CHEMICAL COMPOSITION AND EVOLUTIONARY STATUS OF SPECTRAL BINARY STAR 12 PER

V.V. Leushin[1,2], M.K. Kuznetsov[2,3]

[1] Special Astrophysical Observatory
Nizhnij Arkhyz, Zelenchukskij region, Karachai-Cirkassian Republic 369167 Russia
admsao@sao.ru

[2] Southern Federal University
105 Bolshaya Sadovaya Str., Rostov-on-Don 344006 Russia *rectorat@mis.sfedu.ru*

[3] Institute of Astronomy of the Russian Academy of Sciences Department in Terskol
IC AMER Terskol Observatory, Kabardino-Balkaria Republic, 361605 Russia
admin@terskol.com

ABSTRACT. The star 12 Per is known as a spectroscopic and interferometeric binary. The high resolution spectra in 3700−8000 Å band were obtained with the 2 m telescope at Peak Terskol. A detailed analysis of the atmosphere of system's components was carried out using the collected data.

Key words: stars: binary: spectroscopic and interferometric binary; stars: individual: 12 Per.

1. Introduction

The study of binary systems with large orbital eccentricity (e>0.6-0.7) is a topical problem in the formation and evolution of multiple stars. In general evolutionary status of components and systems can be obtained if we have accurate parameters of stars in the system, including the abundance of their atmospheres. It is important for the stars with chemical features which star 12 Per has, as its components have heightened metallicity. (Barlow et al., 1998, Gardiner et al., 1999). System 12 Per (HD 16739; HIP 12623; HR 788) is the spectral and speckle-interferometric binary. Star of the systems are on the main sequence. Their spectral classes are estimated as F8 V and G1.5 V. There is one notable feature of this star: it has relative small period (P=330.^{d}98) when its eccentricity is big enough (e=0.663). And the system often can be observed with separated spectral liens of the components.

2. The general parameters of components and characteristics of atmospheres

The luminosity of each component and the system as a whole is determined by the distance to it and, consequently, the value of parallax. We used the value of parallax from the work Bagnuolo et al., (2006): π=41.19 mas, which corresponds with the distance to the system at 24.28 pc. Effective temperature of the stars according to Barlow et al., (1998) are as follows: 6125±80K and 5800±70K. Estimates of temperature from photometric measurements confirm these values. The values of photometric measurements are taken from SIMBAD. On the other hand, the study of hydrogen lines and the full flow of radiation (Smalli et al., 2002) leads to a temperature of the components: T_{eff}(A)=6371±176K, T_{eff}(B)=6000±143K. Our calculations for the ionization equilibrium Iron show that the temperature of components are within these limits and T_{eff}(A) = 6195±200K, T_{eff}(B)=6000±200K. Total luminosity of the system is L/L$_\odot$=5.15. Based on analysis of studies made by other authors we have chosen m=0.51 (Bagnuolo et al., 2006). Then, L(A)/L$_\odot$ =3.17 and L(B)/L$_\odot$=1.98. These luminosities and effective temperatures component led to radii: R(A)=1.55 R$_\odot$ and R(B)=1.31 R$_\odot$. Calculated radii and masses of component of M(A)=1.382±0.019 M$_\odot$ and M(B)=1.240±0.017 M$_\odot$ (Bagnulo et al., 2006) provide an acceleration of gravity on surfaces:
log g(A)=4.20±0.10 and log g(B)=4.30±0.10.

3. Observations

Spectral observations of 12 Per were occured in 2005–2007 with eshelle spectrometr in kude's focus 2–m telescope TF INASAN on the mount Terskol. Fig.1 shows a part of the spectrum near H$_\alpha$ lines for different phases. The lines of metals are well separated, and it is allowing to examine each component separately. However, the relative radial velocity of components for each of the observed phases is insufficient to deform the contour lines H_α significantly. As light detector was used CCD camera 1242x1152 pixels from the company Write (Great Britain). The spectra were obtained in the spectral range 3500-8000 Å with a spectral resolution R=45000.

