ATMOSPHERIC PARAMETERS AND CHEMICAL COMPOSITION OF PECULIAR STARS HR465, HD91375, and HD25354

V. Yushchenko[1], V. Gopka[2], A. Yushchenko[3,2], A. Shavrina [4], S. Hubrig [5], F. Musaev [6,7]

[1]Department of astronomy, Odessa National University,
T.G. Shevchenko Park, Odessa, 65014, Ukraine, *12345678e@mail.ru*

[2]Astronomical observatory, Odessa National University,
T.G. Shevchenko Park, Odessa, 65014, Ukraine, *gopkavera@mail.ru*

[3]Astrophysical Research Center for the Structure and Evolution of the Cosmos,
Sejong University, Seoul, 143-747, Korea, *avyushchenko@gmail.com*

[4]Main Astronomical Observatory of National Academy of Sciences of Ukraine,
27 Zabolotnogo Str., 03680, Kyiv, Ukraine, *shavrina@mao.kiev.ua*

[5]European Southern observatory,
Casilla 19001, Santiago 19, Chile, *shubrig@eso.org*

[6]Special Astrophysical Observatory, Russian Academy of Sciences,
Nizhnii Arkhyz, Karachai-Cherkessian Republic, 357147, Russia *faig@sao.ru*

[7]International Center for Astronomical, Medical, and Ecological Research,
Terskol, Kabarda-Balkarian Republic, 361605, Russia

ABSTRACT. We present the results of determinations of the atmospheric parameters and chemical composition of three chemically peculiar stars: HR465, HD91375, and HD25354. We used the observations made at 1.8 meter Bohuynsan observatory (Korea), 1.88 meter Haute-Provence observatory (France), 2.0 meter Terskol observatory (Russia), and 8.2 meter ESO telescopes. The effective temperatures of HR465 and HD25354 are higher than the values, found in earlier investigations. The detailed abundance pattern of HD91375 is found for the first time, the star is a typical member of Am or Ap group.

Key words: stars: abundances; stars: individual (HR465, HD91375, HD25354).

1. Introduction

The chemical composition of peculiar stars of the upper main sequence was one of the results which allowed Burbidge et al. (1957) to finalize the theory of synthesis of the chemical elements in stars. But up to now the nature of these stars is not fully explained. High resolution spectra allow to investigate the magnetic fields, the stratification of chemical elements, the spots, the unidentified lines, the radial and nonradial pulsations in the atmospheres of these objects. The interplay of above mentioned and other effects, like the radiative diffusion and the accretion of interstellar matter results in a variety of different anomalies.

In this paper we show the results of the determination of atmospheric parameters of three peculiar stars of upper main sequence, namely HR465, HD91375, and HD25354. The next sections of the paper are devoted to the description of observations, to the determinations of atmospheric parameters, and to the first iteration of abundance determinations in the atmospheres of these stars. For HR465 and HD25354 our values of temperatures are significantly higher, than it were found in earlier investigations.

2. Observations

HR465. The star was observed at 1.8 meter telescope of Bohuynsan observatory (Korea) in 2004. Spectral resolving power was R=60000, signal to noise ratio S/N>100 in red spectral region, the wavelength coverage was from λ=3800 Å to λ=9500 Å. We used also the spectrum of the star taken from the archive of Haute-Provence observatory 1.88 meter telescope. For this spectrum R=40000, S/N=50-100, the wavelength coverage is 4000-6800 Å. The spectrum was observed in 1996.

HD91375. We used the spectra of the star obtained at 8.2 meter ESO telescope. The wavelength coverage is from λ=3060 Å to λ=9460 Å, R=80000, S/N is near 500 in the spectrum region from λ=5000 Å to λ=6000 Å. All spectra were obtained in ten minutes, the variability of profiles and the asymmetry of spectral lines were noticed. To find the equivalent widths of spectral lines the red and the blue wings of the profile were fitted by different Gauss profiles.

HD25354. Two observations of the spectrum of this star were made at 2.0 meter telescope of Terskol observatory. The wavelength coverage is from λ=3700 Å to λ=9400 Å, S/N=200, R=60000.

