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Abundance analysis of the chemically peculiar star HD 74169 (A0IVp)

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Abstract. We present the results of the abundance analysis of the chemically peculiar star HD 74169 based on the echelle spectrum obtained with the spectrograph UVES. This high resolution and high signal-to-noise observations are compared with a synthetic spectrum computed with the SYNTHE code. As an input atmosphere model for SYNTHE we used an ATLAS 9 model with effective temperature $T_{\rm eff}$ = 10000 K and surface gravity $\log g$ = 4.0 dex. The iterative procedure used to derive stellar individual abundances allows us to take into account even blended lines. The best fit to the observed spectral line profiles was obtained with a rotational velocity $V_e \sin i$ = 20 km s^{-1}and turbulence $V_{\rm turb}$ = 2.1 km s^{-1}. The average abundances of HD 74169 are typical for an Ap star of Cr type: C is deficient, Cr and Fe are strongly overabundant. The analyzed heavy and rare-earth elements are also overabundant.

Key words. Stars: abundances – Stars: atmospheres

1. Introduction

HD 74169 (KR Vel, A0IVp) is one of the chemically peculiar stars in the field of the open cluster IC 2391 (*o* Vel). The first information about peculiarity of this star appeared in the sixties (Bertaud 1965). Buscombe (1965) and Levato and Malaroda (1984) classified HD 74169 as Ap EuCr(Sr). The KR Vel membership in the young cluster IC 2391 was confirmed by Pöhnl et al. (2003). They analyzed the evolutionary status of CP2 stars of this cluster and found that both the location of HD 74169 on the H-R diagram and its age are within the expected error of the overall age of the cluster. Also Dodd (2004) confirmed the cluster membership of this star on the basis of proper motion components as well as infrared multicolour photometry. Furthermore, HD 74169 was suggested by North (1984) as a variable star with the period equal to $4.^{d}59$ obtained on the basis of lightcurves determined in the Geneva photometric system.

In this paper we present the first attempt of the abundance analysis of this star. High quality observations are described in Sect. 2. The iterative method of the abundance analysis and determination of effective temperature and surface gravity are presented in Sect. 3. Results and conclusions are given in Sect. 4.

2. Observations

The spectrum of HD 74169 was obtained on February 8, 2001 at ESO with the VLT UV-Visual Echelle Spectrograph UVES at Unit

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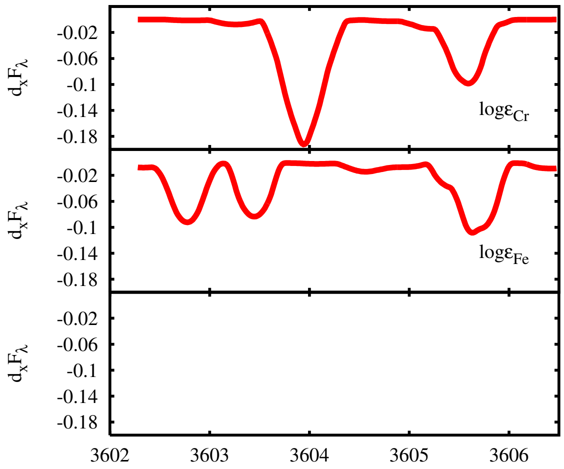
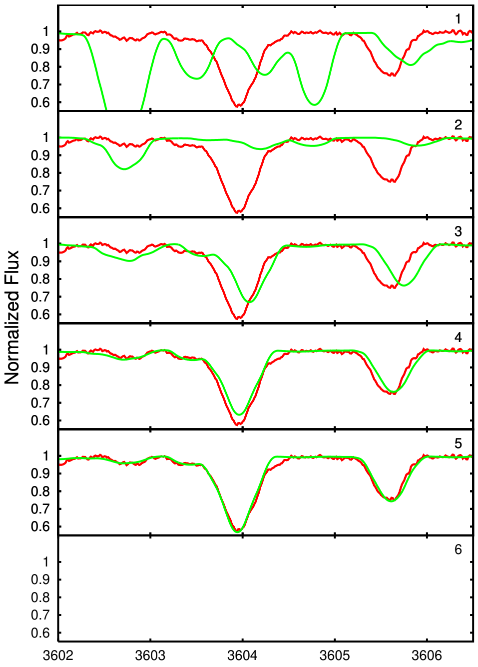

d_xF_λ
-0.02
-0.06
-0.1
-0.14
-0.18
$\log\varepsilon_{Cr}$
$\log\varepsilon_{Fe}$
3602
3603
3604
3605
3606


Normalized Flux
1
2
3
4
5
6
1
0.9
0.8
0.7
0.6
3602
3603
3604
3605
3606

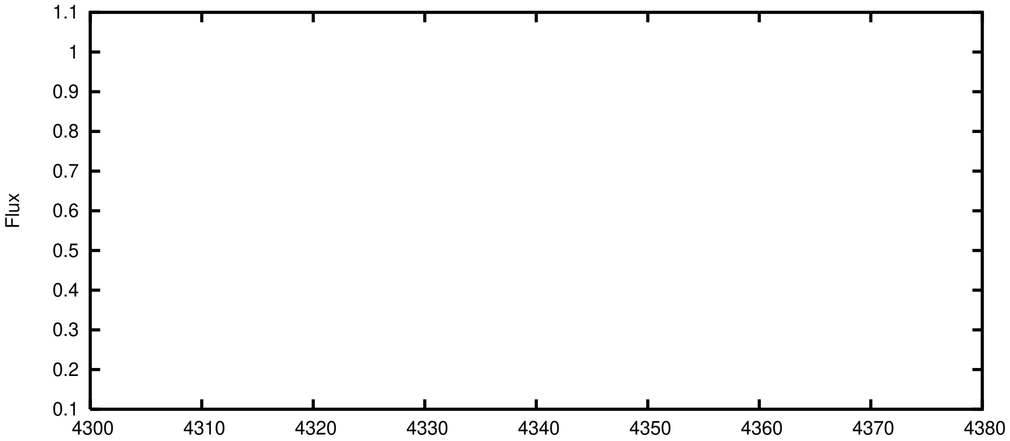

Flux
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
4300
4310
4320
4330
4340
4350
4360
4370
4380