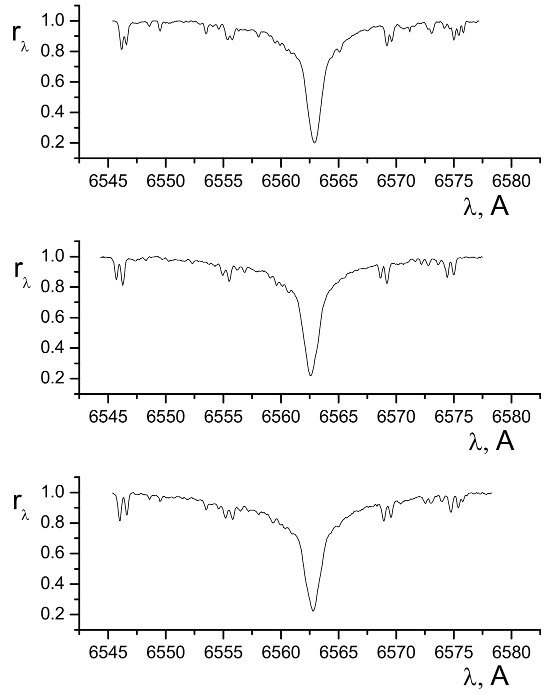

Figure 1: Spectrum 12 Per near H_α for different phases.

4. Models of atmospheres

For further analysis of component, we calculated several models of atmospheres with temperature range T_{eff} (A)=6371±176K and T_{eff} (B)=6000±143K. For each temperature, based on the values of luminosity and mass written above, their value acceleration of gravity on the surface was determined. For 6195K and 6000K log g was 4.20 and 4.30 respectively. The calculations were carried out on the program LLmodels (Shuliak et al. 2004), taking into account all the absorption lines.

Table 1: Parameters of models of atmospheres for components 12 Per

Component	T_{eff}K	log g	V_t,km/s	$V_{sin(i)}$,km/s
A	6195	4.20	1.6	8.0
B	6000	4.30	2.3	8.0

These models were used for calculating the contours of hydrogen lines on the program SintVA (Tsimbal, 2002), then contours for the first and the second component were summarized and compared with observed. Parameters of the model with the best match of theoretical and observed spectra are shown in the table. 1.

5. The content of iron and microturbulences in the atmospheres of components 12 Per

To the determine the iron content in the atmosphere of components of the system we measured the equivalent width of lines FeI and FeII in the summary spectrum of the system. Equivalent width of the spectra of components with its full division, are determined with the help of the observed values of the equivalent width and equation: W(A)=W_{obs}(A)(1-1/n) and W(B)=W_{obs}(B)(1-n). Here: W(A) and W(B) - equivalent width of the absorption lines in the spectra of the first and the second component. W_{obs}(A) and W_{obs}(B) - observed values of equivalent width of lines of the first and the second components, n=L(A)/L(B) - ratio of luminosity of relation component. In our case, m=0.51, n=1.6. The calculations were carring out using the program KONTUR (Leushin, Topilskaya. 1985). According to the results of determine logN (Fe) for different values microturbulences V_{obs} give linear regression were constructed logN(Fe)=lgN$(Fe)_0$+k W_λ ,which allow you to set V_{turb} for atmospheres of stars (by k=0). Obtained coefficients suggest that microturbulences in the atmospheres of components 12 Per are equal V_{turb}(A)=1.60 km/s and V_{turb}(B)=2.30 km/s for the first and the second components, respectively.