3. Atmosphere parameters

HR465. To find the effective temperature and the surface gravity of the star we measured the equivalent widths of 197 lines of neutral iron and 13 lines of ionized iron in 2004 year spectrum. Using the method, described by Yushchenko et al. (1999, 2005) we found the following set of parameters: the effective temperature $T_{\rm eff}$=11840 K, the surface gravity $\log g$=4.3, the microturbulent velocity $v_{\rm micro}$=1.66 km s^{-1}, the iron abundance logN(Fe)=8.68 in the scale logN(H)=12.00.

The variability of the spectrum of HR465 with period near 23 years is known (Preston 1970), that is why to check the stability of effective temperature we analyzed the spectral energy distribution in the ultraviolet region using IUE spectra and the magnitudes and the colors using the observations of HIPPARCOS and TYCHO satellites. The results are shown in Figures 1-3. It is clear that no significant variability of the temperature can be expected, but the total flux of the star is variable. That is why we used the same set of parameters for processing of the observations obtained in 2004 and in 1996 years.

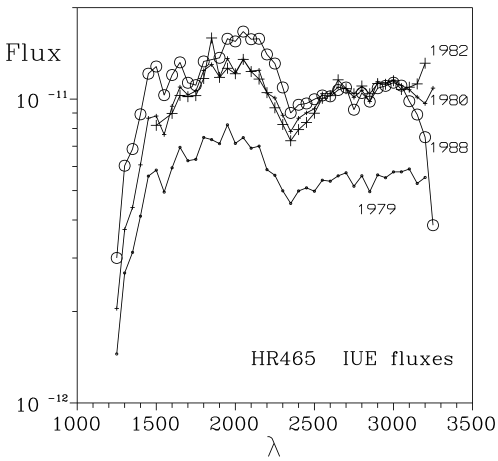

Figure 1: IUE fluxes of HR465. The axes are the wavelength in angstroms and the flux in erg/cm^2/s. The mean spectrum was calculated using all observations obtained during the specified year. Observations of different years are denoted by different symbols.

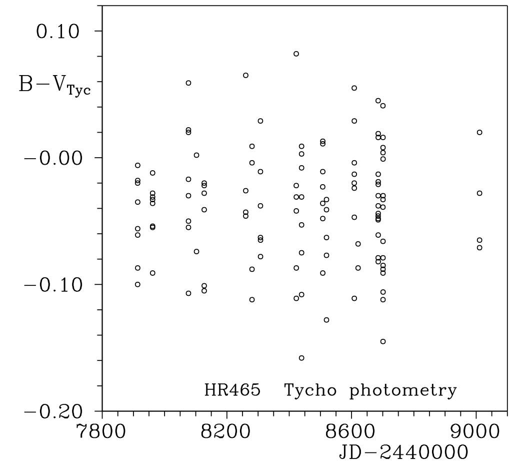

Figure 2: Colors of HR465 observed by TYCHO satellite. The axes are the Julian dates and colors in magnitudes. No significant trend can be found during three years.

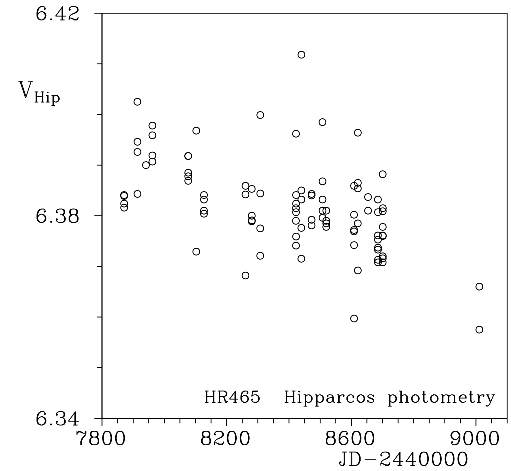

Figure 3: Magnitudes of HR465 observed by HIPPARCOS satellite. The axes are the Julian dates and the magnitudes. The mean flux of the star decreased by at least 0.02^m in three years.

Table 1 shows the effective temperatures and the surface gravities of HR465 obtained by different investigators. The majority of previous determinations of the temperature are lower than our value. It should be noted that the use of calibrations developed for normal stars can lead to strange results for peculiar stars. The metallicity of HR465 is significantly higher than the solar one, that is why only high dispersion spectroscopy and individual atmosphere models can help to find the reliable set of atmospheric parameters.

