DETERMINATION OF THE FUNDAMENTAL PARAMETERS OF THE GIANT CLASSES F AND G HR8718 (F5II), HR8304(G8II), HR8179(G5II), HR8778 (G8IV)

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The atmospheres of giants of the F and G HR8718 (F5II), HR8304(G8II), HR8179(G5II), HR8778 (G8IV) are investigated. Having compared the observed and theoretical value of the photometric indices β, $[c_1]$, Q and resing the parallax method, the effective temperatures and the surface gravity of the stars are determined. The following values of the effective temperature and surface gravity $T_{eff} = 6800 \pm 100K$, logg=4.0±0.1(HR8718); $T_{eff} = 5010 \pm 100K$, logg=2.1±0.1(HR8304); $T_{eff} = 5200 \pm 150K$, logg=2.7±0.2 (HR8179); $T_{eff} = 5300 \pm 100$ K, logg=3.2± 0.1(HR8778).

The parameter (velocity) of microturbulence was investigated along the lines of Fe(II). It is found that, $\xi_t = 3.0$ km/s (HR8718); $\xi_t = 3.2$ km/s (HR8304); $\xi_t = 2.0$ km/s (HR8179); $\xi_t = 1.8$ km/s (HR8778).The abundance of the iron element of stars is determined.The iron abundance is determined on the basis of comparison of the calculated and observed intensity of the spectral lines Fe (II). Calculations of the intensity of the spectral lines were carried out with the help of a program DASA, developed by CrAO. The determined abundance of Fe (II) in the atmospheres of the stars is compared with its contents in the Sun. The abundance of the iron element of the considered giants is close to the Solar one. This means that these giants were formed from a substance with the same metallicity as the Sun.

Keywords: stars–fundamental parameters–chemical composition

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1. INTRODUCTION

In this study, the atmospheres of giants HR8718 (F5II), HR8304 (G8II), HR8179 (G5II), HR8778 (G8IV) have been studied using method of atmosphere and parallax models. The effective temperature, surface gravity, microturbulence velocity and iron abundance in stellar atmospheres have been determined.

According to the modern stellar evolution concepts, changes in the abundances of C, N and O should occur in the surface layers of supergiants of classes A, F and O arising as a result of complete mixing of the star's matter and bringing of the CNO cycle products to its surface. In the atmospheres of supergiants of classes A, F, G, a deficit of carbon, an excess of nitrogen and probably a slight oxygen deficit should be observed. In the atmospheres of supergiants, anomalies in the C, N and O abundances [1,2] predicted by theory are indeed observed. Boyarchuk and Lyubimkov [2] paid attention to the fact that, in addition to deviations in the C, N and O abundances in the atmospheres of supergiants of classes A, F, G, an excess content of Na is apparently observed, an excess of Na increases as g decreases. It has been hypothesized [2] that the excess Na content can be explained by the conversion of a certain amount of neon into sodium in the reactions of the Ne Na-cycle. This excess Na must be vented to the atmosphere as a result of deep mixing. Therefore, the study of the chemical composition of the atmospheres of supergiants is urgent from an evolutionary point of view.

The purpose of our work is to determine the parameters of the stars HR8718 (F5II), HR8304 (G8II), HR8179 (G5II), HR8778 (G8IV) using more accurate methods and the iron abundance in their atmospheres. A detailed description of the method we used is given in the book by L.S. Lyubimkov [4]. In following publications, we plan to perform a chemical composition analysis by paying particular attention to those elements (C, N, Na), of which abundance are subject to evolutionary changes.

2. SOME INFORMATION ON SELECTED STARS AND THEIR OBSERVATIONS.

Some characteristics of selected stars are given in Table 1. Their numbers HR and HD, spectral class Sp, visiual magnitude m_ν [11], parallax π Hipparcos [15], distance d have been specified. As known, the distance is $d = \frac{1}{\pi}$, where π is expressed in arc seconds and d- in parsecs.