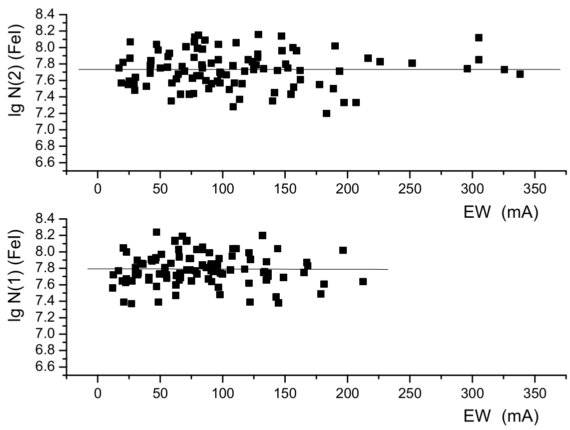

Figure 2: The dependence of the content of Fe I from equivalent width component A and component B

Lines FeI with these values of velocity give the content of iron in the atmospheres of components equal: A logN(Fe)=7.79±0.15, B logN(Fe)=7.73±0.15. The average value of iron content received with help of the lines of FeII, for each of the components are: A logN(Fe)=7.79±0.15, B logN(Fe)=7.78±0.15.

6. The contours of lines of iron

Fig. 3 shows a comparison of some theoretical and observed contours of lines FeI and FeII. Synthetic contours were constructed for three different contents (solar content, the content of the sun - 1 dex and solar content + 1 dex). Microturbulent velocity are V_{turb}(A)=1.60 km/s and V_{turb} (B)=2.30 km/s, respectively, for the first and the second component. The rotational velocity of stars in the models were taken V_{rot}=8 km/s for both components. Synthetic spectrum built using KONTUR (Leushin, Topilskaya, 1985).

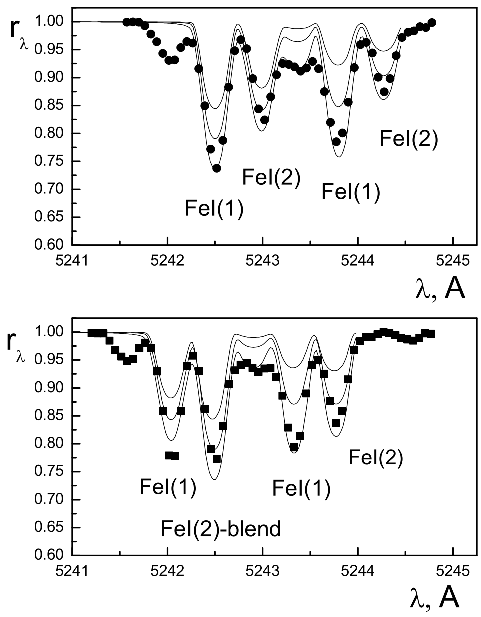

Figure 3: Comparison of synthetic and observed the spectrum of 12 Per for different phases. Points - observed spectra, lines - synthetic spectra for different content Fe.

Analysis of the contours of spectral lines FeI and FeII shows significant excess of iron in the atmosphere of component, is comparison with the solar content. This confirms the results obtained by equivalent width.

7. Conclusions

A detailed analysis of the chemical composition of the atmosphere of each component of the system 12 Per was carried out. The fundamental parameters of stars were precised. Received data on the content of iron in the atmosphere components 12 Per indicate high metallicity system: the value of [Fe]≥0.35. Using refined luminosities (L(A)=3.02$L_\odot$ and L(B)=1.86$L_\odot$) and effective temperature improved (T_{eff}(A)=6195K and T_{eff}(B)=6000K) of the components, we calculated the evolutionary status of the system. In our opinion, its age is 1.12 billion years. The components are are being in the process hydrogen's burning near the main sequence.

References

Bagnuolo W.G., Taylor J.S.F., McAlister H.A., et al.: 2006, *Astron.J.,* **131**, 2695.

Barlow D.J., Scarfe C.D., Fekel F.S.: 1998, *Astron. J.,* **115**, 2555-2560.

Gardiner R.B., Kupka F., Smalley B.: 1999, *Astron. Astrophys.,* **347**, 876-890.

Leushin V.V., Topilskaja G.P.: 1985, *Astrofizika,* **22**, 121.

Shulyak D., Tsymbal V., Ryabchikova T., Stutz Ch., Weiss W.W.: 2004 *Astron. Astrophys.,* **428**, 993.

Smalley B.. Gardiner R.B.. Kupka F.. Bessell M.S.: 2002, *Astron. Astrophys.,* **395**, 601.

Tsinbal V.V.: 2002, *priv. comm.*