HD91375. The effective temperature and the surface gravity of the star were found using the equivalent widths of 25 lines of neutral iron and 34 lines of ionized one. The effective temperature appeared to be equal $T_{\rm eff}$=9100 K, the surface gravity – $\log g$=3.8, the mi-

Table 1: The determinations of atmospheric parameters of HR465.

$T_{\rm eff}$	$\log g$	Reference
10723	3.7	Aller (1972)
10500		Cowley & Aikman (1980)
11500		Floquet (1981)
9450	3.8	Guhtrie (1982)
10600	3.4	Guhtrie (1982)
9700		Carrier et al. (2002)
11840	4.3	This paper

croturbulent velocity – $v_{\rm micro}$=2.12 km s^{-1}, the iron abundance – logN(Fe)=7.66.

Lemke (1989) found for HD91375 the values $T_{\rm eff}$=9300 K, $\log g$=3.65, $v_{\rm micro}$=3.0 km s^{-1}, and the iron abundance logN(Fe)=7.56 in the case of LTE, These results are in the error boxes of our determinations.

HD25354. Wolff (1967) pointed that the temperature of HD25354 is in the range of 11000-12500 K. Pyper & Hartoog (1975) pointed that the temperature of the star is close to $T_{\rm eff}$=11000 K. Floguet (1982) derived the effective temperature and the surface gravity of the star to be equal $T_{\rm eff}$=9050 K, $\log g$=3.5. Kochukhov & Bagnulo (2006) found $T_{\rm eff}$=9840 K using the observations of the star in Geneva photometrical system.

Our attempts to describe the observed spectrum with by synthetic spectrum caclulated with low (near 9000 K) temperature failed. It was necessary to increase the temperature to 12500–13000 K. These value was supported also by the investigation of the profiles of hydrogen lines. Using the equivalent widths of 83 lines of ionized iron and 8 lines of doubly ionized iron we found the effective temperature $T_{\rm eff}$=12900 K, the surface gravity $\log g$=4.5, the microturbulent velocity $v_{\rm micro}$=0.23 km s^{-1}, the iron abundance logN(Fe)=8.44.

It should be noted the the lines of the third spectra of different chemical elements are present in the spectrum of HD25354. Aikman et al. (1979) found the lines of Dy III, Pyper & Hartoog (1975) – the lines of Ce III, Pr III, Yb III. Detectability of the lines of third spectra confirms the high temperature of the star. The second spectra of the elements with high ionization potentials, like Hg, Pt, Ta, Au, were also detected by Pyper & Hartoog (1975).

3. Chemical composition

Using the parameters, derived here before, we calculated the synthetic spectra of investigated stars in the whole observed wavelength region. These synthetic spectra allowed to make the reliable identification of spectral lines. To find the chemical composition of the atmospheres we used Kurucz (2000) programs WIDTH9 and SYNTHE, and Yushchenko (1998) URAN software. Atmosphere models were interpolated from Kurucz (2000) grid of stellar models. The full description of used methodic can be found in Yushchenko et al. (2005).

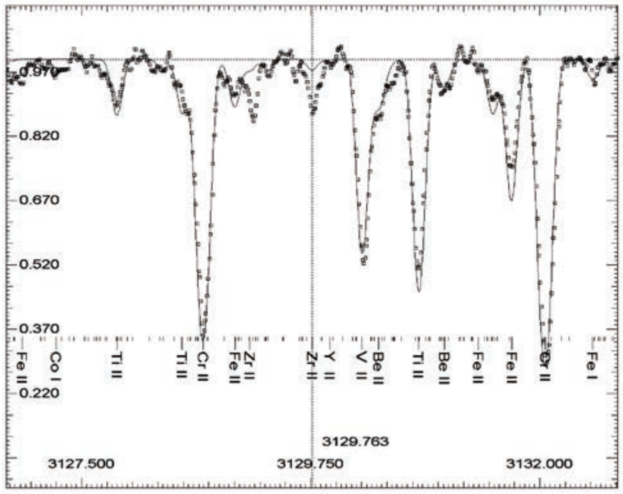

Figure 4: Observed spectrum of HD91375 (open squares) and synthetic spectrum (line) in the vicinity of Zr II line λ 3129.763 Å. The berillium dublet is in the right part of the figure. The axes are the wavelengths in angstroms and the relative fluxes. The positions of the lines used for calculation of synthetic spectrum are marked in the bottom part of the figure. The identification of part of the strong lines are shown. Synthetic spectrum was calculated with solar abundances of heavy elements, that is why the depths of zirconium lines in the synthetic spectrum do not fit the observed one.