Table 1. Atmospheric abundances (third column) $\log\varepsilon$ for HD 74169. In the second column the number of features using to the chemical analysis is presented while in the last one the solar abundances from Grevesse and Sauval (1998) are showed.

Element	n	$\log\varepsilon$	$\log\varepsilon_{\odot}$
C	4	−3.77	−3.52
N	3	−3.51	−4.12
Ne	1	−2.60	−3.96
Na	2	−3.20	−5.71
Mg	6	−4.10	−4.46
Si	12	−4.22	−4.49
P	1	−5.72	−6.59
S	4	−4.47	−4.71
Ar	3	−3.02	−5.48
Ca	8	−4.91	−5.68
Sc	8	−9.12	−8.87
Ti	28	−6.50	−7.02
V	19	−7.34	−8.04
Cr	77	−4.31	−6.37
Mn	26	−5.51	−6.65
Fe	135	−3.60	−4.54
Co	5	−6.02	−7.12
Ni	26	−5.41	−5.79
Cu	1	−6.59	−7.83
Zn	1	−6.27	−7.44
Y	2	−8.42	−9.80
Zr	2	−8.40	−9.44
Ba	1	−10.18	−9.91
Ce	4	−7.83	−10.46
Nd	1	−7.20	−10.54

basis of weak features blending with strong iron peak elements. Only for magnesium and silicon more than four lines were detected and in these cases the mean values are better determined. The other values should be treated with caution. The standard deviation σ for magnesium and silicon abundances are 0.55 dex and 0.85 dex respectively. Large values of standard deviations result from the fact that only mean abundances are derived without a separate assessment of the neutral and ionized species.

4.2. Iron group elements

The spectrum is dominated by the iron peak elements. Except for Co, Cu and Zn the abundances are determined from more than five features. Only Sc (-9.10 dex) has a lower abundance in comparison to the Sun. All other elements are found to be overabundant by more than 0.4 dex. Iron shows a high abundance of -3.60 dex which is significantly greater than the solar value. Another remarkable result is the more than 2.0 dex overabundance of chromium. The standard deviations are relatively small (about 0.35 dex) for Cr, Mn, Fe and Co. For the first three elements this is the effect of many analyzed lines. The existing discrepancies for these and other lines might be explained after the introduction of vertical stratifications for the elements. Higher values of σ for Ca, Ti, V, Ni and Sc first of all can result from the fact that the mean values are computed from both neutral and ionized species. Additionally in the case of Sc and V only the weak lines or blends were analyzed.

4.3. Heavy and rare earth elements

Because of the relatively high rotational velocity of the analyzed star, very few signatures of the heavy and rare earth elements were found as a separate line or blend in the spectrum. In most cases only the influence of such elements to the wings of strong lines were seen. The method we use let us determine the abundance even in these cases. We were able to determine abundances of Y, Zr, Ba as well as rare earth elements: Ce and Nd, identified only on the basis of the Kurucz lines list. The abundances of yttrium (-8.42 dex) and zirconium (-8.40 dex) are enhanced by more than 1.0 dex in comparison with the solar values, whereas barium (-10.18 dex) has a lower abundance. However, the barium abundance was determined on the basis of only one weak line which blends with a relatively strong Fe line. The rare earth elements, cerium (-7.83) and neodymium (-7.20) show overabundances by more than 2.0 dex. HD 74169 seems to be very enhanced in these elements in comparison to the Sun. The same conclusions were deduced by Kato (2003) for another silicon star HD 170973. The list of identified heavy and rare earth elements would be more complete if other sources such as VALD (Kupka et al. 1999) or the DREAM (Biemont et al. 1999) databases were included in the analysis.

4.4. Errors in the abundance analysis

Derived abundances contain errors connected with a number of sources of uncertainty, including the adopted atomic data, most importantly the oscillator strengths, the adopted atmospheric parameters and model, and the observed spectra. For some sources we can directly estimate the associated errors. The abundance differences due to the change of T_{eff} by 200 K show the discrepancy of about 0.25 dex, whereas the change of $\log g$ by 0.2 dex cause the differences within 0.1 dex. The values of the differences depend on the analyzed element.

4.5. Comparison with other stars

Figure 4 shows the comparison of the abundances of light, iron peak, heavy and rare earth elements obtained for HD 74169, with the literature values for the Sun (Grevesse and Sauval 1998), HD 48915, HD 170672, HD 43819, HD 133029, HD 192913 (Saffe and Levato 2004), HD 116458 (Nishimura et al. 2004) and HD 170973 (Kato 2003). Except for HD 48915 (Sirius) and HD 170672 (Vega) all stars are chemically peculiar silicon stars. The abundance pattern of HD 74169 is consistent with the results for other stars, especially for iron peak elements. The abundances of light elements Ne and Ar were determined only for HD 74169.

In this paper we present preliminary results. In the next step we are going to show a more detailed abundance determinations with a separate analysis of the neutral and ionized elements for all normal and chemically peculiar stars of IC 2391.

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