Re-visiting the GCS catalogue - How to use solar analogues to check metallicity and temperature scales

Juliet Datson[1], Chris Flynn[2,3,4] and Laura Portinari[1]

[1]Tuorla Observatory, University of Turku, Finland,

[2]Department of Physics and Astronomy, University of Sydney, NSW 2006 Australia

[3]Finnish Centre for Astronomy with ESO, University of Turku, FI-21500, Piikkio, Finland

[4]Centre for Astrophysics and Supercomputing, Swinburne University of Technology, VIC 3122 Australia

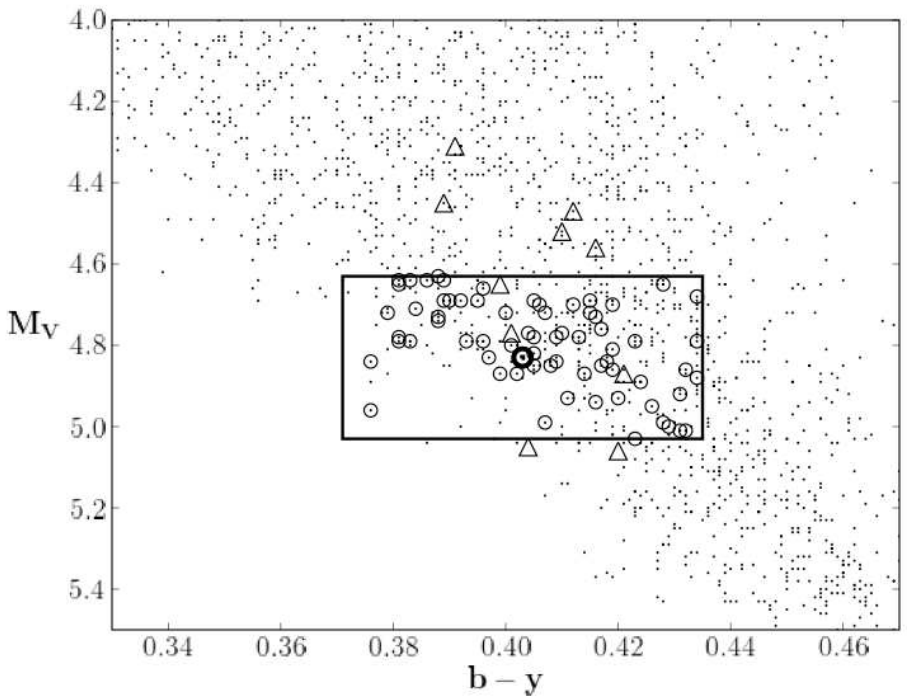
Astronomer's Days 2012
Haikon Kartano, Porvoo, 6th June 2012

Contents

GCS

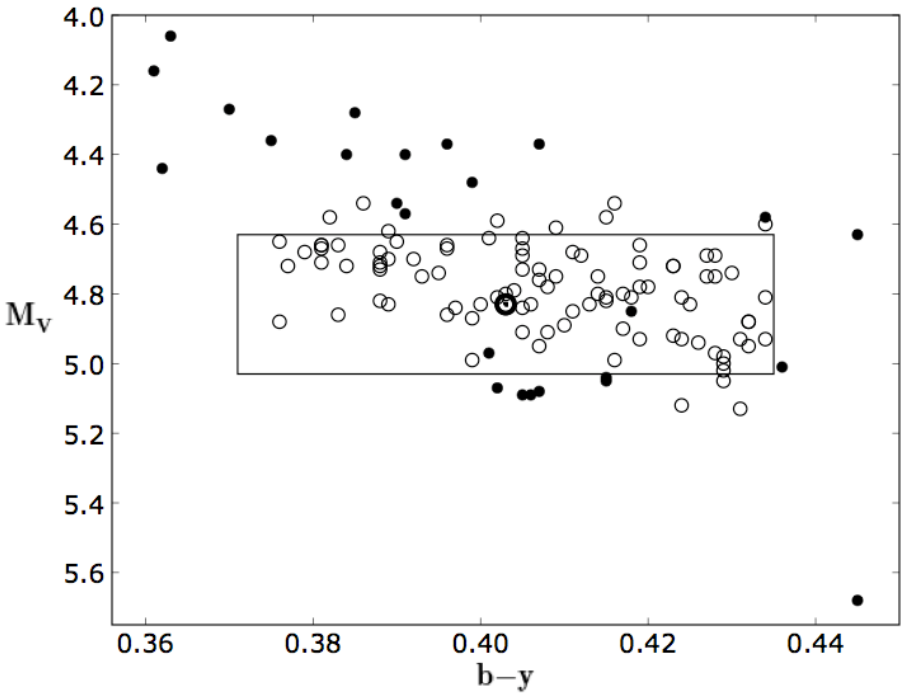
- Geneva-Copenhagen-Survey catalogue (GCS)
- Strömgren colours, absolute magnitudes, metallicities and temperature estimates for 14,000 nearby F to K type stars
- makes it the largest, homogeneous sample of the properties of nearby stars
- apparent magnitude limited selection
- volume limited for F and G stars out to 40pc

