APOGEE

TECHNICAL NOTE

ASPCAP Tests with Real Data

C. Allende Prieto
Instituto de Astrofísica de Canarias

February 8, 2012

Abstract

The first extensive tests of ASPCAP on real data (other than Arcturus) are described: APOGEE observations of the Galactic bulge, the standard stars with FTS data, and APOGEE observations of cluster members. Running ASPCAP with cubic interpolation, abundance steps of 0.25 dex in the chemical abundances, and multiple runs with random initializations for each star is recommended. The pipeline is approaching the specifications for the atmospheric parameters.

1 Introduction

We previously reported on basic tests of ASPCAP using models and simulated observations (Allende Prieto 2011, García Pérez 2011). Now we test ASPCAP and in particular FERRE with commissioning (pre-summer shutdown 2011) observations from the APOGEE spectrograph in the Galatic bulge, post-shutdown observations of clusters, and a selection of FTS spectra for standard stars.

The main difference between the pre- and post-summer shutdown observations from APOGEE have to do with the alignment of the red detector, which before the summer shutdown could only deliver a resolving power of about $\lambda/\delta\lambda \sim 17,000$, while after the summer was in place, delivering a resolving power close to the other two detectors, about 22,500.

2 Problems on the nodes

Soon after we started to run the first APOGEE observations through ASPCAP it was realized that the solutions for some parameters tended to cluster near the nodes of the grid, while away from the nodes for others. The problem was identified to be closely related to the linear interpolation used by FERRE. This had been seen for SEGUE observations as well, so the interpolation scheme was upgraded to use quadratic and cubic bezier interpolation. The effects were reduced with quadratic, but only with cubic interpolation were finally removed. Altering some of the convergence parameters for the Nelder-Mead algorithm (setting `simp` and `stopcr` to their default values of 1e-4), and reducing the grid steps in alpha/Fe and C/Fe from 0.5 dex to 0.25 dex was also found to help.

It has been decided to use cubic interpolation for the tests presented below. This has a negative implication for APOGEE, since the computing time is much longer than for the linear case, approximately by two orders of magnitude: from seconds per star to minutes for the 7-parameter analysis discussed here.

