CHEMICAL ABUNDANCE ANALYSIS OF THE RED GIANT STAR HD 94264 (46LMI)

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HD 94264 is one of the stars that less studied thoroughly in the literature. The atmospheric parameters and abundances of 26 elements (C, N, O, Na, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Y, Zr, Mo, Ba, La, Ce, Pr and Nd) are determined for the star using LTE analysis approach. Abundances of 8 elements (C, N, Cu, Zn, Mo, Ba, Ce and Pr) are determined for the first time for this star. The $^{12}C/^{13}C$ isotope ratio of the star is also determined. Abundance of carbon is studied using the C_2 Swan band at 5086 . The wavelength interval 7980 – 8130 that contains strong $^{12}C^{14}N$ and $^{13}C^{14}N$ molecular features, allowed us to determine the nitrogen abundance and $^{12}C/^{13}C$ isotope ratio as well. Effects of the hyperfine structure is also taken into account for Sc, V, Mn, Co, Cu, La, Ba and Pr.
The spectra of the star is taken by Russian Turkish Telescope (RTT150) which is operated at TÜBİTAK National Observatory. The high resolution (R=40000) and high S/N (>100) spectra are analysed using mixed approach of fine analysis and spectrum synthesis techniques.

Keywords: stars: abundances – stars: fundamental parameters – stars: atmospheres – stars: individual HD 94264

1. INTRODUCTION

Stars go through different evolutionary stages during their lifetime with different thermonuclear reactions occurring in their inner regions. These stages are directly depends on the mass of the stars. Low mass stars climb the red giant branch (RGB) with a degenerate He core. At the beginning of the ascent along the giant branch, the outer convective envelope expand to the interior part where thermonuclear reactions occur and transports the processed metarial up to the atmosphere. This stage called as the 'first dredge-up' and changes the chemical structure of the atmosphere. The changes in Li, C, N element abundances and the isotope ratio of $^{12}C/^{13}C$ are highly depends on the mass and metallicity of the star. After the He-flash phase, the degeneracy is removed and the star begins quiescent He-core burning. All the low-mass stars have similar core masses at the beginning of He- burning. Hence they have similar luminosities and thus their absolute magnitudes are nearly constant. Due to this fact, the red giants at this evolutionary stage exihibit a specific feature in the color - magnitude diagram called 'red clump'. This region occupy with the stars that are ascending for the first time to the RGB and returning back from the Helium Flash phase and it is very difficult to distinguish between stars of these two different evolutionary stages without spectroscopic abundances analysis [1].

HD 94264 (46 LMi) (Vmag = 3.83^m, K0 III-IV) [2] is a red clump canditate star that selected from Tycho-2 Red Clump Candidate Catalog [3]. The star is one of the less studied stars for complete abundance analysis.

2. OBSERVATION AND DATA REDUCTION

The star was observed with RTT 150 telescope of TÜBİTAK National Observatory using the Coudé spectrograph on March 30-31^th, 2012. The resolving power of the spectra is 40000 and the S/N $\geq$ 100. Wavelength range is 3800 Å–10000 Å. The prelimanary reduction of the spectra (bias and dark subtractions, flat- fielding) were carried out with MAXIM DL [4] and the DECH 20 [5] program is used for the continuum normalization.

3. ATMOSPHERIC PARAMETERS

The initial effective temperature is determined via the line depth ratios method [6]. For this purpose, we used line depth ratio of λ6251.83 ÅVI and λ6252.56 ÅFeI lines which are non-blended, temperature sensitive and widely used for this method. The effective temperature is obtained as 4736°K.

The initial surface gravitiy is obtained from the standart equation:

$$logg_* = 0.4(Mv_* + BC - MBol_\odot) + logg_\odot + 4log(Teff_*/Teff_\odot) + log(M_*/M_\odot)$$

The resulting log g is 2.98

Using the initial atmospheric parameters, an initial stellar atmosphere model was computed with ATLAS9 code [7][8]. Then the temperature of the model was changed until the abundance values obtained from the Fe I lines were independent of the excitation potential and minimum scatter around the mean value. The log g value of the model was changed until the abundances from FeI and FeII lines become equal, i.e. ionization balance. The value of microturbulence velocity is determined from a condition that abundance of the iron lines are independent of equivalent widths.

The final atmospheric parameters are;

$$T_{eff} = 4770°K, logg = 2.55V_{mic} = 1.31km/s$$

4. DETERMINATION OF CHEMICAL ABUNDANCES

Two methods were used for abundance analysis. equivalent witdh analysis has been done using ABUNDANCE [9] routine and spectrum synthesis has been done using SPECTRUM package [9].

Because of the star is a K type giant, it's spectrum has numerous molecular bands. Many metal lines are blend with molecular bands. This situation makes the equivalent measurements very difficult. For line identification and line selection, an unbroadened synthetic spectrum has been prepared with SPECTRUM code, then the line list extracted from VALD database [10] and SPECTRUM's own line list mapped on the synthetic spectrum. The SPECTRUM's native line list also includes molecular lines. In this manner the positions of molecular bands and other significant contaminants were determined. The position of the telluric lines have been determined from Solar Flux Atlas of Wallace et. al. [11]. For equivalent width measurements IRAF's [12] spectool package was used and the equivalent widths were measured using Gaussian fits.

Especially for during the spectrum synthesis, all log gf values were checked on the solar spectrum.

Abundances of Si, Ca, Ti, Cr, Fe and Ni elements were determined with equivalent witdh analysis. C, N, O, Na, Al, Sc, V, Mn, Co, Cu, Zn, Sr, Y, Zr, Mo, Ba, La, Ce, Pr and Nd were analyzed with spectrum synthesis method. For the odd atomic numbered elements the hyperfine splitting is taken into account. Also for barium element isotopic shifting and hyperfine structure were taken into account.

Carbon abundance is determined from Swan band at 5086 Åand nitrogen abundance is determined from CN band at 7980 – 8130 Åwavelength interval. The wavelength interval 8002 – 8007 Åwith strong CN lines was analysed in order to determine 12C/13C isotope ratio. Molecular data and log gf values were taken from [13],[14]

Estimated abundances can be seen from Table 1.

5. CONCLUSION

The atmospheric parameters and abundances of 26 elements (C, N, O, Na, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Y, Zr, Mo, Ba, La, Ce, Pr and Nd) are determined for HD 94264 (46LMi) using LTE analysis approach. Abundances of 8 elements (C, N, Cu, Zn, Mo, Ba, Ce and Pr) are determined for the first time for this star. $^{12}C/^{13}C$ isotope ratio is found to be 19. This result is in good agrement with Tomkin's result of 22±4 [15] which is the only value given in literature. Standart evolution predictions suggest that $^{12}C/^{13}C = 20$ - 30 is typical for Red Giant Branch stars [16]. So that, according to our 12C/13C isotope value, we may conclude that HD 94264 (46LMi) is a RGB star.

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