Solar analogues



- colour
  $0.371 < b - y < 0.435$
- absolute magnitude
  $4.63 < M_V < 5.03$
- GCS I (dots in this window), with
  $(-0.15 < [Fe/H] < 0.15)$,
  together with our initial twin candidates (circles) and the candidates from Soubiran and Triaud (diamonds).

Solar analogues II



- two revisions of the GCS
- stars moved in and out of the original box
- found some of the new targets from FEROS archive
- included also some targets from other searches, which we could find from the archive

Why check catalogue scales?

- age of large surveys
- difficult to get reliable parameters, when there is so much data
- be able to trust catalogues
- catalogues should make work easier, not more difficult

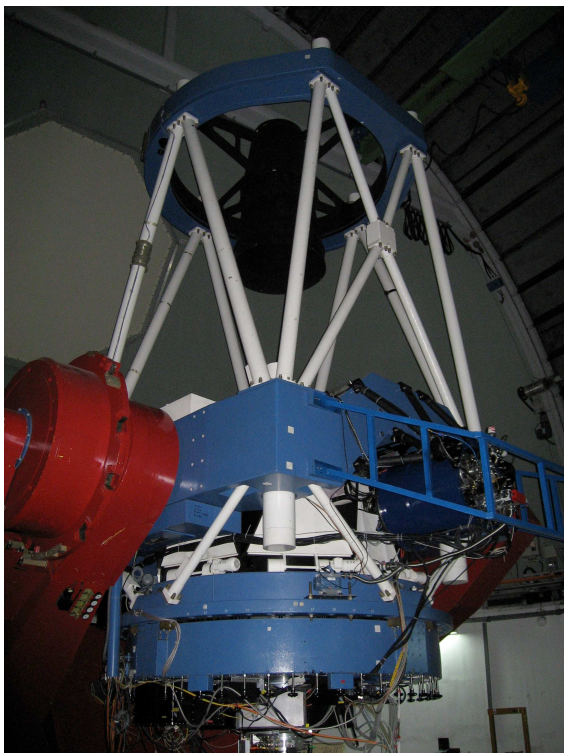
Contents

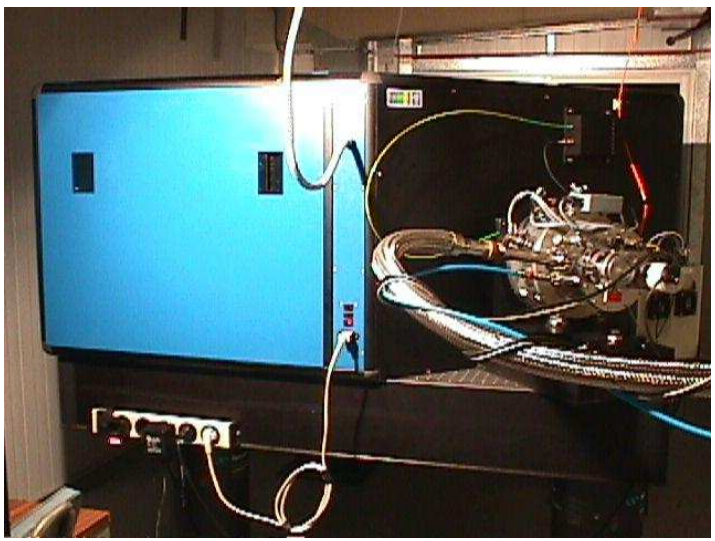
Telescope

Telescope and instrument

- used 2.2m Max Planck Telescope in La Silla, Chile
- FEROS data from June to August 2006
- Fiber-fed Extended Range Optical Spectrograph
- over 70 candidates with a wavelength coverage of 3500-9200Å in 39 orders
- resolution of R=48000
- asteroid Ceres spectrum for comparison to the Sun
- need to compare to something, so see if the values are off or not
- added another 70 spectra from the ESO archive, also FEROS spectra
- typical S/N ∼100-150