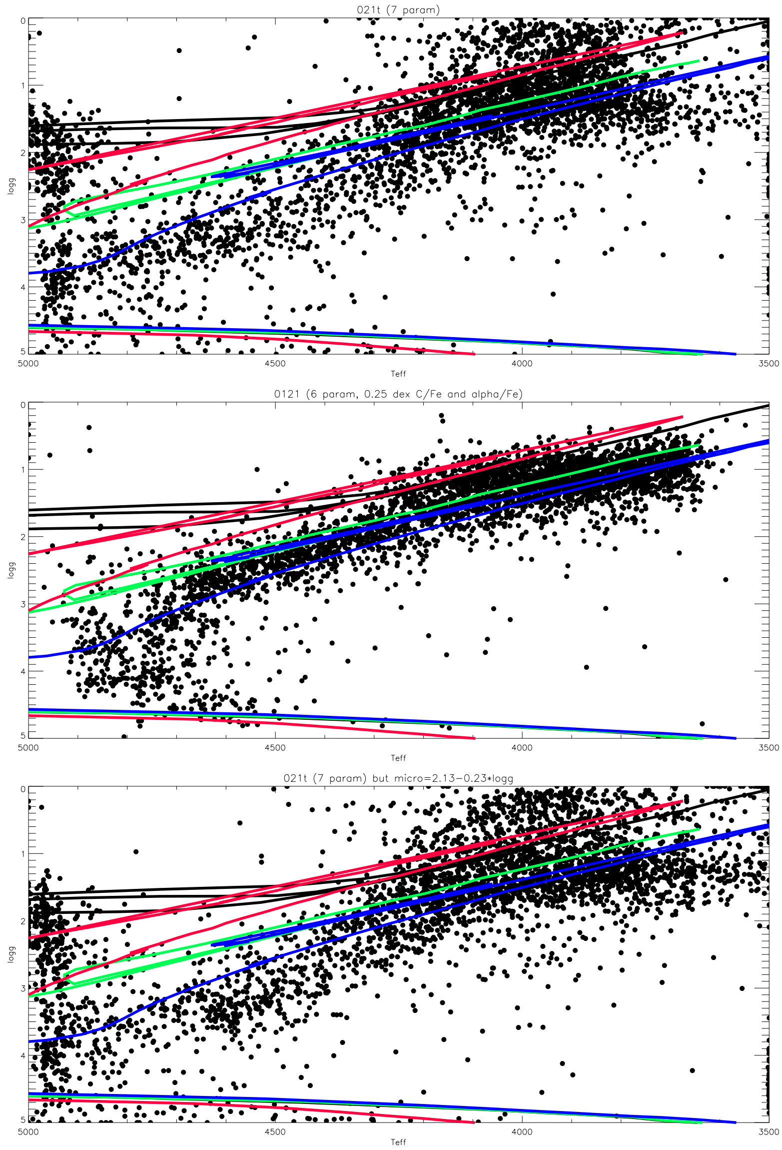

Figure 1: Positions of the stars in the bulge plates in the $\log g$ vs. Teff plane. There are 3849 stars in these 16 plates. The ASPCAP results correspond to the filled circles. The lines are Padova isochrones for solar metallicity and ages of 1e8 (black), 1e9 (green) and 1e10 (blue), as well as [Fe/H]= -0.7 and an age of 1e10 (red).

3 APOGEE Bulge pre-summer shutdown 2011 observations

Fig. 1 compares the Teff/logg distributions derived for the stars with Girardi et al. 2002 isochrones: black, green and blue are for solar-composition and ages of 1e8,1e9 and 1e10 years, respectively; red is for low metallicity ([Fe/H]=-0.7) and 1e10 years. The results with 7 parameters (top panel) show what it looks like the

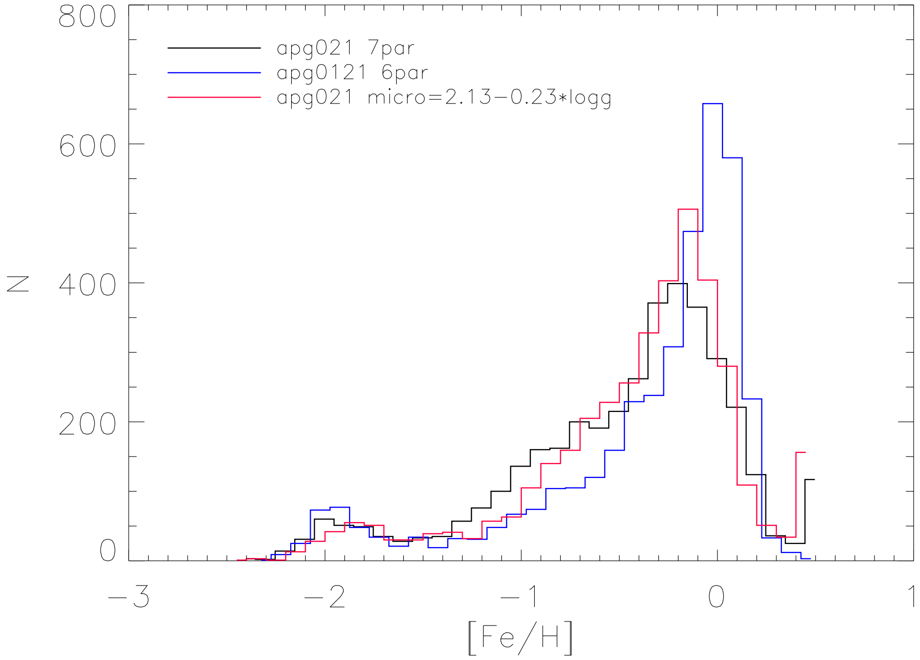

Figure 2: Metallicity distributions found for the cases of fitting 7 parameters (black; 0.5 dex steps in C/Fe and α/Fe), 6 parameters (blue, $\xi = 2$ km/s and 0.25 dex steps in C/Fe and α/Fe), and 6 parameters (red) but $\xi = 2.13 - 0.23 * \log g$ and the smaller steps in C/Fe and α/Fe.

red clump at Teff $\sim$ 4900 K and logg $\sim$ 2[1]. The results with 6 parameters (mid panel) are better contained within the ranges allowed by the isochrones, but they show what resembles a turnoff where none is expected. The bottom panel of Fig. 1 corresponds to holding the micro turbulence fixed to the value predicted by the Kirby equation ($\xi = 2.13 - 0.23 * logg$) – this case shows very similar results to the first one shown in the top panel, with 7 parameters.

