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Preliminary abundances of Fe, Ti, Cr, Mg and He in a sample of ten stars in the Alpha Persei open cluster

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Abstract. Abundances of Fe, Ti, Cr, Mg and He have been determined for 10 stars (5 B, 3 A, 1 F dwarfs and 1 chemically peculiar giant B8IIIp with apparent velocities ranging from 15 to 130 km.s^{-1}) of the Alpha Persei open cluster ($\log age$=7.40 yrs). The method consists in adjusting grids of synthetic spectra calculated with SYNSPEC48 code (Hubeny & Lanz 1992) in the region of 4450-4600 Å and Kurucz's ATLAS9 model atmospheres. A correlation may exist between [Fe/H] and the effective temperature. Further observations of a much larger sample of B, A and F stars in this cluster are foreseen in the near future.

1. Introduction

Abundance determinations for A stars have focused on chemically peculiar A stars because of their low apparent rotational velocities which facilitate line measurements. In contrast, the chemical compositions of the atmospheres of normal A stars remain poorly known as their lines are broadened by rapid rotation.

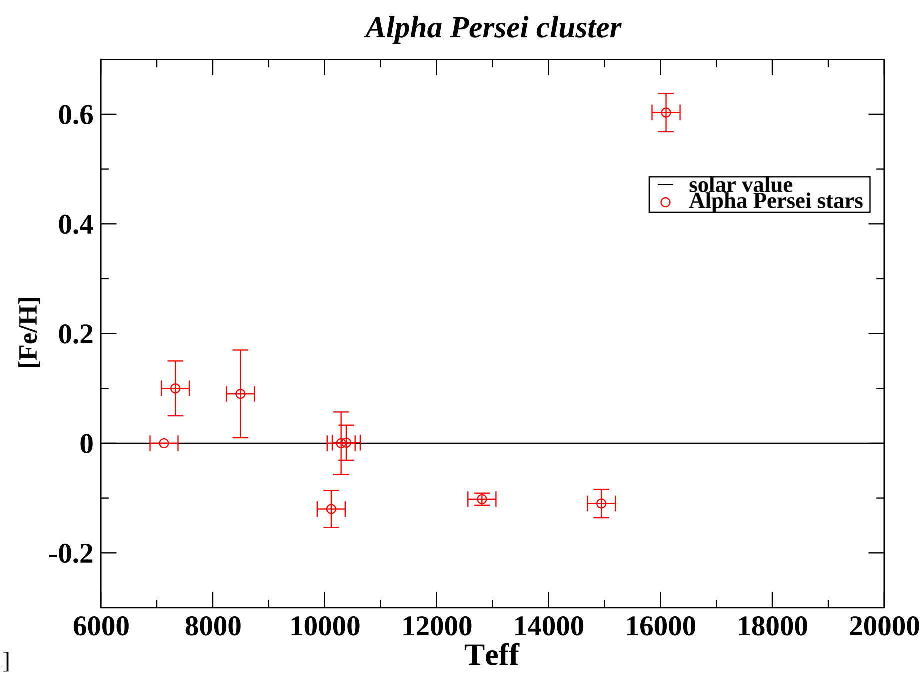
Recently, interest in the chemical composition of normal A stars has been revived because considerable abundance variation can be found from star to star among normal A stars. Using spectral line synthesis, Lemke (1989, 1990), Hill & Landstreet (1993) and Hill (1995) found considerable abundance differences from star to star among the few tens normal field A dwarfs they analysed. Consequently Varenne & Monier (1999) and Monier (2005) found similar behaviour for the A dwarfs in the Hyades open cluster (age ≃ 750 Myrs) and the Ursa Major moving group (age ≃ 500 Myrs). In these two associations, the abundances of iron and other chemical elements vary over a range of 0.7 dex for normal A dwarfs having same surface properties (same effective temperature and surface gravity).

Hui-bon-Hoa & al. (1997) found that atypical abundance patterns may exist in a sample of A stars. These peculiar abundance patterns may be identified as early Am phases in agreement with predictions of time-dependent models including diffusion in A stars. Later on, Hui-Bon-Hoa (1999) found a lack of Am stars in the Alpha Persei cluster which can be explained by the time the anomalies take to appear. The stratification process could cause only marginal underabundances of Ca (and Sc) in this young cluster.

