CHEMICAL COMPOSITION OF PECULIAR STAR HD91375 – THE MEMBER OF SIRIUS MOVING GROUP

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ABSTRACT. We present the results of determinations of the abundances of chemical elements in the atmosphere of hot chemically peculiar star HD91375 - member of Sirius moving group. We used the observations made at 8.2 meter ESO telescope. The abundance pattern of HD91375 is found for the first time, the comparison with the abundances of Sirius A is made. The abundance patterns of Sirius and HD91375 are clearly different. It confirms the possibility of recent accretion event in the Sirius binary system.
Key words: stars: abundances; stars: individual (HD91375, Sirius).

1. Introduction

Stars of the upper main sequence show a variety of abundance patterns, it is still impossible to point the reason of peculiarities - it is hard to find the star with standard solar composition in this region of HR diagram. 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 stars. The interplay of above mentioned and other effects, first of all 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 chemical composition of HD91375. This star is a member of Sirius moving group, that is why we will show the results of comparison of its chemical composition with the chemical composition of Sirius.

2. Observations

We used the spectra observed by S. Hubrig at 8.2 meter ESO telescope. The wavelength coverage is from λ=3060 Å to λ=9460 Å, spectral resolving power is R=80000, signal to noise ratio S/N is near 500 in the wavelength region between λ=5000 Å and λ=6000 Å.

The spectra were obtained during ten minutes, but the variability of profiles and the asymmetry of spectral lines were clearly observed. That is why to measure the equivalent widths of absorption lines the red and the blue wings of the line profiles were fitted by different Gauss profiles.

It should be noted that the asymmetry is the same for all clean lines in the whole observed spectral range. It can be the sign of nonradial pulsations of the star.

3. Chemical composition

Yushchenko et al. (2008) made the review of previous observations of HD91375 and found the following atmosphere parameters: the effective temperature $T_{\rm eff}$=9100 K, the surface gravity – $\log g$=3.8, the microturbulent velocity – $v_{\rm micro}$=2.12 km s^{-1}, and the iron abundance – logN(Fe)=7.66.

Using these values the synthetic spectrum was calculated for the whole observed region. It helps to make the reliable identification of spectral lines. Abundances were found using model atmosphere method. The full description of used methodic can be found in Yushchenko et al. (2005)

Table 1 contains the results of determination of chemical composition of the atmosphere of HD91375. The columns are the atomic numbers, the designations of the elements, the numbers of used lines, the derived mean abundances and its errors, the relative abundances with respect to the Sun.

4. Discussion

The chemical composition of HD91375 is typical for Am stars but the existence of magnetic field can be the reason of the classification of the star as a member of Ap group.

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 700 K higher than the that of HD91375, but no detectable magnetic field was found for Sirius A.

Fig. 1 shows the comparison of chemical composi-

Table 1: Chemical composition of HD91375

Z	Element	n	logN	Error	Star-$\odot$
4	Be II	1	1.18		0.03
6	C I	3	8.30	0.20	-0.25
7	N I	5	7.63	0.13	-0.34
8	O I	5	8.63	0.15	-0.24
11	Na I	2	6.39	0.03	0.06
12	Mg I	2	7.25	0.31	-0.33
	Mg II	1	7.31		-0.27
13	Al I	2	6.58	0.08	0.11
	Al II	1	6.77		0.30
14	Si II	2	7.39	0.10	-0.16
16	S I	3	7.54	0.10	0.21
18	Ar I	1	6.77		0.25
20	Ca I	7	6.50	0.05	0.14
	Ca II	1	6.44		0.08
21	Sc II	13	3.13	0.24	-0.04
22	Ti II	23	5.51	0.27	0.49
23	V II	2	4.83	0.37	0.83
24	Cr II	4	5.71	0.06	0.04
25	Mn II	8	6.30	0.07	0.91
26	Fe I	25	7.63	0.06	0.13
	Fe II	34	7.68	0.14	0.18
27	Co II	1	5.71		0.79
28	Ni I	3	6.63	0.13	0.38
29	Cu I	1	5.12		0.91
30	Zn I	2	5.17	0.25	0.57
38	Sr II	3	3.56	0.08	0.59
39	Y II	11	3.21	0.23	0.97
40	Zr II	18	3.67	0.17	1.07
41	Nb II	2	2.18	0.06	0.76
44	Ru II	1	2.47		0.63
56	Ba II	3	3.09	0.11	0.96
57	La II	4	2.03	0.10	0.86
60	Nd III	4	2.39	0.22	0.89
64	Gd II	1	3.26		2.14
66	Dy II	2	2.13	0.06	0.99
68	Er II	2	2.46	0.22	1.52
70	Yb II	1	1.54		0.46
72	Hf II	2	2.25	0.36	1.37