Fig. 2 compares the metallicity distributions associated with the previous cases. Fig. 3 shows the derived microturbulence velocities vs. other parameters for the case of fitting 7 parameters. In the top left panel, the green line shows the Kirby relation. Katia circulated a plot comparing micro vs. logg for her own results and others she favors; these show also a good correlation, and are a little higher and with a more pronounced slope than Kirby's.

---

[1] Thanks to Verne Smith for pointing this out!

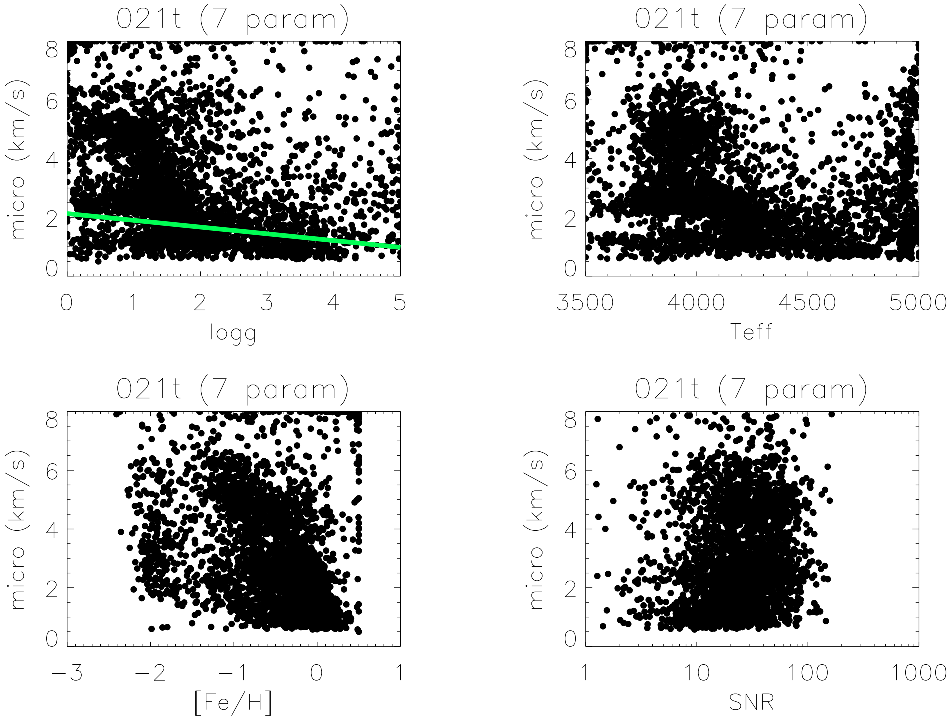

Figure 3: Microturbulence velocities (ξ) derived as a function of other stellar parameters for the 7-parameter grid.

4 FTS standards

The second set of tests involved the FTS spectra provided by Verne Smith. HD 199799, an S star, is shown in red, since it's too cool for our grid (Teff $\simeq$ 3400 K). These observations have a high signal-to-noise (> 100) and a resolving power about 55,000. We nonetheless degrade the observations to match the resolving power of the pre-summer 2011 shutdown APOGEE instrument, nearly 22,000 in the blue and red chips and ablut 17,000 in the red detector. These tests involve only FERRE, and not the entire ASPCAP pipeline; the spectra are pre-processed with a short script custom-made to handle these observations.

The 1-run case is essentially what was discussed at the ASPCAP review in Fort Worth: [Fe/H] is recovered decently, $T_{\rm eff}$ is fine at ~4300 K but too high at the cool end, $\log g$ is somewhat high, and the other abundances are not recovered well[2]. Using the same algorithm, but 10 runs initialized at random and retaining the best fit (when only 1 run is used, it is always initialized at the center of the grid), the results improve significantly, with rms scatter in [Fe/H], [C/Fe], [N/Fe], [α/Fe], $\log_{10}\xi$, $T_{\rm eff}$,$\log g$ of 0.15 dex, 0.19 dex, 0.23 dex, 0.22 dex, 0.23 dex, 85 K, and 0.3 dex, respectively.

