https://doi.org/10.18524/1810-4215.2023.36.290802

FUNDAMENTAL PARAMETERS OF SUPERGİANT STAR HD40589(A0Iab)

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ABSTRACT. The atmosphere of HD40589(A0Iab) supergiant star of A spectral class was studied using the model atmosphere and parallax methods. The effective temperatures (T_{eff}) and surface of gravity (log g) were determined using a comparison of the observed and calculated values of the photometric quantities [c_1], Q and the equivalent widths of the hydrogen Balmer lines and parallax. Based on the Fe II lines the microturbulent velocity (ξ_t) and metallicity [Fe/H] were determined. Metallicity of the program star is close to the metalicity of the Sun. This shows that our program star and the Sun are formed from the interstellar medium of a similar metallicity.

Keywords: A-type supergiants, fundamental parameters.

АНОТАЦІЯ. У цій роботі були визначені фундаментальні параметри зорі-надгігінта HD 40589 (A0Iab), а саме ефективна температура (T_{eff}), прискорення сили тяжіння (*log* g), мікротурбулентна швидкість (ξt) і металічність [Fe/H]. Відстань до зорі 1734 пк. Висота над площиною Галактики становить 67,5 пк.

Спектри HD40589 були отримані 19 грудня 2019 року за допомогою спектрографа, оснащеного ПЗЗ, що живиться від 2-метрового телескопа Шамахинської астрофізичної обсерваторії (роздільна здатність R=56000, відношення сигнал/шум S/N=150-400). Спектри HD40589 оброблені за програмою DECH 30.

Ефективна температура і прискорення сили тяжіння зорі нашої програми були визначені моделлю атмосфери та методом паралакса. Ефективну температуру та поверхневу силу тяжіння визначали на основі порівняння спостережуваних та розрахункових значень фотометричних величин [c_1], Q та еквівалентних ширин спектральних ліній водневої серії Бальмера, а також за допомогою методу паралакса.

Індекс [c_1] визначається як [c_1]= c_1-0.2(b-y) у фотометричній системі uvby, а індекс Q визначається як Q=(U-B)-0.72(B-V) у системі UBV. Діаграма, що визначає T_{eff} і *log* g дає T_{eff}=10750±150K і *log* g=1.65±0,2. Визначення мікротурбулентної швидкості ґрунтується на дослідженні еквівалентних ширин спектральних ліній заліза. З кожної спектральної лінії можна отримати певний вміст *log* ε. Відхилення від LTE не впливає на лінію FeII. Тому мікротурбулентну швидкість ξ_t і вміст заліза визначали за допомогою ліній FeII. В аналізі використовувалися лише досить слабкі лінії. Ці лінії утворюються в глибоких шарах атмосфери.

У нашому аналізі ми використовували сітку моделей атмосфери Castelli and Kurucz (2003), а атомні дані спектральних ліній були взяті з VALD3.

Металічність зорі [Fe/H]= -0.10. Металічність HD 40589 визначається вперше.

Ключові слова: Надгіганти А-типу, фундаментальні параметри зір.

1. Introduction

In this work the fundamental parameters of our program star HD40589 (A0Iab), namely effective temperature (T_{eff}), surface gravity (log g), microturbulent velocity (ξ_t) and metallicity [Fe/H] were determined. The distance to the star is 1734 pc. The Galactic latitude is 2.23°. The height above the Galactic plane is 67.5 pc. Knowing the effective temperature and surface gravity, the atmosphere models were calculated, and on the basis of these models the chemical composition was determined. The evolutionary parameters of our program star – mass, radius, luminosity, and age were determined. Microturbulence is considered as a broadening mechanism affecting width of the spectral line, therefore, to determine the chemical composition, it is necessary to know accurate value of the microturbulent velocity. The metallicity is one of the main fundamental parameters of stars.

2. Observation material

Spectra of HD40589 were recorded on 19 December 2019 with the help of spectrograph equipped with CCD fed by 2-m telescope of the Shamakhi Astrophysical Observatory of ANAS (resolving power R=56000, signal-to-noise ratio S/N=150−400). The spectra of HD40589 were processed with DECH program (Galazutdinov, 1992).

