Chemical Abundances in the Universe: Connecting First Stars to Planets
Proceedings IAU Symposium No. 265, 2009
K. Cunha, M. Spite & B. Barbuy, eds.

doi:10.1017/S1743921310000591

Accurate Fundamental Stellar Parameters

Hans Bruntt[1,2]

[1]LESIA, Observatoire de Paris-Meudon, 92195, France
[2]Sydney Institute for Astronomy, School of Physics, The University of Sydney, NSW, Australia
email: bruntt@phys.au.dk

Abstract. We combine results from interferometry, asteroseismology and spectroscopic analyses to determine accurate fundamental parameters (mass, radius and effective temperature) of 10 bright solar-type stars covering the H-R diagram from spectral type F5 to K1. Using "direct" techniques that are only weakly model-dependent we determine the mass, radius and effective temperature. We demonstrate that model-dependent or "indirect" methods can be reliably used even for relatively faint single stars for which direct methods are not applicable. This is important for the characterization of the targets of the CoRoT and *Kepler* space missions.

Keywords. stars: fundamental parameters, stars: abundances, stars: late-type

1. Why are fundamental parameters important?

Fundamental parameters are critical for the interpretation of both the exoplanet and asteroseismic data from CoRoT and *Kepler*. These space missions will provide a huge leap forward in our understanding of the interior physics of stars. This is possible by comparing the observed oscillation frequencies with theoretical pulsation models. It will allow us to examine how we can improve the approximations of the physics in the evolution models. To limit the range of models we need reliable estimates of the fundamental parameters of the target stars. Also, characterization of stars hosting exoplanets is important to understand the properties of transiting systems. Since the targets of CoRoT and especially *Kepler* are faint we must use indirect methods. We will compare direct and indirect methods and determine to what extent we can constrain $T_{\rm eff}$, mass and radius.

$T_{\rm eff}$ from spectroscopy with 50 K accuracy

We compared two methods to determine $T_{\rm eff}$ of 10 bright solar-type stars. (1) We used measured angular diameters from the literature combined with the bolometric flux (Fig. 1) yielding $T_{\rm eff}$ from its basic definition. These results are nearly model-independent; only the limb-darkening is from models. (2) We made a "classical" spectroscopic analysis of 100s of Fe I lines requiring that lines with a range of different excitation potentials and line strengths yield the same abundance. We use the VWA tool (Bruntt *et al.* 2008, Bruntt 2009) employing 1D LTE MARCS atmospheric models (Gustafsson *et al.* 2008; spectra are from HARPS@ESO except η Boo observed with FIES@NOT). As shown in Fig. 2 (left top panel) the mean difference is $\Delta T_{\rm eff} = -48 \pm 49\,{\rm K}$ (rms scatter), and there is no significant correlation with $T_{\rm eff}$. We thus claim that after correcting for the $\Delta T_{\rm eff}$ offset we can determine $T_{\rm eff}$ from a high-quality spectrum to $\simeq 50$ K in the spectral range from Procyon A (F5) to α Cen B (K1). The stars are shown in the H-R diagram in Fig. 2.

Radius with 3% accuracy without interferometry

We determined the radii of the stars using a direct and an indirect method: (1) We combined the measured angular diameters from the literature with the updated parallaxes from van Leeuwen (2007). (2) We combined the spectroscopic $T_{\rm eff}$ with the luminosity

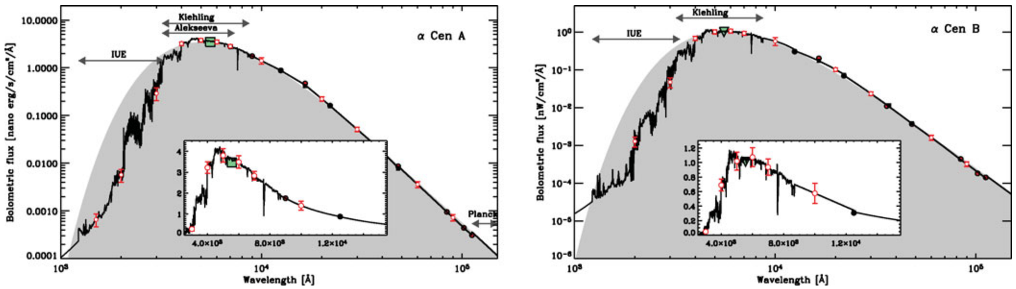

Figure 1. The data used to determine the bolometric flux of α Cen A+B . IUE and ground-based spectrophotometric data are shown with thin lines and filled symbols are broad-band fluxes.

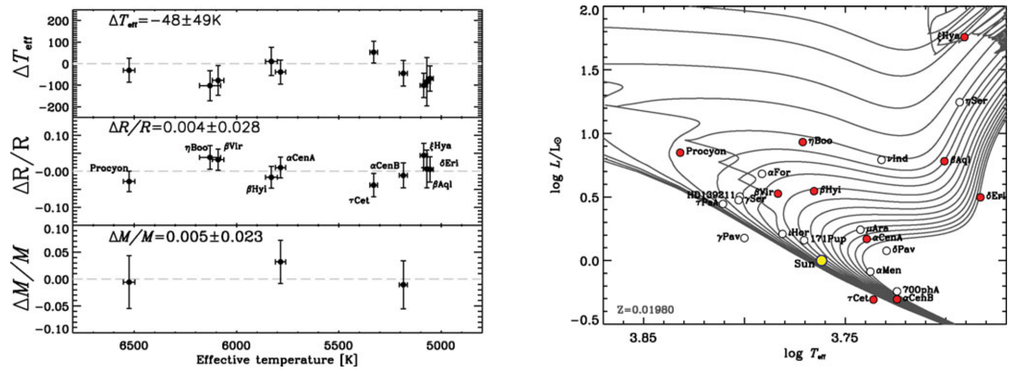

Figure 2. *Left panel:* Comparison of $T_{\rm eff}$, R and M from direct and indirect methods. *Right panel:* H-R diagram with ASTEC tracks. Solid circles are stars with measured angular diameters.

through $L/L_\odot = (R/R_\odot)^2\,(T_{\rm eff}/T_{\rm eff;\odot})^4$. The luminosities were determined from the V magnitude, BC from Girardi *et al.* (2002), and the parallax from van Leeuwen (2007). The comparison of the two methods to determine R is shown in Fig. 2 in the left middle panel. The agreement is good and shows that radii can be determined from indirect methods to $\simeq 3\%$ (1-σ uncertainty).

Mass with 4% accuracy for single stars

Three of the stars are members of binary systems and have well-determined masses ($< 2\%$). For all stars the radius has been measured ($< 2\%$) from interferometry and the mean density is inferred from asteroseismic data (large separation) by scaling from the Sun. Combining the radius and density we get the mass to $\simeq 4\%$. The left lower panel in Fig. 2 compares the mass for the two methods (Procyon A and α Cen A+B). Although the number of stars is small it is reassuring that the agreement is good (2% rms scatter).

References

Bruntt, H., 2009, *A&A* accepted, arXiv 0907.1198
Bruntt, H., De Cat, P., Aerts, C., 2008, *A&A* 478, 487
Girardi, L., *et al.*, 2002, *A&A* 391, 195
Gustafsson, B., *et al.*, 2008, *A&A* 486, 951
van Leeuwen, F., 2007, *A&A* 474, 653

https://doi.org/10.1017/S1743921310000591 Published online by Cambridge University Press