Synthesis of the Beryllium 3131Å Spectral Region

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1. Introduction

The synthesis of the Beryllium region presented in this paper was carried out with the objective of determining the Be abundance of 4 stars in the open cluster NGC6633 (one of which exhibits chemical peculiarities) using new CCD data from the UV Visual Echelle Spectrograph (UVES) on the Very Large Telescope (VLT) (see Ashwell et al. in preparation).

As both components of the BeII doublet are blended with other lines it is necessary to synthesis this region of the spectrum. This synthesis has been carried out using an updated version of the LTE analysis code MOOG (Sneden, C., 2002, MOOG An LTE Stellar Analysis Program) and atmospheres interpolated for the individual stellar parameters from the Kurucz ATLAS9 grids.

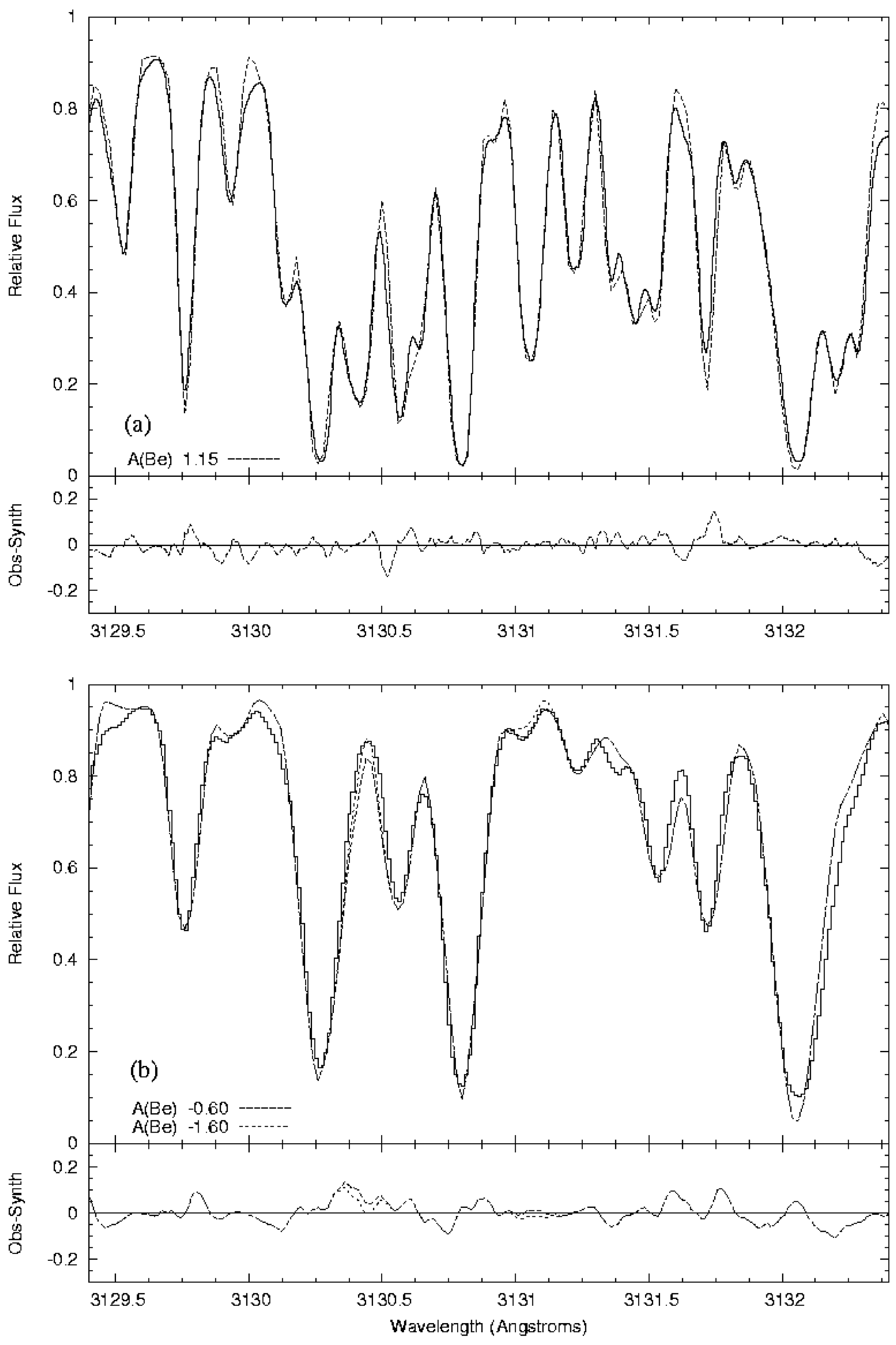

Figure 1: Spectral synthesis of the Solar BeII doublet (3130.4Å and 3131.1Å) region from the NOAO Solar atlas (a) and Procyon (b). The upper portion of each plot shows the spectrum (solid line) and synthesis (dashed line). The lower portion of each plot shows the residuals.

2. Line List Selection

The 3131Å spectral region which contains the BeII resonance doublet is rich with strong atomic and molecular lines in solar type stars. This results in substantial line absorption and a deficit of true continuum regions making normalisation difficult. Though, spectrum synthesis can reduce normalisation problems by taking into account possible blending features, laboratory studies of the identification, precise wavelengths and oscillator strengths of many features in this spectral region are limited.

The initial line list used consists of selected atomic and molecular lines from the ATLAS9/Kurucz CD-ROMs with the lines selected on the basis of having an excitation potential less than 10.0 eV and log-*gf* greater than -10.0.

Abstract

The beryllium spectral region of the Sun, Procyon and 4 stars in the open cluster NGC6633 up to T_{eff} = 7500K has been synthesised using the ATLAS9 model atmospheres and the MOOG spectral synthesis program.

The line list used for these syntheses has been modified from the ATLAS9 line list to improve the quality of the fits in light of the improved opacities in the new version of the MOOG code.

Significant changes have been made to the MnI line at ATLAS9 wavelength 3131.037Å and an OH line has been added at 3131.358Å. In addition there are a number of minor changes to gf-values throughout the synthesized region thus improving the fit for the spectra across the temperature range considered.