FEROS

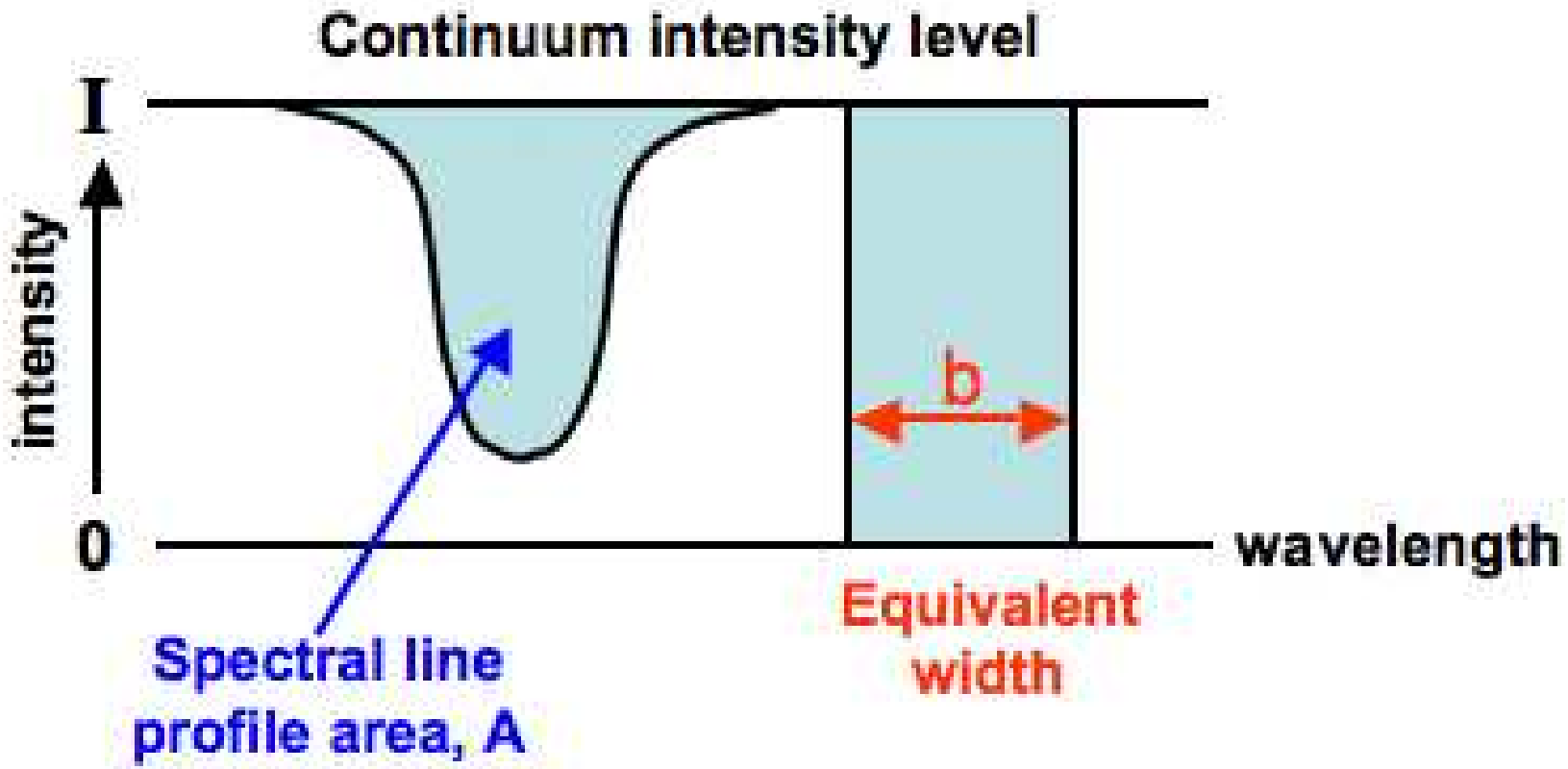




Reduction and analysis tools

- FEROS pipeline
- additional normalizing needed, as the resulting spectra are very wiggly
- developed our own program to determine equivalent widths and line depths of selected lines - TWOSPEC
- comparison of two spectra
- used 109 weak, unblended spectral lines without telluric contamination of 19 different elements
- cover 5000-8000Å