Elemental radiative diffusion is probably the dominant process leading to the anomalous abundances in these stars. However, other processes, such as turbulence, mass loss,

Table 1. Photometric indices, temperature and surface gravity of the stars

star	V	$B-V$	$b-y$	m1	c1	β	spectral type	$T_{eff}(K)$	log g
HD21699	5.47	-0.115	-0.041	0.111	0.369	2.697	B8IIIp	16101	4.11
HD22136	6.89	-0.01	0.014	0.106	0.648	2.766	B8V	12811	4.14
HD20961	7.635	0.12	0.086	0.128	0.94	2.875	B9.5V	10386	4.27
HD19805	7.94	0.12	0.074	0.137	0.945	2.887	B9.5V	10294	4.33
HD20969	9.05	0.34	0.215	0.182	0.721	2.758	A8V	7331	4.30
HD21071	6.08	-0.077	-0.029	0.103	0.444	2.727	B7V	14945	4.26
HD21455	6.235	0.132	0.120	0.073	0.587	2.731	B7V	13627	3.98
HD20122	9.25	0.43	0.274	0.163	0.754	2.736	F2V	7129	3.98
HD21092	8.48	0.2	0.11	0.2	0.952	2.895	A5V	8495	4.26
HD20842	7.85	0.1	0.075	0.131	0.965	2.886	A0V	10117	4.25



[b!]

Fig. 1. Abundance of iron versus effective temperature

accretion and meridional circulation may play a role as well (Michaud, 2005).

2. Observations and data reduction

Ten stars have been observed in October 2003 with the AURELIE spectrometer placed at the coudé focus of the 152cm telescope of the Haute Provence Observatory (OHP). The resulting spectra span 4450-4600 Å with a resolving power of 30000 (FWHM ~ 0.15 Å). The apparent rotational velocities were obtained by adjusting the MgII line (4481 Å). The IRAF software was used to reduce all spectra following the standard procedure (offset substraction, division by flat field and wavelength calibration using a Thorium-Argon lamp). The

Table 2. The adopted $\log gf$ used for the computation of the synthetic spectrum

element	wavelenght(Å)	$\log gf$	accuracy	reference
MgII	4481.1260	0.730	B	Biermann et al., 1948
MgII	4481.325	0.575	B	Biermann et al., 1948
TiII	4450.482	-1.448	D	Danzmann et al., 1980
TiII	4468.507	-0.600	D	Danzmann et al., 1980
TiII	4501.273	-0.770	D	Danzmann et al., 1980
TiII	4533.969	-0.530	C	Roberts et al., 1973
TiII	4563.761	-0.690	D	Roberts et al., 1973
FeII	4491.405	-2.690	C	Fuhr et al., 1988
FeII	4508.288	-2.210	C	Fuhr et al., 1988
FeII	4515.339	-2.490	C	Fuhr et al., 1988
FeII	4520.224	-2.600	C	Fuhr et al., 1988
FeII	4522.634	-2.190	C	Fuhr et al., 1988
FeII	4541.524	-3.050	C	Fuhr et al., 1988
FeII	4549.474	-1.750	C	Fuhr et al., 1988
FeII	4555.893	-2.280	D	Fuhr et al., 1988
HeI	4471.469	-2.198	A	Treffitz et al., 1957
HeI	4471.473	-1.028	A	Treffitz et al., 1957
HeI	4471.473	-0.278	A	Treffitz et al., 1957
HeI	4471.485	-1.028	A	Treffitz et al., 1957
HeI	4471.488	-0.548	A	Treffitz et al., 1957
CrII	4539.595	-2.530	D	Wujec et al., 1981
CrII	4554.988	-1.373	D	Kostyk et al., 1983
CrII	4558.650	-0.659	D	Wujec et al., 1981
CrII	4592.049	-1.217	D	Kostyk et al., 1983

spectra were then normalized to the local continuum by interpolating cubic splines.

3. Synthetic spectrum and chemical abundance analysis

3.1. Atmospheric parameters

Effective temperature (T_{eff}) and surface gravity ($\log g$) were determined using Napiwotzki et al.'s (1993) UVBYBETA code and are collected in Table 1.

3.2. Synthetic spectrum

The synthetic spectra were computed using SYNSPEC48 (Hubeny & Lanz, 1992) and the LTE model atmospheres were computed using Kurucz's ATLAS9 program with a solar abundance for all the elements. Microturbulent velocities for each star were adopted following Smalley's prescriptions (2004).
Two important files are used as input to SYNSPEC48 program: the line list and the model atmosphere. The abundances in the synthetic spectra were then modified in order to achieve the best agreement between observed and computed profiles of selected lines.