The star spectra have been obtained with 2-m telescope of the Shamakhy Observatory of ANAS, using the echelle spectrograph with a CCD matrix. The spectra have been processed by using the DECH-20 program [3].Equivalent widths of the spectral lines widths have been measured.

Table 1. Some information about the stars.

HR	HD	Sp	m_ν	π, "	d, pk
8718	216756	F5II	$5^m.91$	0".02563	38
8304	206731	8II	$6^m.09$	0".00321	311
8179	203574	G5III	$6^m.11$	0".00804	124
8778	217944	G8IV	$6^m.43$	0".01347	74

3. ATMOSPHERE PARAMETERS. EFFECTIVE TEMPERATURE AND SURFACE GRAVITY

Determination of the effective temperature T_{eff} of stars and the surface gravity force on their surfaces logg has been performed using method of atmospheric models and based on the application of parallaxes described in [19]. In the atmospheric models method, the following criteria are being considered:

a). Comparison of the observed and theoretically calculated values of the β index.

b). Comparison of the observed and theoretical values of the index $[c_1]$.

c). Comparison of the observed and theoretical values of the Q index.

In the narrow-band four-color uvby photometric system and the UBV photometric system, the indices $[c_1]$ and Q are determined by the formulas $[c_1] = c_1$-0.2 (b-y) and Q = (U-B) - 0.72 (B-V), respectively.The uvby system has been supplemented with a β value to measure intensity of the $H\beta$ lines. By comparing the values of the above indices found from observations with theoretical values, the T_{eff} and logg values have been determined. The observed values of $[c_1]$, Q and β are found using a catalog [10].

Calculations of the color indices in the UBV and uvby systems, required for the calculation of the Q and $[c_1]$ indices, have been performed by Castelli and Kurucz [8]. The theoretical values of the β-index are taken from Castelli and Kurucz [9].

In addition to the above criteria, the parallax method is used to determine T_{eff} and logg.

d). Application of parallaxes.

This method does not depend on atmospheric models and can significantly improve the accuracy of determining g. The method is new and is described in detail in the article by L.S. Lyubimkov et.al. [19]. The diagram for determining Teff and logg is given in Fig1.

Based on fig.1, the following values of atmospheric parameters have been taken: $T_{eff} = 6800 \pm 100K$, logg = 4.0 ± 0.1 (HR8718);T_{eff} = 5010± 100 K, logg = 2.1 ± 0.1 (HR8304);$T_{eff} = 5200 \pm 150K$, logg = 2.7 ± 0.2 (HR8179);

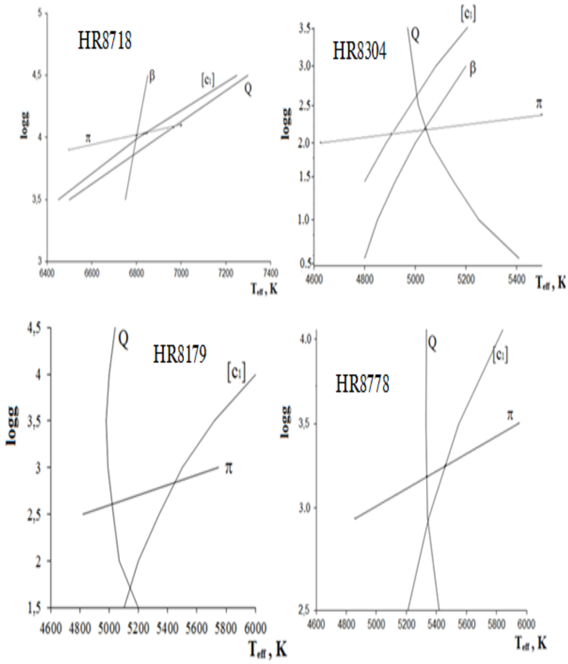

Fig. 1. Diagram for determining the parameters T_{eff} and logg of the stars HR8718 (F5II), HR8304 (G8II), HR8179 (G5II), HR8778 (G8IV).