Figures 4-6 show the examples of observed and calculated spectra in the vicinities of lines of heavy elements for HD91375 and HD25354.

Figures 7-9 show the results of our determinations of the abundances of chemical elements in the atmospheres of HR465, HD91375, and HD25354 with the parameters, found in the previous section.

HR465. The variability of the strengths of absorption lines in the spectrum is clearly observed. It results in the variation of abundances of chemical elements. The lines of chromium and the lines of lanthanides and actinides vary in the opposite phases. The differences in the lanthanides abundances are as high as 1-2 dex. The abundance of chromium in 2004 is 0.7 dex lower than in 1996. (Gopka, Shavrina,Yushchenko, 2007)

The overabundances of lanthanides can reach 6-7 dex with respect to the solar values. It should be noted that HR465 is a spectroscopic binary with orbital period near 273 days (Carrier et al. 2002). The lines of the

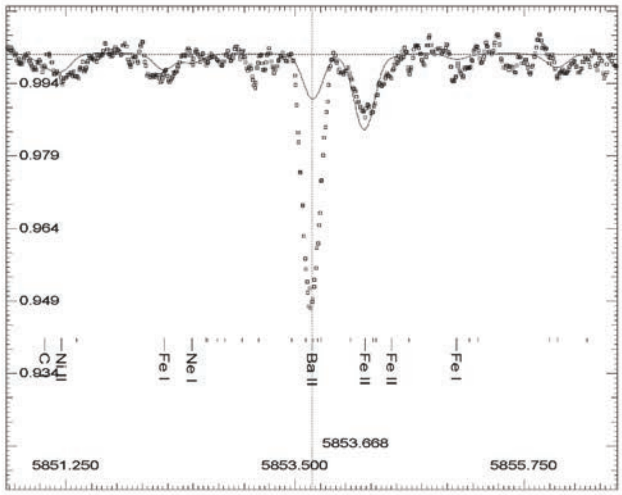

Figure 5: The same as Fig. 4 but in the vicinity of barium line λ 5853.668 Å.

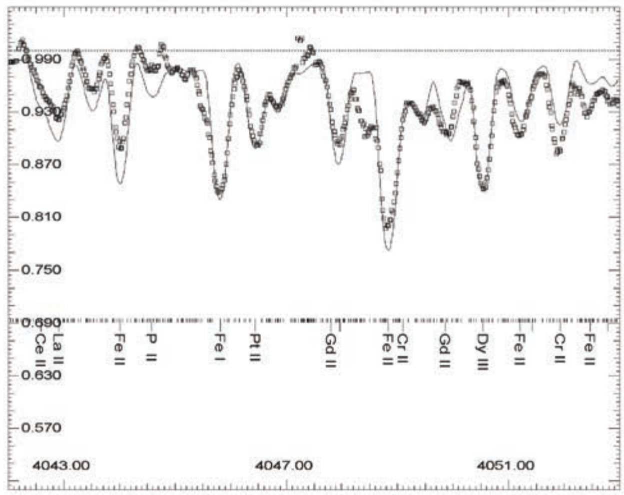

Figure 6: The same as Fig. 5 but for HD25534. The abundances of heavy elements are enhanced in accordance with our result. Note the line of ionized platinum in the central part of the figure.

secondary component are not detected in the spectrum. If the unvisible companion is a neutron star (NS), the chemical composition of HR465 should be influenced by NS (Gopka et al., 2007, 2008).