---

[2] See `https://trac.sdss3.org/wiki/APOGEE/ASPCAP/Meetings/texas` for details

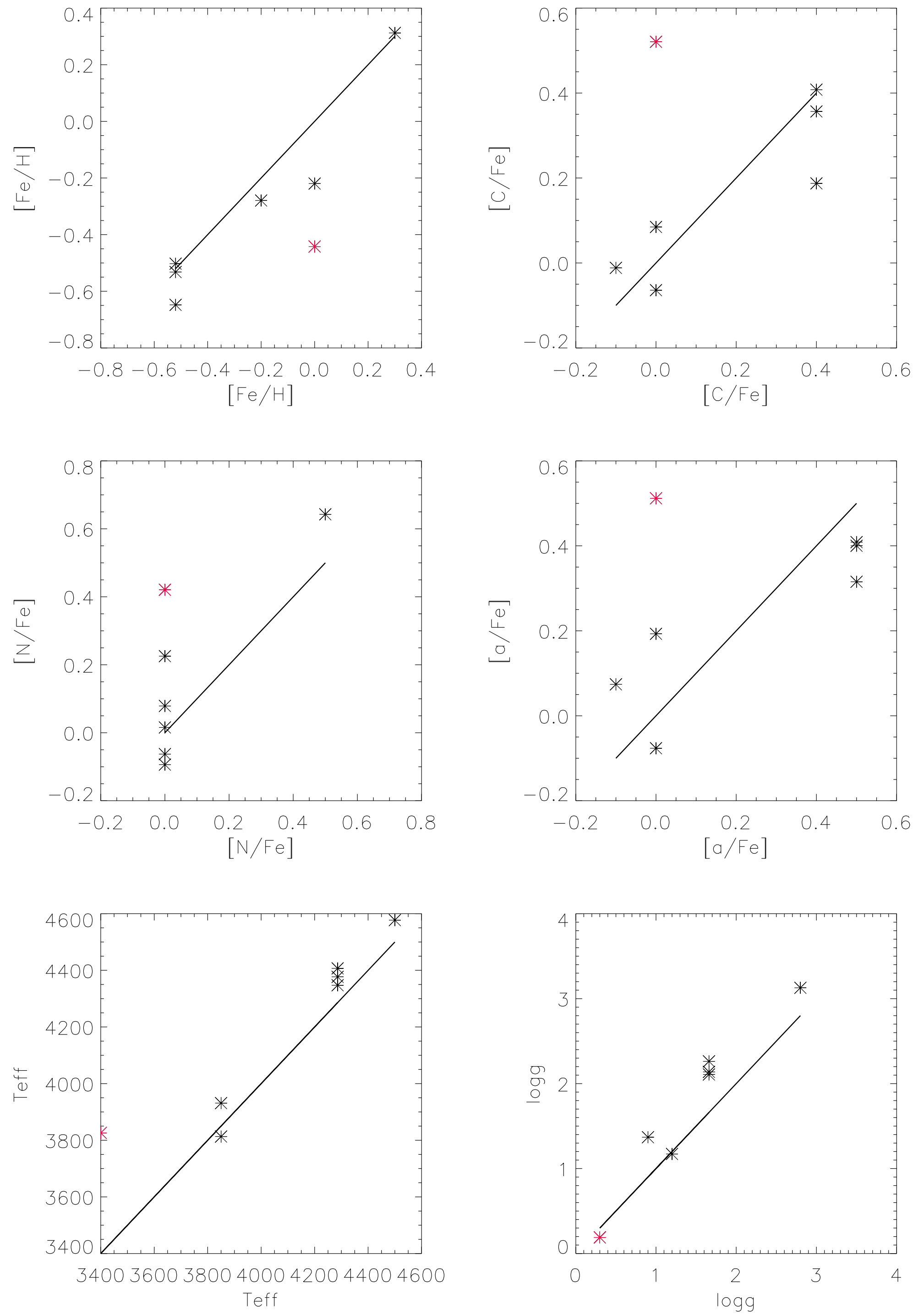

Figure 4: Reference atmospheric parameters provided by V. Smith (x-axis) and ASPCAP results (y-axis) for the case in which the micro-turbulence is set to $\xi = 2.13 - 0.23 \log g$. The red symbol is HD 199799, an S star too cool for our grid.

