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DETERMINATION OF EFFECTIVE TEMPERATURES AND SURFACE GRAVITY OF A NUMBER F-SPECTRAL CLASS STARS BASED ON OBSERVED PHOTOMETRIC INDICES

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ABSTRACT

Basic atmospheric parameters — the effective temperatures and surface gravities — were determined for a number of F–type stars: HD 142 (F7V), HD 432 (F2III), HD 493 (F3V), HD 571 (F5II), HD 693 (F8V), HD 905 (F0IV), HD 1324 (F5V), HD 4919 (F3III), and HD 6210 (F6V). The determination of the effective temperature ($T_{\rm eff}$) and surface gravity ($\log g$) of stars is one of the fundamental tasks of astrophysics. Knowledge of these parameters allows the derivation of evolutionary characteristics such as stellar mass, luminosity, radius, and age. The effective temperatures ($T_{\rm eff}$) and surface gravities ($\log g$) of the investigated stars were obtained by comparing observational results with theoretically calculated values of the photometric indices $[c_1]$, Q, and β. The derived atmospheric parameters agree well with the spectral and luminosity classes of the stars.

Key words: stars: fundamental parametrs, effective temperature, surface gravity

1 INTRODUCTION

The determination of the chemical composition of stellar atmospheres is one of the key problems in astrophysics. Recently, the chemical composition of supergiant star atmospheres has attracted increasing attention. During stellar evolution, significant variations occur in the abundances of certain elements in the atmospheres of A-, F-, G-, and K-type supergiant stars — in particular, an excess of nitrogen and a deficiency of carbon are commonly observed.

In giant and supergiant stars of spectral classes A, F, G, and K, deep convective mixing takes place. As a result, the products of thermonuclear reactions occurring in the stellar core are transported to the outer atmospheric layers. Therefore, observational determination of the chemical composition of stellar atmospheres is essential for testing predictions of modern theories of stellar chemical evolution.

We have previously investigated the atmospheres of numerous A-, F-, and G-type stars, including supergiants (e.g. Lyubimkov & Samedov 1985, 1987, 1990; Samedov 2019; Samedov et al. 2023, 2024). The first step in analyzing stellar chemical composition is the determination of the effective temperature ($T_{\rm eff}$) and surface gravity ($\log g$). These parameters form the basis of stellar atmosphere models, and the accuracy of abundance determinations strongly depends on the precision of the adopted atmospheric model.

Furthermore, knowledge of $T_{\rm eff}$ and $\log g$ allows the derivation of fundamental evolutionary parameters, such as stellar mass, luminosity, radius, and age. Thus, accurate determination of $T_{\rm eff}$ and $\log g$ remains one of the important challenges in astrophysics.

2 DETERMINATION OF EFFECTIVE TEMPERATURES ($T_{\rm EFF}$) AND SURFACE GRAVITY (G)

In this work, the main atmospheric parameters — effective temperatures ($T_{\rm eff}$) and surface gravity (g) — of the F-type stars HD142 (F7V), HD432 (F2III), HD493 (F3V), HD571 (F5II), HD693 (F8V), HD905 (F0IV), HD1324 (F5V), HD4919 (F3III), and HD6210 (F6V) have been determined. The effective temperatures ($T_{\rm eff}$) and surface gravity (g) of the examined stars were derived by comparing the observed values with the theoretically calculated values of the $[c_1]$, Q, and β quantities. This method is a simple and accurate approach, allowing the determination of $T_{\rm eff}$ and g for a large number of stars.

The method was originally proposed by L. S. Lyubimkov

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Table 1. Observational values of photometric quantities of stars.

Star	Sp. Type	$b-y$	c_1	$[c_1]$	β	$U-B$	$B-V$	Q
HD 142	F7V	0.332	0.416	0.3496	2.639	0.022	0.516	−0.3495
HD 432	F2III	0.216	0.785	0.7418	2.709	0.101	0.341	−0.1445
HD 493	F3V	0.263	0.603	0.5504	2.682	0.060	0.424	−0.2453
HD 571	F5II	0.274	1.082	1.0272	2.650	0.252	0.396	−0.0331
HD 693	F8V	0.328	0.405	0.3394	2.621	−0.014	0.492	−0.3682
HD 905	F0IV	0.222	0.613	0.5686	2.717	−0.020	0.314	−0.2461
HD 1324	F5V	0.288	0.615	0.5574	2.665	0.069	0.453	−0.2572
HD 4919	F3III	0.212	0.792	0.7496	2.719	0.130	0.361	−0.1299
HD 6210	F6V	0.356	0.475	0.4038	2.615	0.110	0.547	−0.2838