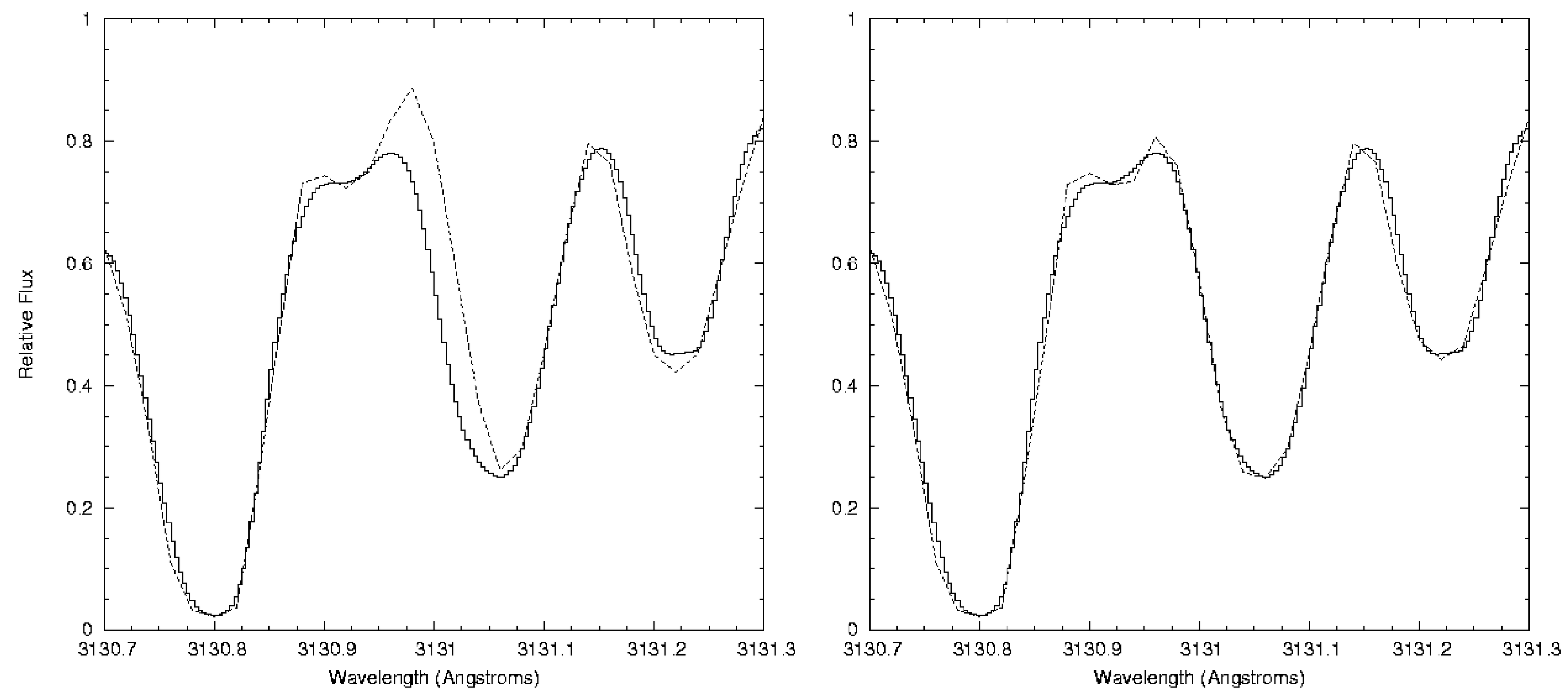

Figure 2: A magnified section of Figure 1a showing the changes made to the MnI line at 3131.037. The left plot shows the original ATLAS9 line list parameters and the right plot shows the fit achieved by altering these parameters (see section 3.1).

3. Line List Calibration

Throughout the 3129.5 - 3132.5Å region synthesized the oscillator strengths for a number of lines were altered from their ATLAS9 values to better fit both the NOAO Solar Atlas (Kurucz et al., 1984, Solar flux Atlas from 296 to 1300 nm, National Solar Observatory Atlas No. 1, Harvard University) *and* a spectrum of Procyon (F5 IV) obtained with UVES by (Bagnulo et al., 2003, Messenger, 114, 10) (see Figure 1).

Possible arbitrary changes were avoided by adopting the philosophy that *gf*-values which needed the least adjustment should be chosen where a number of lines affected the same feature. The resulting solar A(Be) = 1.15 is in excellent agreement with the photospheric abundance quoted in (Anders & Grevesse, 1989, Geochimica et Cosmochimica Acta, 53, 197), whilst Procyon is confirmed as very Be-depleted (A(Be)<-0.5).

To simultaneously match the Procyon spectrum, with T_{eff} = 6700, log g = 4.05 (Lemke, Lambert & Edvardsson, 1993, PASP, 105, 486); and the Sun a few major changes were made.