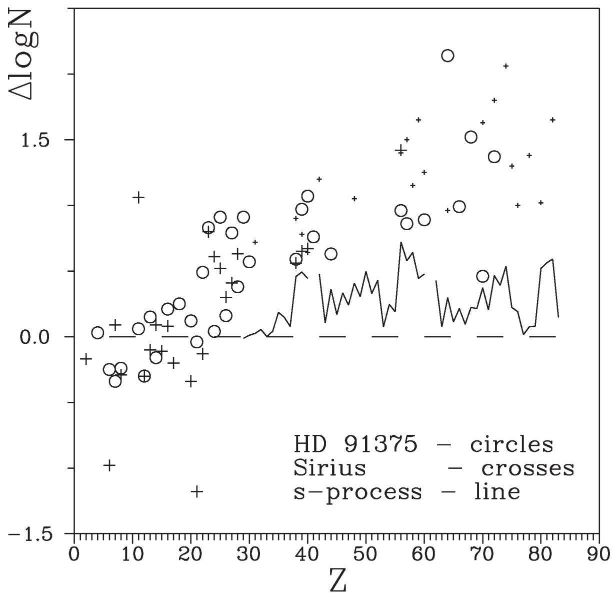

Figure 1: Chemical composition of HD91375 (open circles) in comparison with Sirius A (big crosses – Landstreet, 2011; small crosses - Yushchenko et al., 2007) and s-process enriched pattern (line, Yushchenko et al. 2004). The axes are the atomic numbers of the elements and the abundances with respect to the Sun

tion of HD91375 with the abundance pattern of Sirius A (Landstreet 2011, and our preliminary results on the abundances of heavy elements) and with typical s-process enriched pattern. It is obvious that the distribution of abundances in HD91375 is different from that of the Sirius A.

It is worth to note that the abundance pattern of Sirius A (maybe) was influenced by accretion of s-process enriched matter from its binary companion, now it is white dwarf Sirius B. The differences in chemical composition of HD91375 and Sirius A permit to confirm the possibility of accretion event in the Sirius binary system.

Recently Landstreet (2011) found that at least 0.5 solar mass of the matter of AGB star (white dwarf now) were accreted to Sirius A. It confirms the contamination of the atmosphere of Sirius A by s-process enriched matter found by Yushchenko & Gopka (2006) and Yushchenko et al. (2007).

Note that the mass of Sirius A now is close to 2 solar masses, that is why the star increased its mass at least by one third. It means that the comparison of chemical compositions of Sirius A and other members of Sirius moving group is not correct. Other members of Sirius moving group maybe were not affected by strong accretion in the past. That is why it is necessary to make independent analysis of the abundance pattern of HD91375.

Fig. 2 compares the abundances in HD91375 with classical r-, and s-processes abundance distributions.

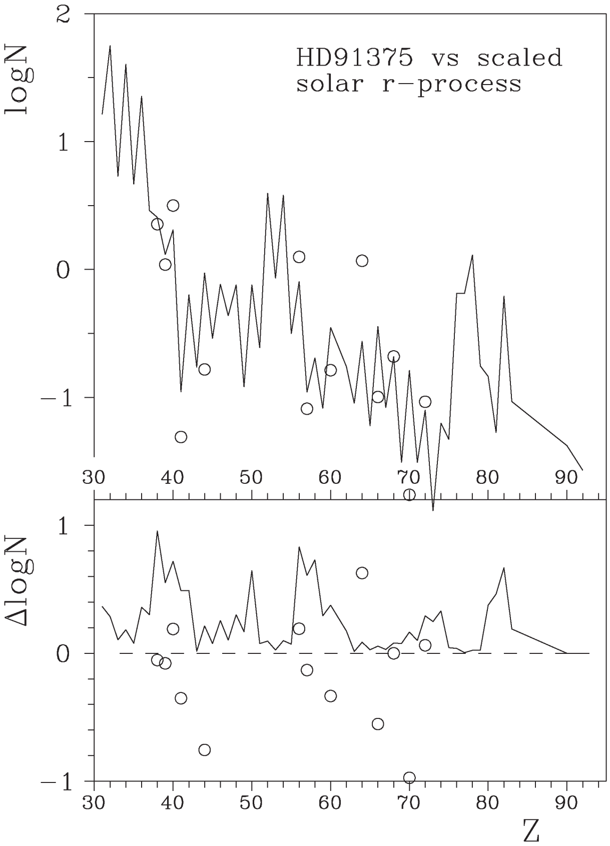

Figure 2: Upper panel compares the surface abundances in HD91375 (circles) with the solar system $r-$process abundance distribution scaled at the observed Dy abundance (line). The solar system $r-$process abundances are taken from Simmerer et al. (2004). The bottom panel shows the deviations of the observed abundances in HD91375 from scaled solar system $r-$abundances. The line is the deviations of solar photosphere abundances from solar $r-$process abundance distribution. The maximums of this curve correspond to the elements with the highest relative $s-$process contributions.