Spectral lines

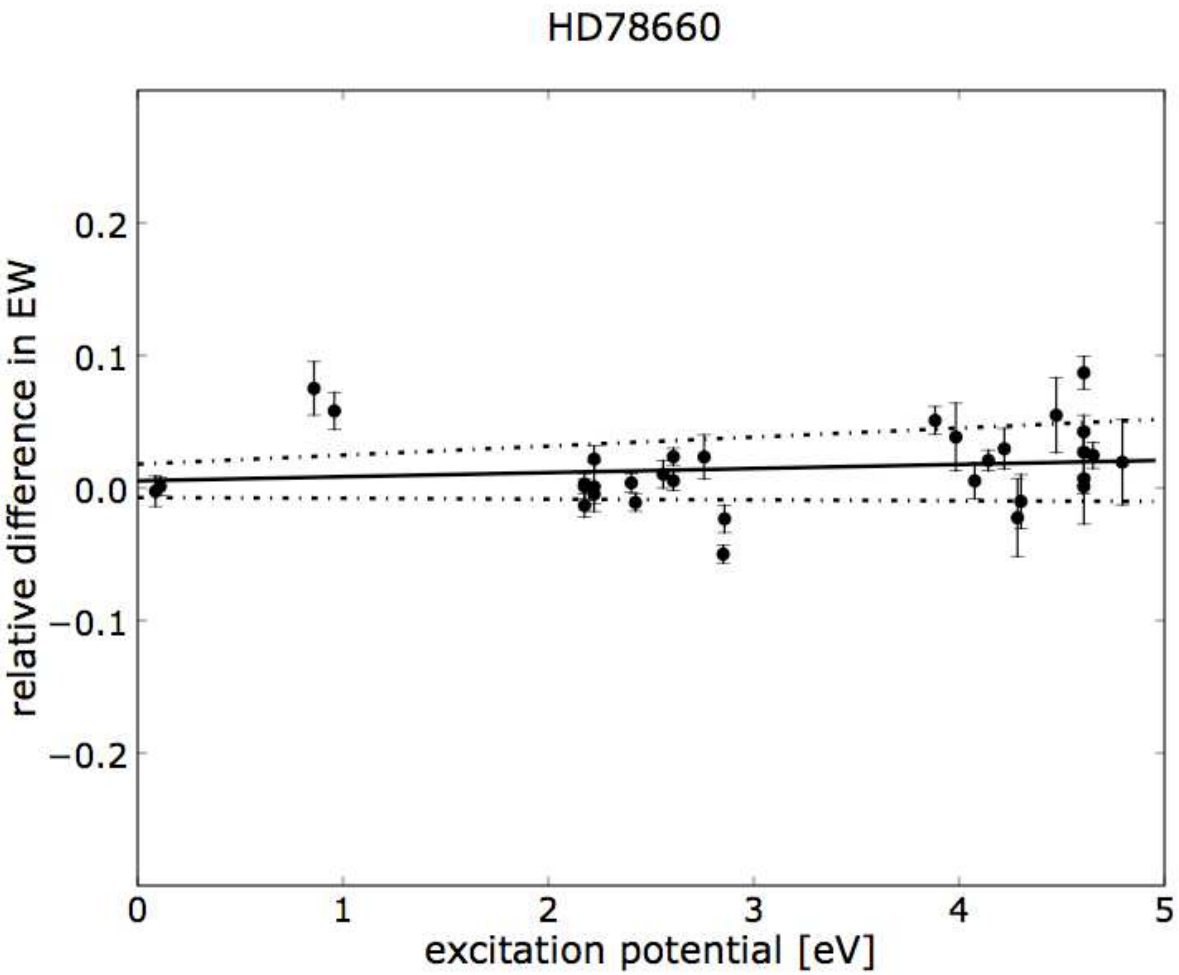


Contents

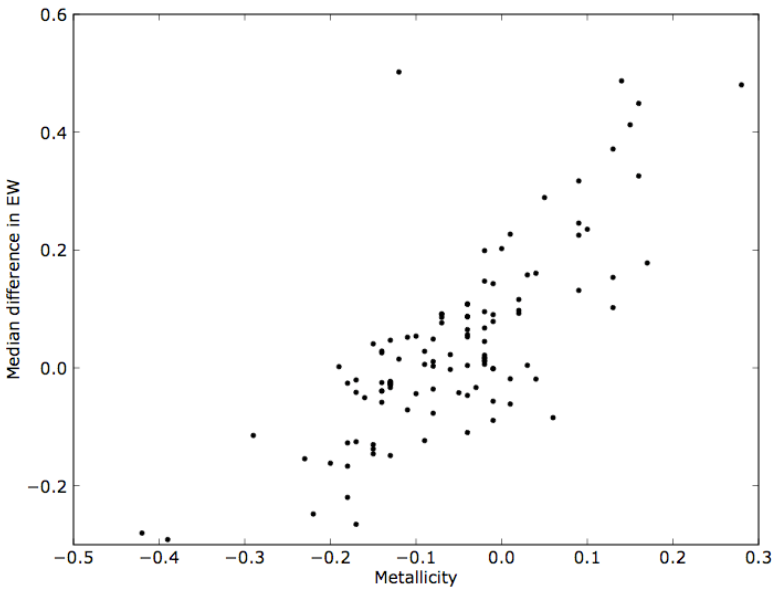
Analysed quantities

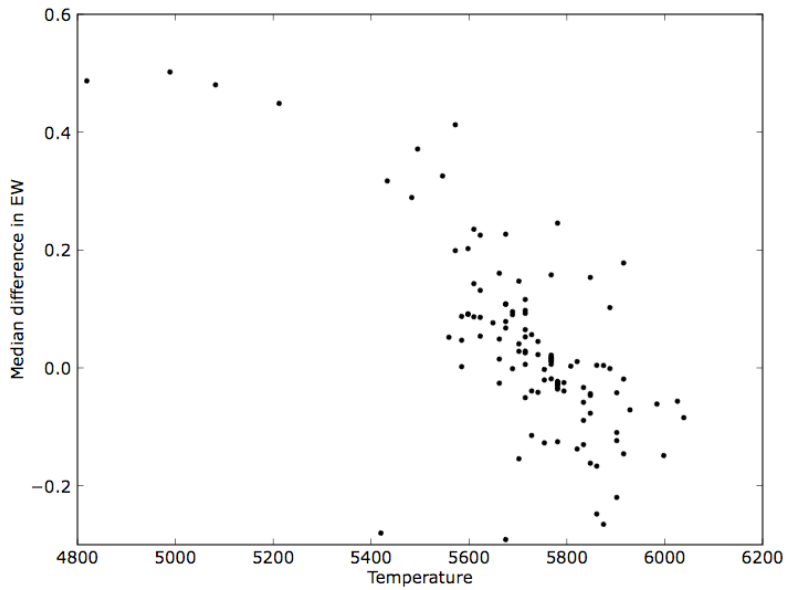
- which information to take from the spectra to analyse?
- $\Delta\mathrm{EW_{all}} = (\mathrm{EW}(\star) - \mathrm{EW}(\odot))/\mathrm{EW}(\odot)$
- $\Delta\mathrm{EW_{FeI}} = (\mathrm{EW_{FeI}}(\star) - \mathrm{EW_{FeI}}(\odot))/\mathrm{EW_{FeI}}(\odot)$
- slope of the relation between $\Delta\mathrm{EW_{FeI}}$ and the excitation potential (χ_{exc}) of each Fe I line
- $\Delta\mathrm{LD_{FeI}} = (\mathrm{LD_{FeI}}(\star) - \mathrm{LD_{FeI}}(\odot))/\mathrm{LD_{FeI}}(\odot)$
- slope of the relation between $\Delta\mathrm{LD_{FeI}}$ and the excitation potential (χ_{exc}) of each Fe I line
- for temperature determination only: line depth ratios $\Delta\mathrm{LDR} = (\mathrm{LDR}(\star) - \mathrm{LDR}(\odot))/\mathrm{LDR}(\odot)$

Slopes


HD78660
relative difference in EW
0.2
0.1
0.0
−0.1
−0.2
0
1
2
3
4
5
excitation potential [eV]

