NON-STATIONARY HE-WEAK STAR HD182255?

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ABSTRACT. It is known that the chemical elements distribution on the surface of chemically peculiar (CP) stars are associated with the distribution of the magnetic field. It is interest to study CP stars of various types and temperatures for the distribution of chemical elements on the surface. To this aim our research program includes HgMn star HD 182255 with no magnetic field, but with spectral and photometric variability, which is unusual in terms of the aforementioned. We suspect that the non-uniform distribution of helium and silicon on the surface of the star is due to the influence of the weak magnetic field.

Key words: Stars: He-weak: magnetic field; stars: individual: HD182255, 3 Vul

1.Introduction

So far there have no doubt that the distribution of chemical elements on the surface of CP stars associated with the distribution of the magnetic field. For example, in the atmospheres of He-rich stars He is weaker at the magnetic equator and accumulated at the magnetic poles due to the influence of solar-type wind (Vauclair, Dolez, Gough, 1991). Silicon, on the contrary, accumulates at the magnetic equator (Vauclair, Hardorp, Peterson, 1979). The calculations are supported by observational data. For example, for He-weak star HD 21699 the intensity of the helium line reaches its maximum at the magnetic poles, while the intensity of the silicon lines reaches its minimum in the same place. Silicon abundance is maximal in the regions where the magnetic field is predominantly tangential to the stellar surface (Shavrina et al. 2010). On the other hand the work of Megessier (1984) argued that the concentration of silicon at the equator is not stable. It gradually migrates along the magnetic lines toward the magnetic pole. Depending on the age of the star the distribution of silicon changes. Young stars have a maximal excess of silicon on the magnetic equator, and the stars with the age over 10^8 years, have a mild excess at the equator and other areas. In the oldest stars the silicon excess is observed only at the poles and consist only of 5 - 10 times. In this connection it is interest to investigate chemically peculiar stars of various types and temperatures for the distribution of chemical elements on the surface. Our research program included HgMn star HD 182255 (Jashek, Egret, 1985) with no magnetic field (Hubrig et al. 2006), but with spectral and photometric variability (Catanzaro, Leone, Catalano 1999), which is unusual in terms of the above mentioned. In the paper Catanzaro, Leone, Catalano (1999) the star HD 182255 is represented as a He-weak star. In the plot of equivalent widths - T_{eff} for the He I line 5876 Å this star falls in the region occupied by stars of luminosity class III, although it has log g = 4.17. Consequently, the line of helium slightly weakened, making the star to be closer to the He-weak stars, than to HgMn stars. In this case one can suspect that it has a weak magnetic field of several tens of gauss. In the papers of Lesh, 1968; Hoffleit and Jaschek, 1982, the spectral class V6III is indicated, but Palmer et al., 1968, reported B7-B8V, depending on the criteria used. All the authors show that the star belongs to the chemically peculiar objects. HD182235 is a one-lined spectroscopic binary system with an orbital period of 367 days (Hube, Aikman, 1991). This work also reported that the lines of Si II 4128, 4130, 6347 Å experience rapid fluctuations in shape and intensity during the night, which is unusual for typical CP stars. In addition, there are secular spectral changes. For example, in 1987 the line Si II 6347A have a complex structure in the center, and in

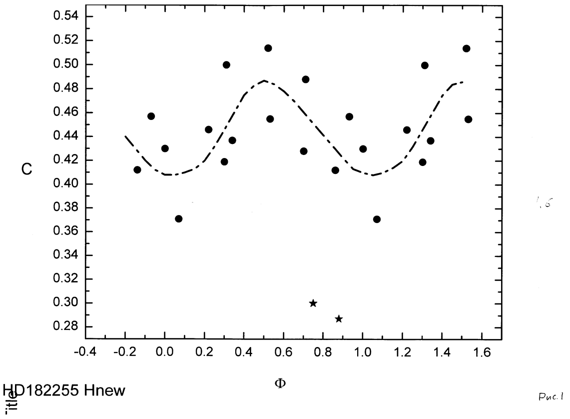

Figure 1: The points show the central intensity of the H_δ line in 2008-2009, and asterisks - the same in 2002-2003 (EA spectra).