Further, holding micro fixed at $2.13 - 0.23 \log g$ (case 2), where $\log g$ is derived in a first run with 7 param., reduces the scatter (same order in the parameters as above) to 0.09 dex, 0.11 dex, 0.12 dex, 0.16 dex, –, 54 K, and 0.22 dex, respectively. The reference and ASPCAP parameters for this case are compared in Fig. 4. Holding [N/Fe]=0, the rms scatter is 0.04 dex, 0.13 dex, –, 0.11 dex, 0.24 dex, 107 K, 0.22 dex, respectively, and holding both $\xi = 2.13 - 0.23 \log g$ and [N/Fe]=0 we get 0.06 dex, 0.10 dex, –, 0.08 dex, –, 88 K, and 0.19 dex, respectively. Clearly, reducing the dimensionality of the search helps, and these figures are already approaching the specifications for ASPCAP.

5 Cluster metallicities

It is interesting to compare the literature metallicities for several clusters observed by APOGEE and the average values returned by ASPCAP for stars in the clusters. Matthew Shetrone has kindly selected the cluster members and produced the average for the ASPCAP 6-parameter runs ($\xi = 2.0$ km/s), while the literature values are from the Harris (1996) catalog (2010 version available online). This test involves the entire ASPCAP pipeline, not just FERRE.

As shown in Fig. 5, there is excellent agreement between the two sets of metallicities, but they differ at the lowest metallicities. This is not totally unexpected, since the spectra of these stars at [Fe/H]< -2 have very few lines, and we still try to fit 6 parameters simultaneously.

6 References

- Allende Prieto, C. 2011, Basic Tests with FERRE Using a Gaussian LSF, APOGEE Technical Note
- García Pérez, A. E. 2011, , Testing ASPCAP with Synthetic Spectra, APOGEE Technical Note
- Harris, W.E. 1996, AJ, 112, 1487

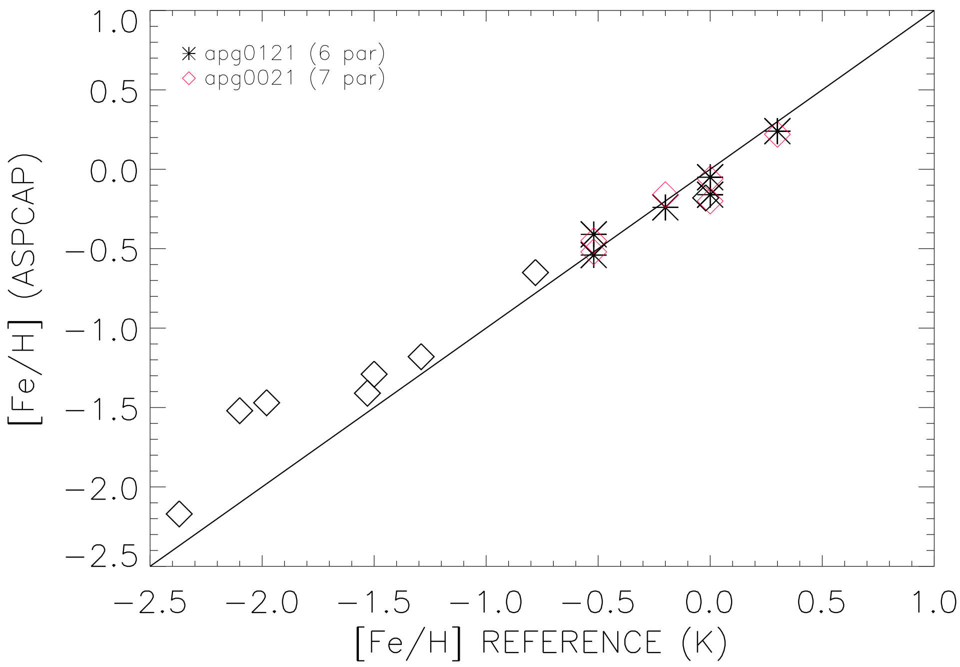

Figure 5: Average metallicities found for several clusters observed with APOGEE (black rhombi). The figure also shows the metallicities derived for the FTS standards described in Section 4 for both the 7-parameter analysis (red rhombi) and 6-parameter case (black asterisks).