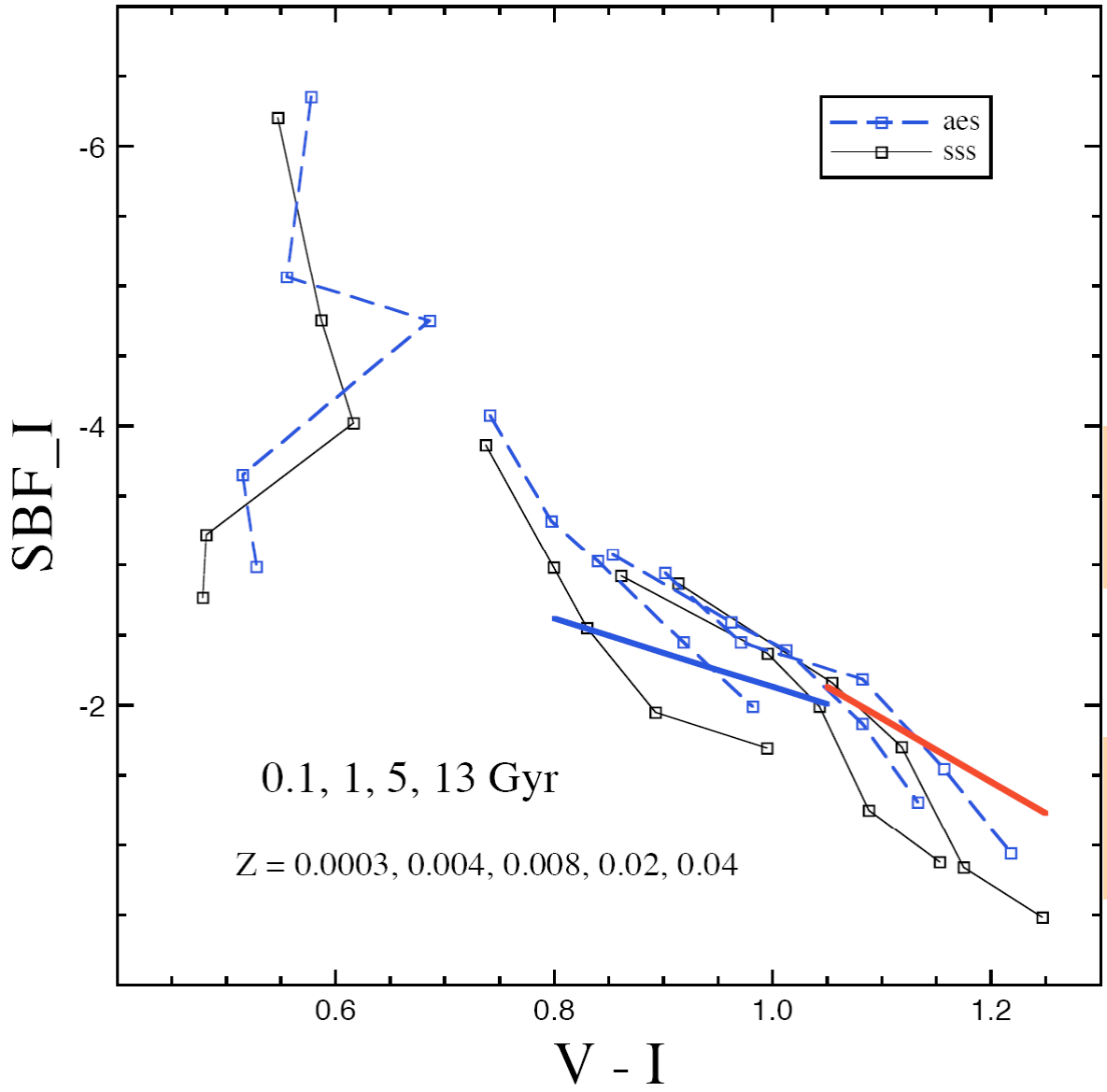
The manifested "Ca underabundance" of early-type galaxies against Mg *b* is not outstanding against Fe indices. It seems that while Mg, Na, and perhaps N are enhanced with respect to Fe, Ca is not.





When models are 1Gyr.

2006, AAS 208, Calgary



The blue line is
SBF_I = -2.13 + 2.44 * [(V – I) – 1.00]
from Mieske et al. (astro-ph/0605660)

The red line is
SBF_I = -1.68 + 4.5 * [(V – I) – 1.15]
from Mei et al. 2005, ApJ, 625, 121

Our *preliminary* version of surface brightness fluctuation models indicate that alpha-enhanced models are needed to match massive red galaxies while solar-scaled models are fine for dwarf blue galaxies
to reproduce their independently estimated ages and metallicities.

AN EMPIRICAL UBVRIJHK COLOR-TEMPERATURE CALIBRATION FOR STARS

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Draft version May 1, 2006

ABSTRACT

A collection of Johnson/Cousins photometry for stars with known [Fe/H] is used to generate color-color relations that include the abundance dependence. Literature temperature and bolometric correction dependences are attached to the color relations. The JHK colors are transformed to the Bessell & Brett (1988) homogenized system. The main result of this work is the tabulation of seven colors and the V-band bolometric correction as a function of T_{eff}, log g, and [Fe/H] for $-1.06 < V - K < 10.2$ and an accompanying interpolation program. Improvements to the present calibration would involve filling photometry gaps, obtaining more accurate and on-system photometry, knowing better log g and [Fe/H] values, improving the statistics for data-impoverished groups of stars such as K dwarfs, applying small tweaks in the processing pipeline, and obtaining better empirical temperature and bolometric correction relations, especially for supergiants and M stars. A way to estimate dust extinction from M dwarf colors is pointed out.

Subject headings: stars: fundamental parameters — stars: general

1. INTRODUCTION

Stellar evolutionary tracks and isochrones calculate physical radius, luminosity, and effective temperature. In order to compare with observable quantities, almost always magnitudes and colors, a transformation is essential. The need for such transformations is also felt when integrated light models (population synthesis models) are constructed for comparisons to colors from galaxies and star clusters. Color-temperature transformations are also

Revised Yale Isochrones (Green et al. 1987) that provides colors tabulated for a (long) list of temperatures, surface gravities, and [Fe/H] values. The strategy used by Green was to begin with empirical color-color relations for solar-metallicity stars, and adopt the ridge line as the starting place. Then one attaches a color-T_{eff} relation and adds [Fe/H] and gravity dependence by working differentially within synthetic color tables. The approach here is to do the same, except that the gravity and abundance dependences are fit to the stars themselves.

```
nsspm:~hclee$ ./a.out
 enter log g
1.0
 enter [Fe/H]
-1.0
 enter Teff
4000

U-B =    1.599 +/- 0.078
B-V =    1.454 +/- 0.022
V-R =    0.759 +/- 0.013
V-I =    1.472 +/- 0.023
J-K =    0.933 +/- 0.014
H-K =    0.154 +/- 0.004
V-K =    3.406 +/- 0.039
BCv =   -0.914 +/- 0.055
nsspm:~hclee$
```