Temperature and metallicity scales



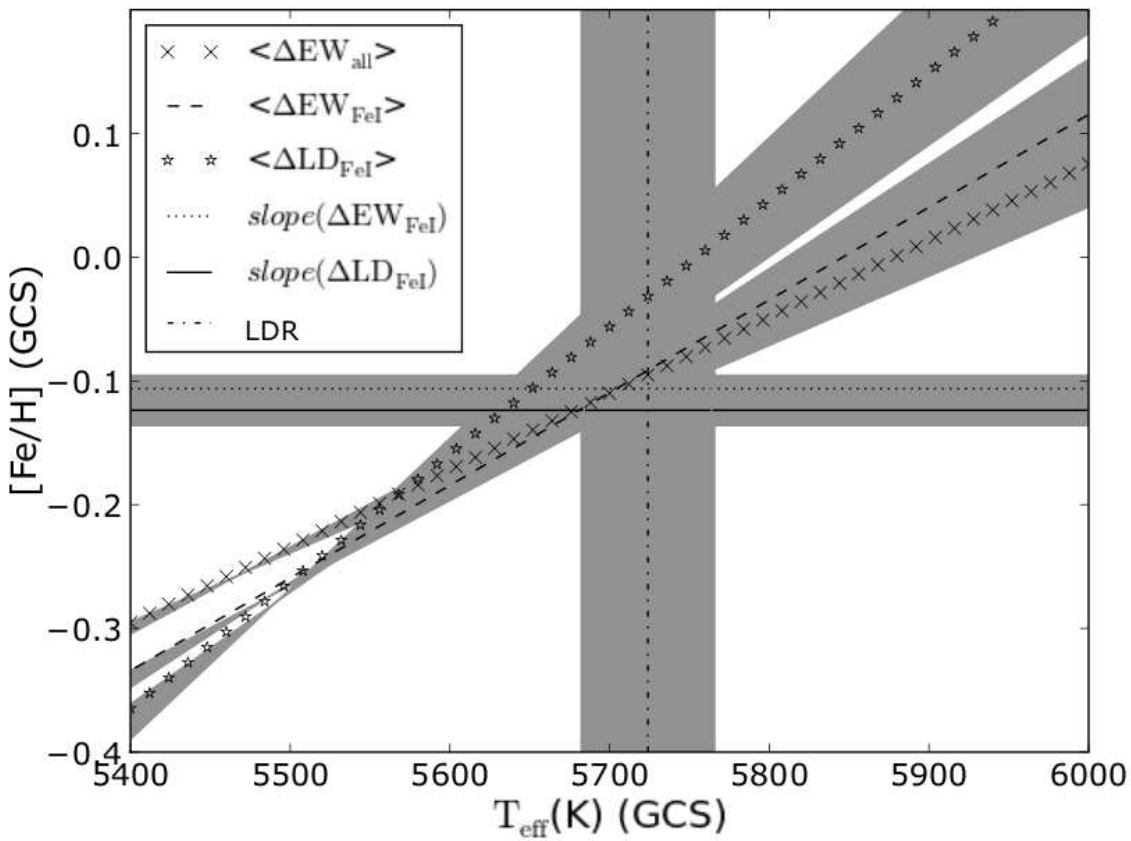


- $\Delta EW_{\rm all} = 1.056 \times [{\rm Fe/H}] - 3.646 \frac{{\rm T_{eff}} - 5500}{5500} + 0.250$
- $[{\rm Fe/H}]_{EW_{all}} = 3.451 \frac{{\rm T_{eff}} - 5500}{5500} - 0.237$

Temperature and metallicity scales

- determine all these dependancies for the mean ΔEW and slope of ΔEW versus excitation potential
- ideal solar twin has all mean ΔEWs and slopes=0
- give the temperature and metallicity of an ideal solar twin in the GCS