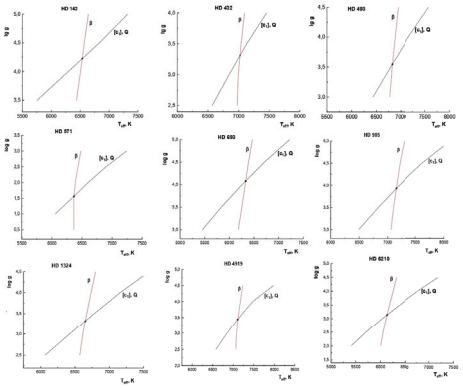

Figure 1. $\log g$–$T_{\rm eff}$ diagrams

(Lyubimkov et al. 2010). The Q index in the UBV photometric system is defined as

$$Q = (U-B) - 0.72(B-V),$$

while the $[c_1]$ index in the *uvby* photometric system is defined as

$$[c_1] = c_1 - 0.2(b-y)$$

These indices are free from the effects of interstellar absorption. The observed values of c_1, $b-y$, $U-B$, $B-V$, and β quantities were taken from the catalogue of Hauck & Mermilliod (Hauck & Mermilliod 1998). The theoretical values of c_1, $b-y$, $U-B$, and $B-V$ were calculated by Castelli & Kurucz (Castelli et al. 2003), while the theoretical β values were calculated by Castelli & Kurucz (Castelli & Kurucz 2006). The observed photometric quantities for the investigated stars are listed in Table 1.

The theoretical values of the $[c_1]$, Q, and β indices were compared with the observed measurements, and for each index a pair of $T_{\rm eff}$ and $\log g$ values was determined. These $T_{\rm eff}$–$\log g$ pairs were then plotted on the $\log g$–$T_{\rm eff}$ diagram. In the $\log g$–$T_{\rm eff}$ plane, the lines corresponding to the $[c_1]$, Q, and β indices were constructed, and the intersection point of these lines yields the final values of $T_{\rm eff}$ and $\log g$ (Fig. 1).

Table 2. Atmospheric parameters of F-type stars: effective temperature ($T_{\rm eff}$) and surface gravity ($\log g$).

#	Star	Spectral type	$T_{\rm eff}$ [K]	$\log g$
1	HD142	F7V	6510	4.21
2	HD432	F2III	7024	3.31
3	HD493	F3V	6826	3.55
4	HD571	F5II	6368	1.55
5	HD693	F8V	6332	4.08
6	HD905	F0IV	7153	3.93
7	HD1324	F5V	6652	3.21
8	HD4919	F3III	7112	3.45
9	HD6210	F6V	6140	3.18

3 CONCLUSION

Based on the comparison of the observed and theoretically calculated values of the $[c_1]$, Q, and β quantities, the main atmospheric parameters—effective temperatures ($T_{\rm eff}$) and surface gravity ($\log g$)—of the F spectral class stars HD142 (F7V), HD432 (F2III), HD493 (F3V), HD571 (F5II), HD693 (F8V), HD905 (F0IV), HD1324 (F5V), HD4919 (F3III), and HD6210 (F6V) have been determined. The following values were obtained: $T_{\rm eff}$ = 6510 K, $\log g$ = 4.21 (HD142); $T_{\rm eff}$ = 7024 K, $\log g$ = 3.31 (HD432); $T_{\rm eff}$ = 6826 K, $\log g$ = 3.55 (HD493); $T_{\rm eff}$ = 6368 K, $\log g$ = 1.55 (HD571); $T_{\rm eff}$ = 6332 K, $\log g$ = 4.08 (HD693); $T_{\rm eff}$ = 7153 K, $\log g$ = 3.93 (HD905); $T_{\rm eff}$ = 6652 K, $\log g$ = 3.21 (HD1324); $T_{\rm eff}$ = 7112 K, $\log g$ = 3.45 (HD4919); $T_{\rm eff}$ = 6140 K, $\log g$ = 3.18 (HD6210).

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