$T_{eff} = 5300 \pm 100K$, logg = 3.2 ± 0.1 (HR8778). As shown in the catalogs, the star 8718 is not of luminosity class II but IV-V, in accordance with the parameters set for this star. The method that we are using is widely described in [4, 19] and the accuracy of this method is justified. Therefore, we believe that the results we have identified are preferable.

Fundamental parameters T_{eff} and logg of the stars HR8718 and HR8304 have been determined by other authors [2, 6, 7, 16] and the following values have been obtained: for the star HR8718 $T_{eff} = 6860K$,
logg = 4.11 [7], T_{eff} = 6725K, logg = 3.9 [16]; for the star HR8304, T_{eff} = 5000 K, logg = 2.0 [6], T_{eff} = 5030K [12]. The previous estimates of T_{eff} and logg are well coherent with our results.

4. MICROTURBULENT VELOCITY AND IRON ABUNDANCE

Knowledge of one more value-the microturbulence velocity ξ_t is required to analyze the chemical composition. As shown in [4], you must have a list of lines of any atom or ion in a wide range of equivalent widths W_λ to determine the microturbulence velocity ξ_t. The microturbulence velocity ξ_t is selected so that

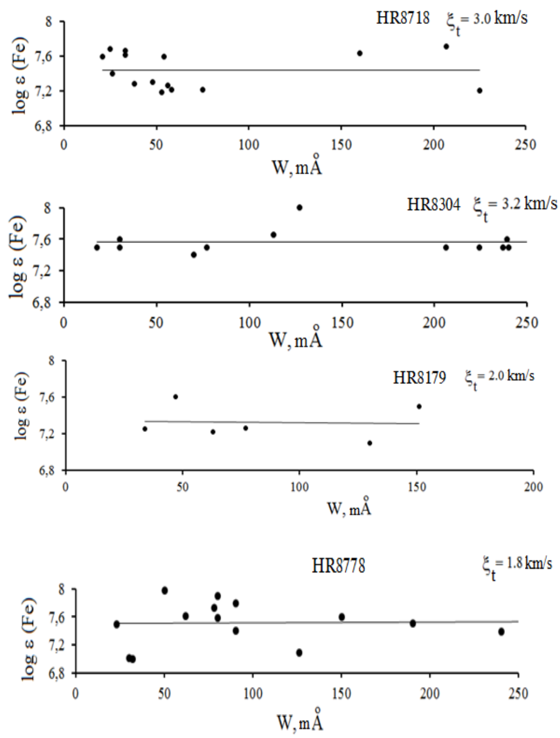

Fig. 2. Determination of the microturbulence parameter ξ_t.

the determined element contents do not display the course as W_λ increases. The most numerous in the spectra of the stars under study were the lines of neutral iron FeI, further the lines of ionized iron FeII. However, the lines of neutral iron FeI can be subject to significant deviations from LTE. If we neglect deviations from, this will lead to underestimation of the determined iron abundance $log\epsilon$ (Fe Interestingly, unlike the FeI lines,) the FeII lines turned out to be insensitive to non-LTE effects. In determining microturbulence velocity in the atmosphere of stars (stellar atmosphere) we have used ξ_t values found by ionized iron lines.

As shown by Lyubimkov and Samedov [5], the microturbulence parameter ξ_t in the atmospheres of F-supergiants can grow with height. The stronger the line, the more noticeable the action of this effect. However, for relatively weak lines, this dependence can be neglected and the parameter ξ_t in the atmosphere can be considered constant. Therefore, in determining ξ_t, we use only fairly weak lines. These lines are formed in deep layers, which can be considered as plane-parallel layers in the LTE state.