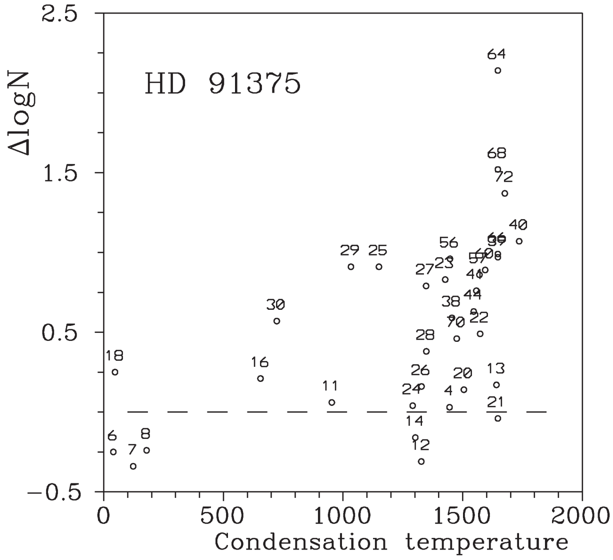

Figure 3: The plot of the relative surface abundances of chemical elements in HD91375 as a function of the condensation temperature of these elements. The values of condensation temperatures for a solar-photosphere composition gas are taken from Lodders (2003) calculations. The atomic numbers of the elements are marked.

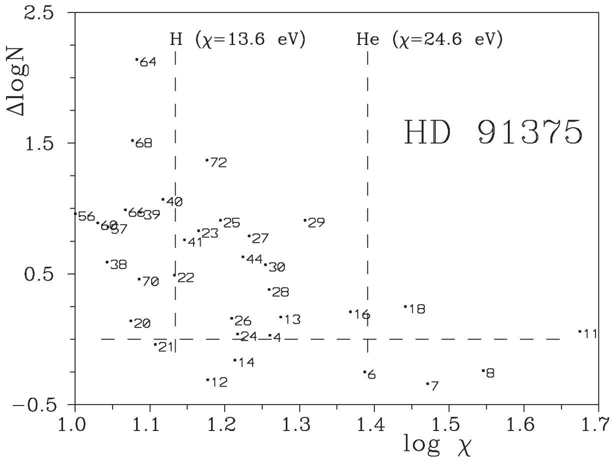

Figure 4: The plot of the relative surface abundances of chemical elements in HD91375 as a function of the second ionization potential (log χ) of these elements. The positions of the ionizations energies of hydrogen and helium are marked by vertical dotted lines. The atomic numbers of the elements are marked near the corresponding points.

The examination of this plot allow to conclude that the distribution of abundances of heavy elements is quit close to r-process, but the deviations are as high as 1.0 dex. These discrepancies can not be described as the influence of s-process.

Fig. 3 shows the distribution of abundances of chemical elements in the atmosphere of HD91375 as a function of condensation temperatures of these elements. Venn & Lambert (1990, 2008) found that the existence of dust envelope in λ Boo type stars (the effective temperatures of these stars are close to that of HD91375) results in the anticorrelation of relative abundance vs the condensation temperatures. We found nothing like this in HD91375, that is why it is possible to conclude that the dust is absent in the environment of HD91375.

Fig. 4 is the plot of relative abundances in the atmosphere of HD91375 with respect to the second ionization potentials of these elements. As it was shown in papers from Greenstein (1949) to Bohm-Vityense (2006) the accretion of interstellar gas by stars with radiative atmospheres results in charge-exchange reactions of the hydrogen and helium atoms which are the main components of interstellar medium with the atoms in the stellar photosphere. The result of these reactions is the understandable of the elements with ionization potentials close to those of hydrogen and helium atoms, namely 13.6 and 24.6 eva.

These underabundances, first of all the underubundances of Ca and Sc are clearly observed in Sirius A and other Am type stars, but it is not detected in the atmosphere of HD91375. As it was pointed here before, the temperatures and the gravities of HD91375 and Sirius A are not very distinct, that is why the reason of different chemical composition can be the existence of magnetic field in HD91375 or different evolutionary status of these stars.

Landstreet (2011) pointed that the accretion in the Sirius binary system took place 50-100 millions years before. This time was sufficient for charge-exchange reactions to set the main features of Am type stars abundance pattern. The absence of these features in the atmosphere of HD91375 may be the result of low density of interstellar medium along the path of the star in Galaxy, or the magnetic field. Maybe the second case is more important as the difference in the paths of Sirius moving group members can not be very distinct.

5. Conclusion

The detailed abundance pattern of HD91375 is found for the first time. The abundances of 34 chemical elements allow to claim the significant difference between the chemical composition of the members of Sirius moving group - Sirius and HD91375. It is obviously explained by the binarity of Sirius. The single star approximation can not be used for explanation of Sirius evolutionary path.

The distribution of abundances of heavy elements in HD91375 can be roughly fitted by r-process, but the deviations are as high as 1.0 dex. Maybe no signs of s-process are present in the atmosphere of HD91375.

The chemical composition of HD91375 was not influenced by dust or gas accretion, but the accretion was very important in the case of Sirius. It seems reasonable that the presence of weak magnetic field in the case of HD91375 can be responsable for the absence of accretion.

The signs of possible nonradial pulsations of HD91375 were found, but the used spectra were observed during 10 minutes only, that is why we can say nothing about the mode of pulsation.

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