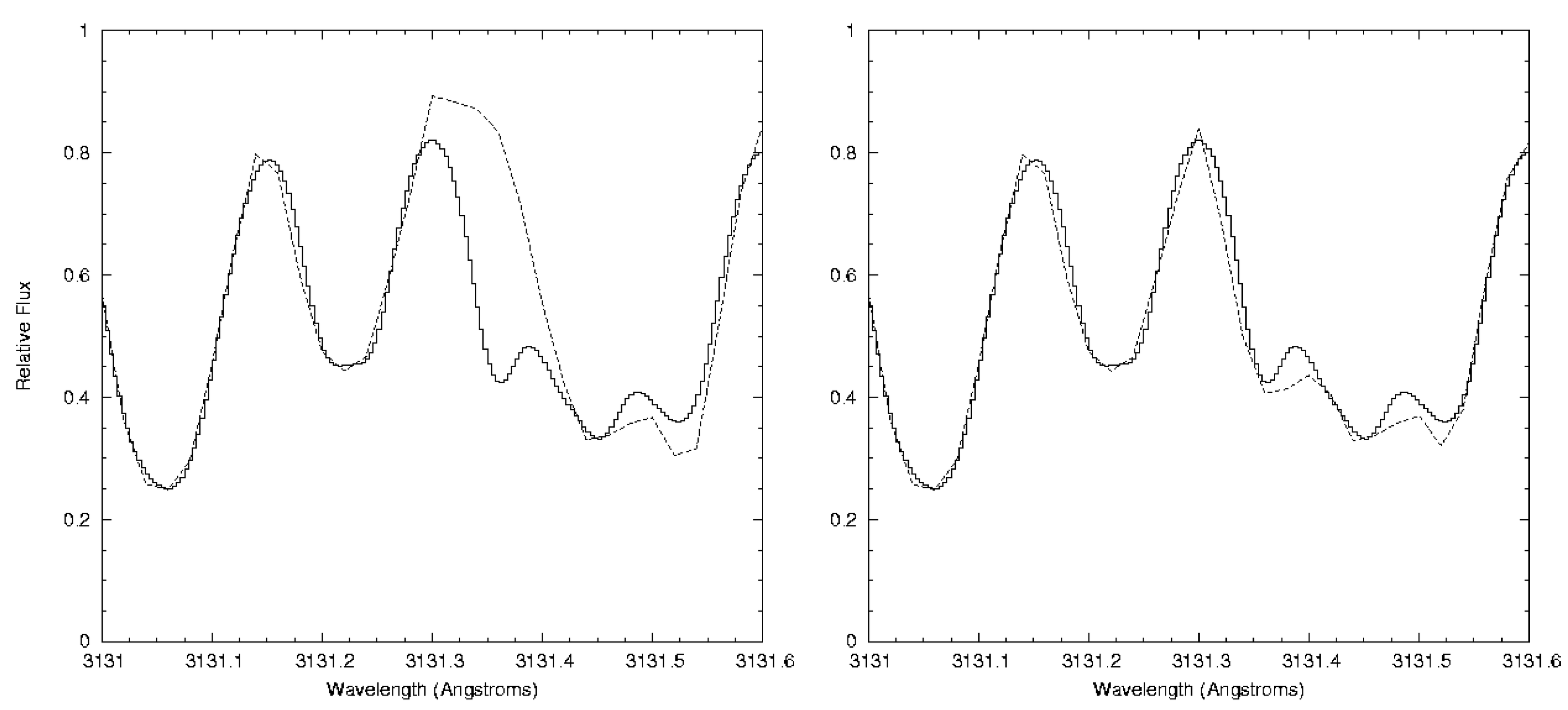

Figure 3: A magnified section of Figure 1a showing the changes made red-ward to the BeII doublet. The left plot shows the original ATLAS9 line list parameters and the right plot shows the fit achieved by adding an OH molecular line (see section 3.2).

4. Line List Modifications

Very few major changes were made to the ATLAS9 line list and of these only two affect the BeII lines directly. The first is an alteration of both the wavelength and gf-value of an MnI line and the second is the addition an OH molecular line where a line is clearly missing in the ATLAS9 line list.

The wavelength of the MnI in the ATLAS9 list is stated as 3131.037Å with a log *gf*-value of -1.725 and gives the fit shown in the left plot of Figure 2 using the MOOG code. The synthesis (dashed line) is clearly discrepant from the spectrum (solid line) appearing to be positioned at too longer wavelength.

However, a remedy to this problem is suggested by King, Deliyannis & Boesgaard, 1997, ApJ, 478, 778. They suggest that shifting the MnI line to 3131.017Å (a shift of ~0.02Å is not unreasonable when considering errors) could account for the discrepancy. Therefore, by shifting this line and increasing its *gf*-value by +1.56 dex the fit shown in the right hand plot of Figure 2 is achieved.

The addition of an OH molecular line as seen in the right hand plot of figure 3 corrects for the apparently missing line at 3131.350. The line with a wavelength of 3131.358, excitation potential of 1.941 and log *gf*-value -1.347 was used in the line list for various King papers including King, Deliyannis & Boesgaard (1997) however, the *gf*-value used here has been increased by 0.110 dex.

5. Conclusions

Via a combination of small changes to the *gf*-values of a number of line across the spectral region synthesised and a few more major changes in the immediate vicinity of the BeII doublet lines an accurate fit to the spectra of both the Sun and Procyon have been achieved.

Furthermore, the same line list is capable of synthesising the high resolution VLT/UVES spectra of four stars in NGC6633 within a temperature range of 6300-7600K (see Ashwell et al, in preparation).