HD91375. No detailed investigation of the chemical composition of this star was made earlier. Holweger et al. (1986) compared the relative intensities absorption lines of iron group elements, helium, carbon, magnesium, and barium in the spectra of several stars including HD91375. Lemke (1989, 1990) derived the abundances of iron, titanium, carbon, silicon, calcium, strontium, and barium. The abundances of carbon, silicium, and iron were found by Holweger & Sturenburg (1993), the abundances of sodium and sulfur – by Rentzsch-Holm (1997). Mathys & Hubrig (2006) investigated the magnetic field of the star and found the value 1662 gauss for quadratic magnetic field using the lines of neutral iron, but only the upper limit of the strength of magnetig field was found using the lines of ionized iron (<2681 gauss).

We found the abundances of 34 chemical elements in the atmosphere of HD91375. The abundance pattern is typical for Ap stars. HD91375 is a member of Sirius group (Palous & Hauck 1986), so it will be very interesting to compare the chemical composition of HD91375 and the chemical composition of Sirius A. The temperature of Sirius A is only 800 K higher than the temperature of HD91375, but no detectable magnetic field was found for Sirius A.

The chemical composition of HD91375 is typical for Am stars but the existence of magnetic field (liked *o* Peg).

HD25354. The abundances of 18 chemical elements from oxygen to erbium are found in the atmosphere of this star. The lines of helium, strontium, gadolinium, platinum, and several other elements were identified, but it will be analyzed later, when the new atmosphere model will be constructed. The abundance pattern is similar to that of HR465. It is necessary to note that the intensities of helium lines in the observed spectrum are significantly weaker than in the synthetic one. Maybe the star is a helium weak object.

4. Summary

The use of high resolution spectral observations allow to find the atmosphere parameters of the investigated stars. For two of them the derived temperatures appeared to be higher than the earlier determinations. For HR465 the difference with the highest previously published value is 340 K, for HD25354 – 400 K.

The detailed abundance pattern of HD91375 is found for the first time. The star appeared to be a typical Am or Ap type star. The selection between these two possibilities needs additional investigation. The chemical composition of HR465 and HD25354 shows the high overabundances of heavy elements – up to 6-7 dex.

The obtained results will be used to construct the individual atmosphere models of these objects. The models will be used to find more precise chemical composition.

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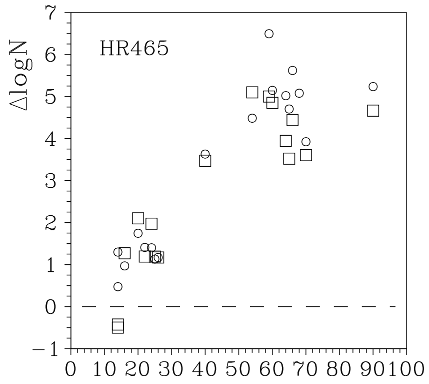

Figure 7: Chemical composition of HR465. The axes are the atomic numbers of the elements and the chemical composition with respect to the solar one. Circles and squares denote the observations made in 2004 and 1996 respectively.

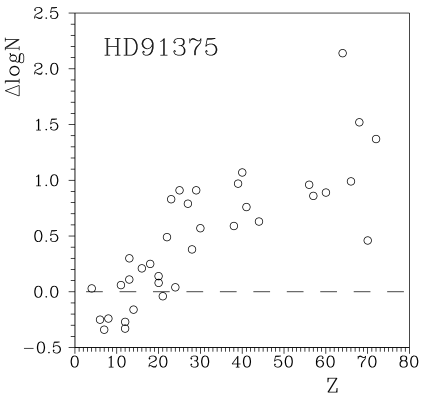

Figure 8: Chemical composition of HD91375.

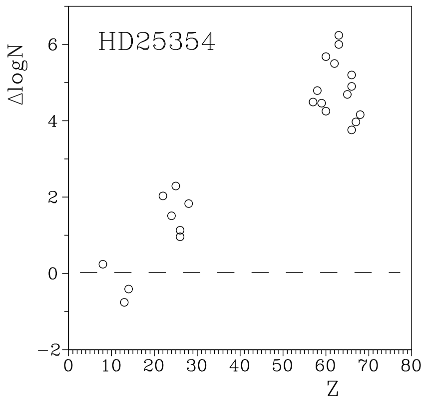

Figure 9: Chemical composition of HD25354.

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