Temperature and metallicity scales

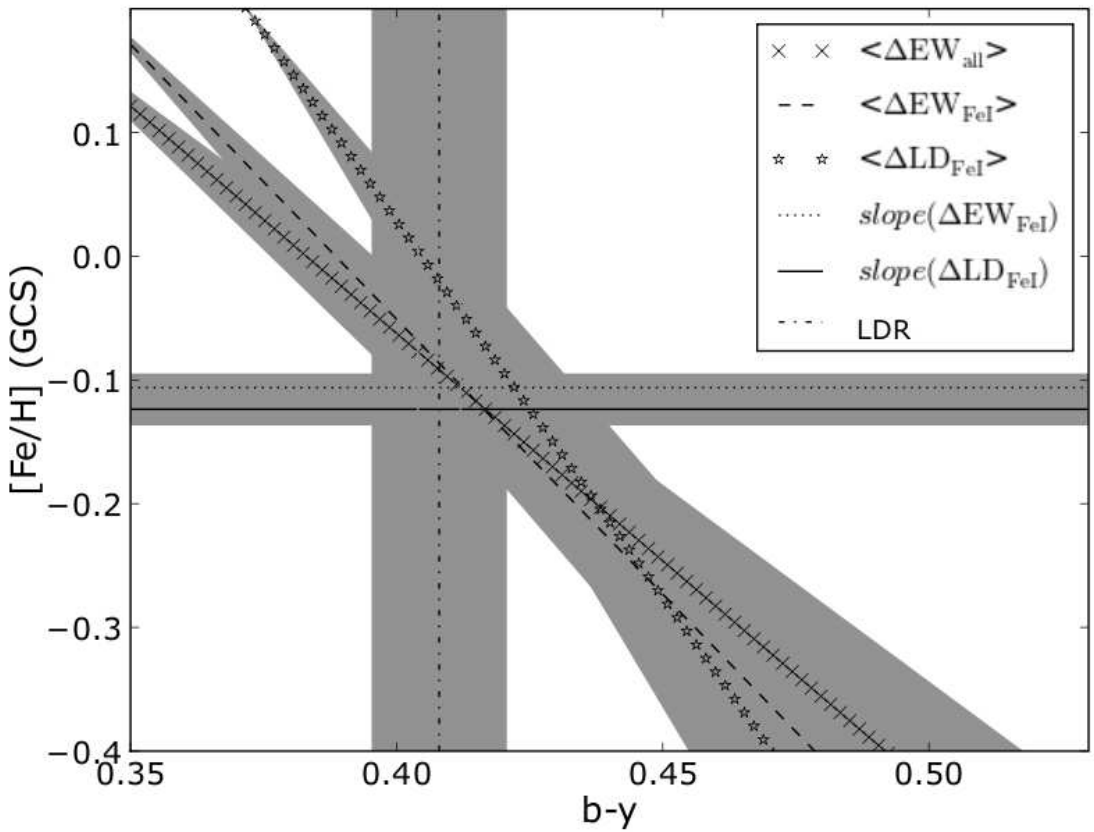


Contents

Temperature and metallicity offsets

- $T_{eff} = 5680 \pm 40\mathrm{K}$ ($T_{eff,\odot} = 5777$)
- $[Fe/H] = -0.12 \pm 0.02\mathrm{dex}$ ($[Fe/H]_{\odot} = 0$)
- yields offsets in the GCS of:
- $\Delta T_{eff} = 97\mathrm{K}$ and $\Delta[Fe/H] = 0.12\mathrm{dex}$
- large offset
- will change other results of the survey, it will change ages, chemical composition, etc.
- see also Casagrande et al. 2010 for similar results: offsets of about 100K and 0.1dex.

Solar colours



Solar colours

- same approach to determine the solar b–y colour
- no direct method possible to measure it
- started out with b–y=0.403 (Holmberg et al. 2004)
- using degeneracy lines, we now find b–y=0.414 ± 0.007
- Casagrande et al. 2010 find b–y=0.409 ± 0.010 and Meléndez et al. 2010 find b–y=0.411 ± 0.002
- our value seems very red, but within the errors of last years' estimates