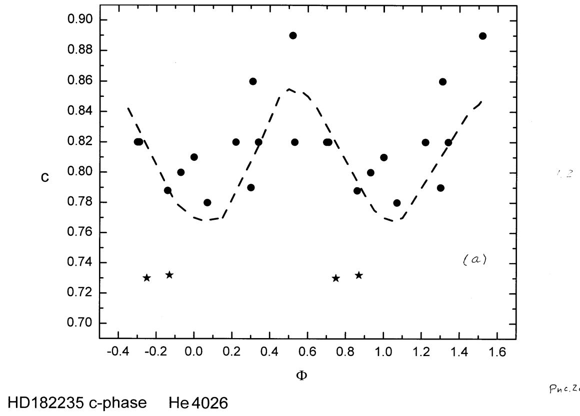

Figure 2: Central intensities of He I 4026 Å . The points show the central intensity of the H_δ line in 2008-2009, and asterisks - the same in 2002-2003 (EA spectra).

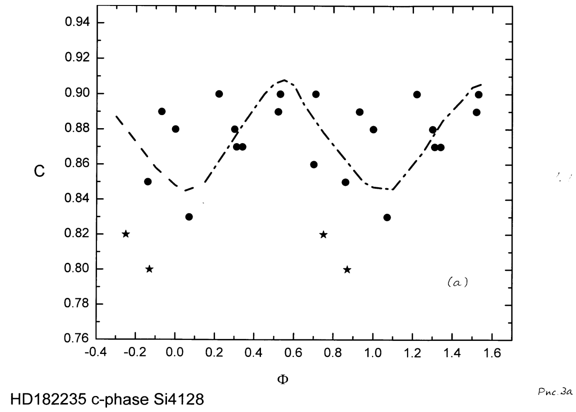

Figure 3: Central intensities of Si II 4128, 4130 Å . The points show the central intensity of the H_δ line in 2008-2009, and asterisks - the same in 2002-2003 (EA spectra).

1988, these lines were without distortion during three nights. The authors note that these changes are not associated with rotation and non-periodic changes in radial velocity are observed. Thus, there are signs of non-stationary processes. In the paper of Mathias, Aerts and Briquet, 2001, the evidence of the non-radial pulsations in the star's atmosphere is provides and the assumption that the star belongs to variables of 53 type is made. However it is unclear why the Si II 6347 Å line in 1988 for three nights have not been distorted by non-radial pulsations. Perhaps the pulsations sometimes disappear? It is also unclear why there are changes of the spectrum and brightness with the phase of the rotation (Catanzaro, Leone, Catalano, 1999). Our goal is the further study of helium and silicon distributions of on the surface of chemically peculiar B-stars by the example of HD182235.

2.The observational data and calculations

Our spectra with resolution R = 15000 were obtained on Main stellar spectrograph of the 6-m telescope for the period of 68 nights, from November 2008 to January 2009. Spectral range 4000 - 4240 Å was recorded on a matrix 2Kh2K with the image slicer (Chountonov, 2003). Signal to noise ratio was 300. We also used the spectra of The ELODIE Archive (hereinafter EA), obtained in September 2002 and November 2003.

Synthetic spectra of HD 182255 were calculated by the program SYNTHV [Tsymbal, 1996], version 2009. The Kurutcz model atmospheres (1993) and lists of atomic lines VALD (Kupka et al. 1999) of version of 2009 were used. From the comparison of the calculated synthetic spectra with observations the averaged abundances of chemical elements were determined at first without accounting their stratification. The stratification of helium and silicon has been studied using the sensitivity of the calculated profiles to given distribution of elements with depth in the atmosphere (the two-steps approximation was used). The wings of lines allow to determine the abundance of the element in the deep layers of the atmosphere, the central part of the lines - the abundance in the upper layers and the layer of the abundance jump.