3. Effective temperature and surface of gravity

As it was mentioned above, the effective temperature and surface gravity of our program star were determined by the atmosphere model and parallax method. This method is described in detail in Lyubimkov, Rachkovskaya and Poklad (2009), Lyubimkov, Lambert and Rostopchin (2010). The effective temperature and surface gravity were determined based on a comparison of the observed and calculated values of the photometric quantities [c_1], Q and

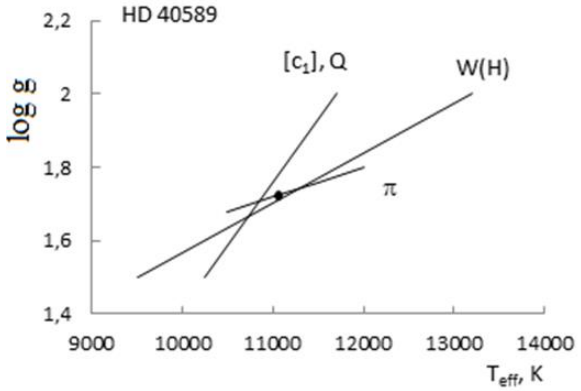

Figure 1: log g–T_{eff} diagrams

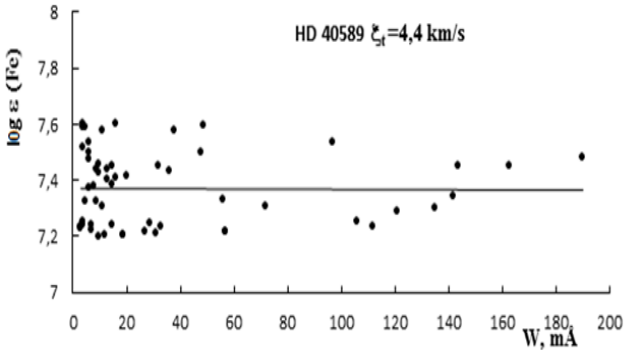

Figure 2: To the determination of the microturbulent velocity

the equivalent widths of the spectral lines of the hydrogen Balmer series, as well as using parallax method.

The index $[c_1]$ is defined as $[c_1]= c_1-0.2(b-y)$ in the uvby photometric system, while the Q index is defined as $Q=(U-B)-0.72(B-V)$ in the UBV system. The observational values $[c_1]$ and Q are determined using the catalogue (Hauck & Mermilliod, 1998). The calculated values of the equivalent widths of the Balmer series lines are given in (Kurucz, 1993). Calculated values $[c_1]$, Q can be found in (Castelli & Kurucz, 2003). Parallax of our program star was measured in (VizieR Online Data Catalog, 2020). The diagram defining T_{eff} and log g is shown in Figure 1: T_{eff}=10750±150K and log g=1.65±0.2.

In (Zorec, Cidale & Arias, 2009) the following value T_{eff}=10970 K for HD40589 is given.

4. The microturbulent velocity

The determination of the microturbulent velocity is based on the study of equivalent widths of spectral lines of iron. From each spectral line one can derive abundance a certain element log ε. Note that the deviation form LTE does not affect the FeII line. Therefore, the microturbulent velocity ξ_t and iron abundance were determined using FeII lines. Only quite weak lines were used in analysis. These lines are formed in deep atmosphere layers.

In our analysis we used Castelli and Kurucz (2003), grid of atmosphere models, and atomic data of spectral lines were taken from the VALD 3 (Ryabchikova et al., 2015).

In Fig.2 the dependence of the abundance log ε(Fe) determined from FeII lines on their equivalent widths W_λ is shown. The slope is about zero, and this is enables us to determine an accurate value of the microturbulent velocity.

From Fig. 2 we can derive the mean iron abundance log ε(Fe) =7.37. The abundance of iron in the Sun is log ε (Fe) =7.47 (Scott, Asplund & Grevesse, 2015). Metallicity of star is [Fe/H]= −0.10. The coincidence between the iron abundance in young nearby stars and that of the 4.5 Gyr old Sun, is interesting from the viewpoint of models of the Galactic chemical evalution (GCE). The question arises: may this result be compatible with models of GCE? One may cite the recent work of Spitoni et al. (Spitoni et al., 2009), where an enrichment of the solar neighbourhood by various metals is studied, in particular, by Fe. One sees from those results that during the Sun's lifetime the Fe abundances in its neighbourhood are predicted to be incresed by about 0.15 dex. The ususal accuracy of the derived abundances in stars seem to be insufficient to detect such a small enrichment. Note that the metallicity of our program star is determined for the first time, thus we cannot compare it to the results of other authors.

5. Main results

1. The effective temperature, surface gravity, and microturbulent velocity of HD40589 (A0Iab) have been determined using the atmosphere model, and parallax methods. The results are following: T_{eff}=10750±150K, log g=1.65±0.2, $\xi_t = 4.4 \pm 0.5$ km/s.

2. Metallicity of this star is log ε(Fe)=7.37±0.12 (in the scale, where the arbitrary hydrogen abundance is 12.00). It has been found that the iron abundance [Fe/H]= −0.10 is close to the solar abundance. This shows that our program star, and the Sun were formed from the interstellar matter of similar metallicity.

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