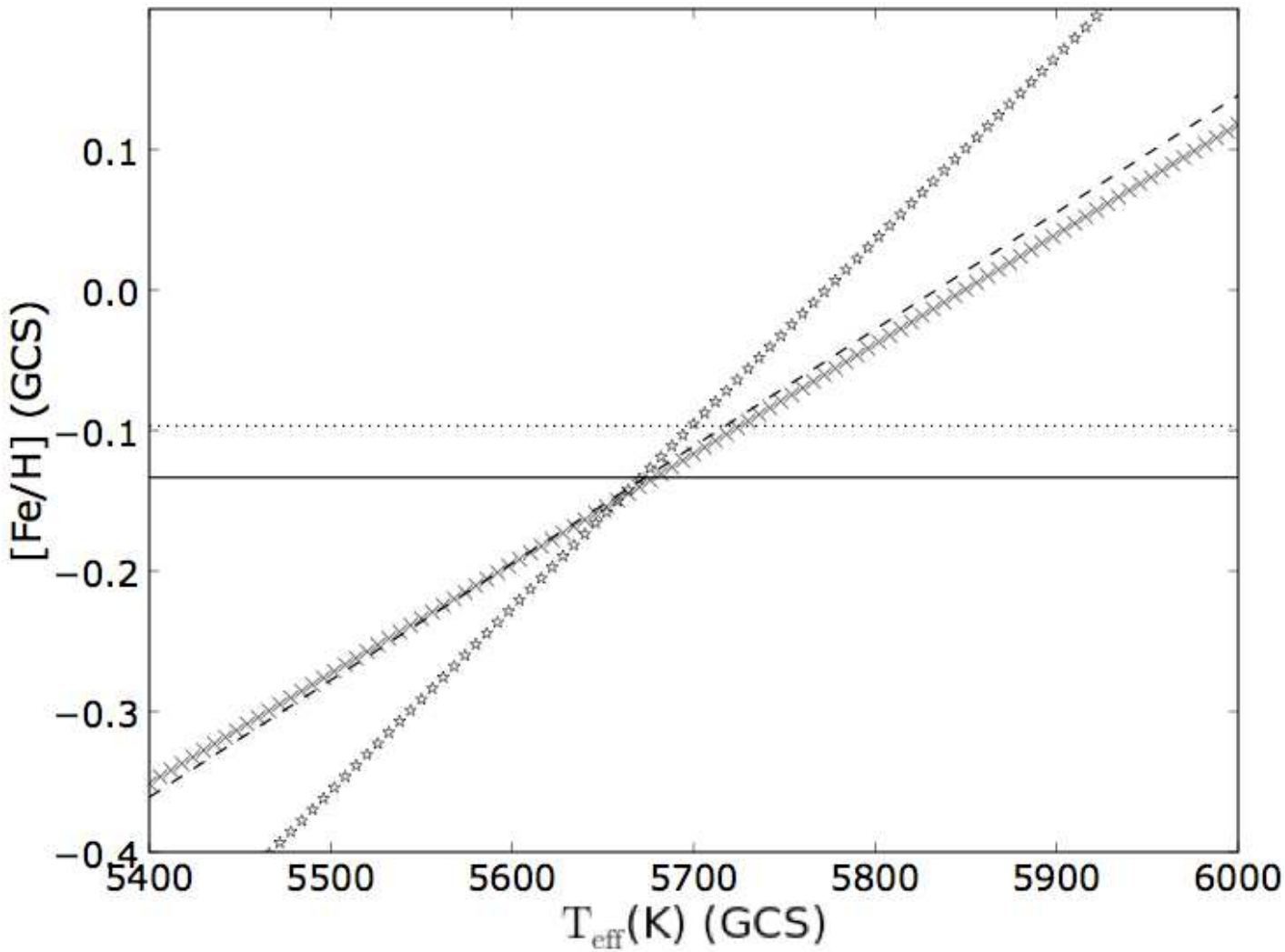
Contents

What is HARPS?

- fibre-fed, high-resolution spectrograph on the 3.6m telescope, also on La Silla, Chile
- High Accuracy Radial velocity Planet Searcher
- R$\sim$115000
- spectral range is 3780–6910Å
- nowadays the 3.6m telescope is dedicated to HARPS
- used spectra of 174 stars from the HARPS archive, same constraints as the FEROS sample
- different line list, 300 lines

Telescope

Results


0.1
0.0
−0.1
−0.2
−0.3
−0.4
[Fe/H] (GCS)
5400
5500
5600
5700
5800
5900
6000
T_eff(K) (GCS)

Results II

- $T_{eff} = 5697 \pm 25\text{K}$ ($T_{eff,\odot} = 5777$)
- $[Fe/H] = -0.12 \pm 0.02\text{dex}$ ($[Fe/H]_{\odot} = 0$)
- yields offsets in the GCS of:
- $\Delta T_{eff} = 80\text{K}$ and $\Delta[Fe/H] = 0.12\text{dex}$

Contents

To take home

- checking catalogue scales is important, there might be offsets
- GCS temperature and metallicity scales seem to be offset by about -100K and -0.1dex, maybe even the solar b-y colour
- see also Datson et al. 2012 (submitted)
- using data from different telescopes allows to make sure that the offsets are real

Future

- use even more data from more telescopes to confirm (ESO proposal???)
- check other catalogues

Thank you!

Thank you very much for your attention!