3.Preliminary results

1) The star undergoes spectral variability linked with rotation, as well as fast variability. It follows, in particular, from Fig.1, where the points show the central intensity of the H_δ line in 2008-2009, and asterisks -

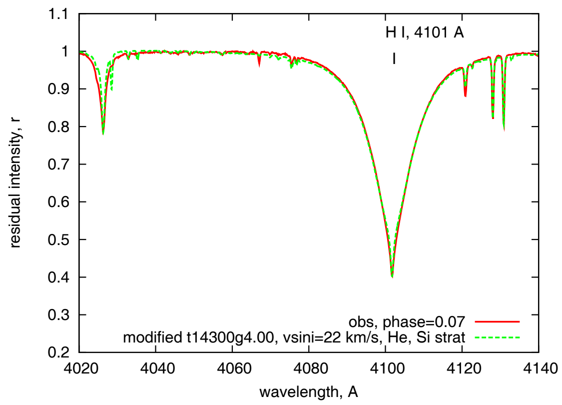

Figure 4: The fit of model profile of H_δ to observed one in the phase 0.07 taking into account modified T-P distribution and He, Si stratification.

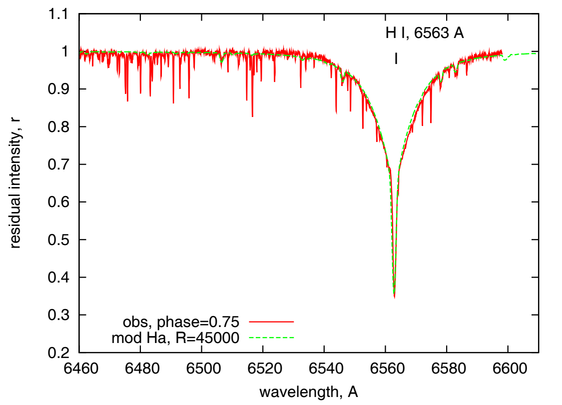

Figure 5: The fit of model H_α profile to observed one in the phase 0.75 (EA spectrum) taking into account modified T-P distribution.

the same in 2002-2003 (the EA spectra).

2) Central intensities of He I 4026 Å line behave similarly (Fig.2). The estimation of the He abundance shows, that together with general underabundance over the surface, it is intensified in the phase ϕ=0. It is also means that the star belongs to the He-weak type.

3) The fact that the helium abundance is increased in the magnetic poles in the comparison with other regions can be an indication of the presence of wind on the magnetic poles.

4) Central intensities of Si II 4128, 4130 Å lines (Fig.3) behave similarly, but the silicon abundance determined with full line profiles modeling is opposite to helium one, i.e. the silicon is weakened where the helium is strengthened.

5) As silicon (theoretically Vauclair et al.1979, 1991) accumulates in the areas between the magnetic poles, where the magnetic force lines are located horizontally

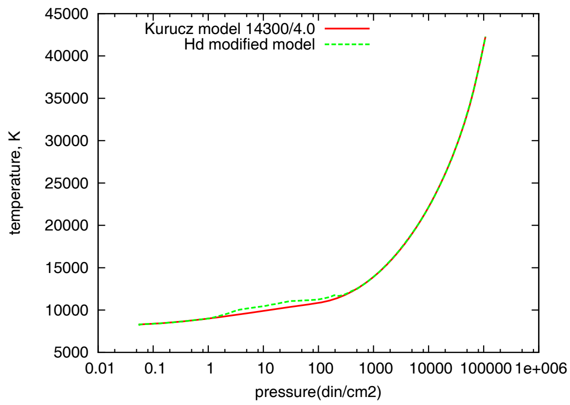

Figure 6: Dependence T-P for phase ϕ=0.07 in 2008-2009 obtained with the H_δ profile.

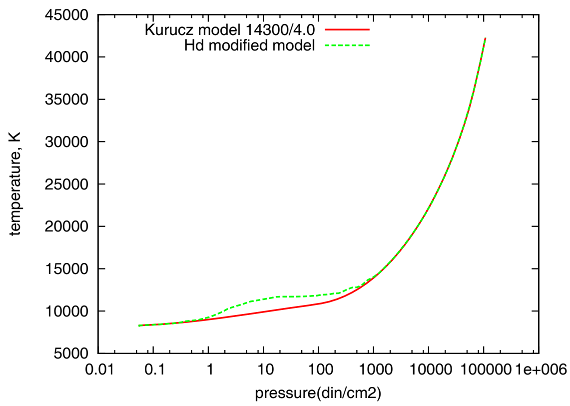

Figure 7: Dependence T-P for phase ϕ=0.53 in 2008-2009 obtained with the H_δ profile.