Based on the Kurucz atmosphere model [14], corresponding to the found parameters T_{eff} and logg, we have calculated the abundance logϵ (FeII) for several values of ξ_t. The iron abundance content has been determined based on comparison of the calculated and observed equivalent widths of the FeII spectral lines. Calculations of the equivalent widths of spectral lines have been made using the DASA program developed by Kr.AO. We have used atomic data from the VALD-2 database for spectral lines [13]. As is seen from Fig.2 on which the abundance of log (FeII) is plotted depending on the equivalent widths, there is no correlation between log and W_λ at ξ_t = 3.0 km/s (HR8718); ξ_t = 3.2 km/s (HR8304); ξ_t = 2.0 km/s (HR8179); ξ_t = 1.8 km /s (HR8778).

When analyzing the microturbulence velocity from the FeII lines, the iron content logε (Fe) is being determined simultaneously. Table 2. shows [Fe/H] = $\Delta log\varepsilon = log\epsilon_*(Fe) - log\varepsilon_*(Fe).log\epsilon$ (Fe) = 7.45 obtained in [20].

Fundamental parameters of the investigation stars are given in Table 2.

Table 2. Fundamental parameters of the investigation stars

Stars	T_{eff}, K	logg	ξ_t, km/s	$log\varepsilon_*$	$\Delta log\varepsilon = log\varepsilon_* - log\varepsilon$
HR8718	6800±100	4.0±0.1	3.0	7.47	0.02
HR8304	5010±100	2.1±0.1	3.2	7.56	0.11
HR8179	5200±150	2.7±0.2	2.0	7.32	-0.13
HR8778	5300±100	3.2±0.1	1.8	7.51	0.06

It should be noted that the [Fe/H] value is often used as an indicator of the metallicity of a star. This value can be considered to be as one more fundamental parameter, since it features the abundance of metals in the substance from which the star was formed. It is seen that the metallicity of stars considered is close to that of the Sun. This means that the stars considered were formed from matter with the same metallicity as the Sun. Note that the considered stars are located in the solar region (in the vicinity of the Sun).

In [7, 16], the iron abundance in the atmosphere of the star HR8718 has been determined and in comparison with the solar one, the difference has been found: $\Delta log\epsilon$ (Fe) = - 0.08, [7] and $\Delta log\epsilon$ (Fe) = - 0.05 [16]. The iron abundance in the atmospheres of giants and supergiants in the solar region (in the vicinity of the Sun) has been determined by many authors (for example [17–19]) and it has been shown that metallicity of these stars is close to that of the Sun. This conclusion is interesting from the point of view of the galactic chemical evolution models.

5. SUMMARY

Let us list the main results obtained in this study.

1.Effective temperature and surface gravity of the stars HR8718 (F5II), HR8304 (G8II), HR8179 (G5II), HR8778 (G8IV) have been determined using methods of atmosphere and parallax models. The following values of the effective temperature and surface gravity have been found: $T_{eff} = 6800 \pm 100K$, logg = 4.0 ± 0.1 (HR8718); $T_{eff} = 5010 \pm 100K$, logg = 2.1 ± 0.1 (HR8304); T_{eff} = 5200 ± 150K, logg = 2.7 ± 0.2 (HR8179); $T_{eff} = 5300 \pm 100K$, logg = 3.2 ± 0.1 (HR8778). The star HR8718, as shown in the catalogs, is not of luminosity class II, but IV-V.

2. Parameter of microturbulence velocity has been investigated by FeII lines. Found, ξ_t = 3.0 km / s (HR8718); ξ_t = 3.2 km / s (HR8304); ξ_t = 2.0 km / s (HR8179); ξ_t = 1.8 km / s (HR8778).

3. Iron abundance in the atmosphere of the giants under study has been determined and compared with its abundance in the Sun. It has been found that the iron abundance of the considered giants is close to that of the Sun. This means that the considered giants were formed from matter with the same metallicity as the Sun.

6. ACKNOWLEDGEMENTS

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