(ϕ=0.5), it is possible to assume that the star has a magnetic field with the magnetic pole, passing through the central meridian in ϕ=0.

6) The structure of the atmosphere changes with time. Fig.6,7 demonstrate the distribution of temperature in the atmosphere of HD 182255 in different phases of the rotation period, obtained from the profiles of hydrogen lines in 2008-2009. Fig.8 shows the same as Fig. 6,7 in 2002-2003, EA spectra. Different structures of the atmosphere at different epochs are evident.

7)A two-level stratification of helium in Fig.9 shows its general deficiency and strengthening in the phase ϕ=0.07 near the presumable magnetic pole.

8) A two-level stratification of silicon in Fig.10 shows its general overabundance and strengthening between presumable positions of poles.

9) Basing on its parameters we can conclude that the star HD182255 is probably a young CP star, which has just arrived on the Main Sequence.

10) The results have a preliminary character.

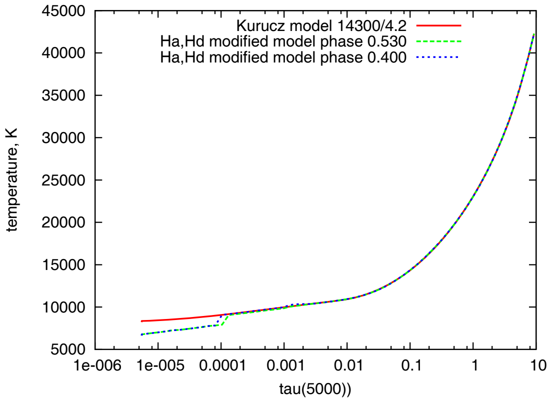

Figure 8: Dependence T-P for 2 phases of EA spectra from H_δ and H_α profile.

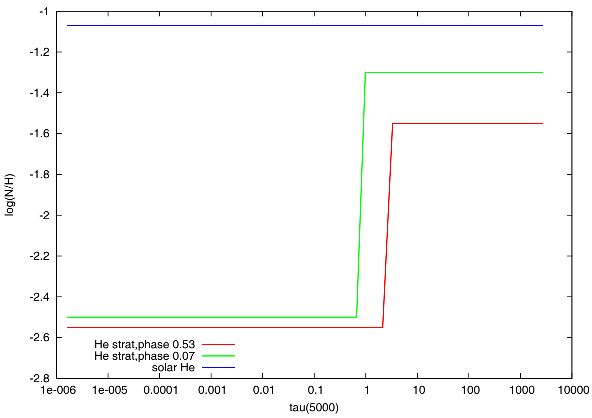

Figure 9: The He stratification, obtained with He I, 4026 Å profile in two phases ϕ= 0.07 (dash line) 0.53 (solid line). Solar abundance of He (horizontal line) was taken from Grevesse, Asplund, Sauval, 2007).

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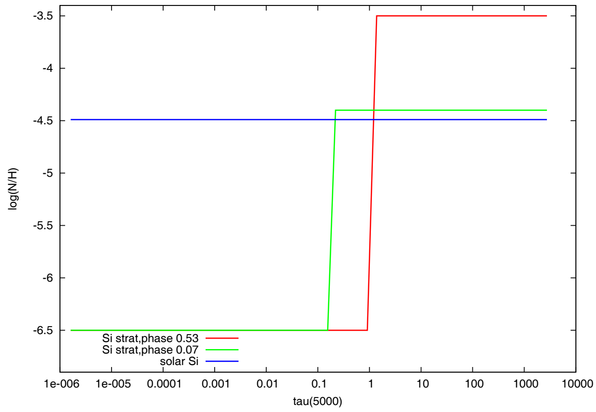

Figure 10: The Si stratification, obtained with Si II 4128, 4130 Åprofiles in two phases ϕ= 0.07 (dash line) 0.53 (solid line).Solar abundance of Si (horizontal line) was taken from Grevesse, Asplund, Sauval, 2007).

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