3.3. Linelists

The linelist was built from Kurucz's gfhyperall.dat (http://kurucz.harvard.edu). Only transitions between 4450 and 4600 Å were retained.
Many $\log gf$ for Fe, Mg, Ti and Cr were changed using more accurate values from NIST's database (http://physics.nist.gov/PhysRefData/ASD/lines-form.html). Table 2 represent the adopted elements and the associated $\log gf$, accuracy and reference.

Table 3. Abundances of Fe, Ti, Cr, Mg, Cr, and He in the Alpha Persei stars

Element	number of lines	$< \log(\frac{N}{N_H})_* >$	σ	$\log(\frac{N}{N_H})_\odot$	$\frac{(\frac{N}{N_H})_*}{(\frac{N}{N_H})_\odot}$	$[\frac{N}{N_H}]$
		HD21699 $v \sin i = 45 km/s$				
FeII	5	-3.767	±0.035	-4.37	4.010	0.603
HeI	4	-3.398	±0.00	-1.00	0.004	-2.397
MgII	2	-5.29	±0.00	-4.46	0.150	-0.823
		HD22136 $v \sin i = 20 km/s$				
FeII	5	-4.473	±0.01	-4.37	0.79	-0.102
HeI	4	-1.26	±0.00	-1.00	0.55	-0.259
MgII	2	-4.79	±0.00	-4.46	2.40	0.380
TiII	2	-7.573	±0.00	-7.05	0.30	-0.522
		HD20961 $v \sin i = 25 km/s$				
FeII	6	-4.36	±0.03	-4.37	1.02	0.009
HeI	4	-1.046	±0.00	-1.00	0.90	-0.045
MgII	2	-4.18	±0.00	-4.46	2.20	0.342
TiII	4	-7.177	±0.047	-7.05	0.75	-0.124
		HD19805 $v \sin i = 15 km/s$				
FeII	6	-4.37	±0.057	-4.37	0.99	-0.004
HeI	4	-1.70	±0.00	-1.00	0.20	-0.698
MgII	2	-4.28	±0.00	-4.46	1.50	0.176
CrII	2	-6.16	±0.07	-6.37	1.63	0.212
TiII	3	-7.02	±0.04	-7.05	1.071	0.03
		HD20969 $v \sin i = 21.5 km/s$				
FeII	5	-4.27	±0.05	-4.37	1.25	0.097
MgII	2	-4.28	±0.00	-4.46	1.50	0.176
CrII	2	-6.16	±0.07	-6.37	1.63	0.212
TiII	4	-7.04	±0.01	-7.05	1.01	0.004
		HD21071 $v \sin i = 50 km/s$				
FeII	7	-4.48	±0.03	-4.37	0.77	-0.113
HeI	4	-1.39	±0.00	-1.00	0.4	-0.397
MgII	2	-4.346	±0.00	-4.46	1.30	0.114
CrII	1	-6.37	±0.00	-6.37	1.00	0.000
		HD21455 $v \sin i = 130 km/s$				
FeII	-	-4.67	±0.00	-4.37	0.50	-0.301
HeI	4	-1	±0.00	-1.00	1.00	0.000
MgII	2	-4.46	±0.00	-4.46	1.00	0.000
		HD20122 $v \sin i = 100 km/s$				
FeII	2	-4.37	±0.00	-4.37	1.00	0.000
MgII	2	-4.31	±0.00	-4.46	1.40	0.146
TiII	2	-7.05	±0.00	-7.05	1.00	0.000
		HD21092 $v \sin i = 78 km/s$				
FeII	6	-4.28	±0.08	-4.37	1.24	0.093
MgII	2	-4.38	±0.00	-4.46	1.20	0.079
CrII	2	-6.26	±0.00	-6.37	1.30	0.114
TiII	3	-6.96	±0.02	-7.05	1.23	0.090
		HD20842 $v \sin i = 75 km/s$				
FeII	7	-4.49	±0.03	-4.37	0.75	-0.124
HeI	4	-1.09	±0.00	-1.00	0.80	-0.096
MgII	2	-4.16	±0.00	-4.46	2.00	0.301
TiII	4	-7.30	±0.15	-7.05	0.56	-0.252

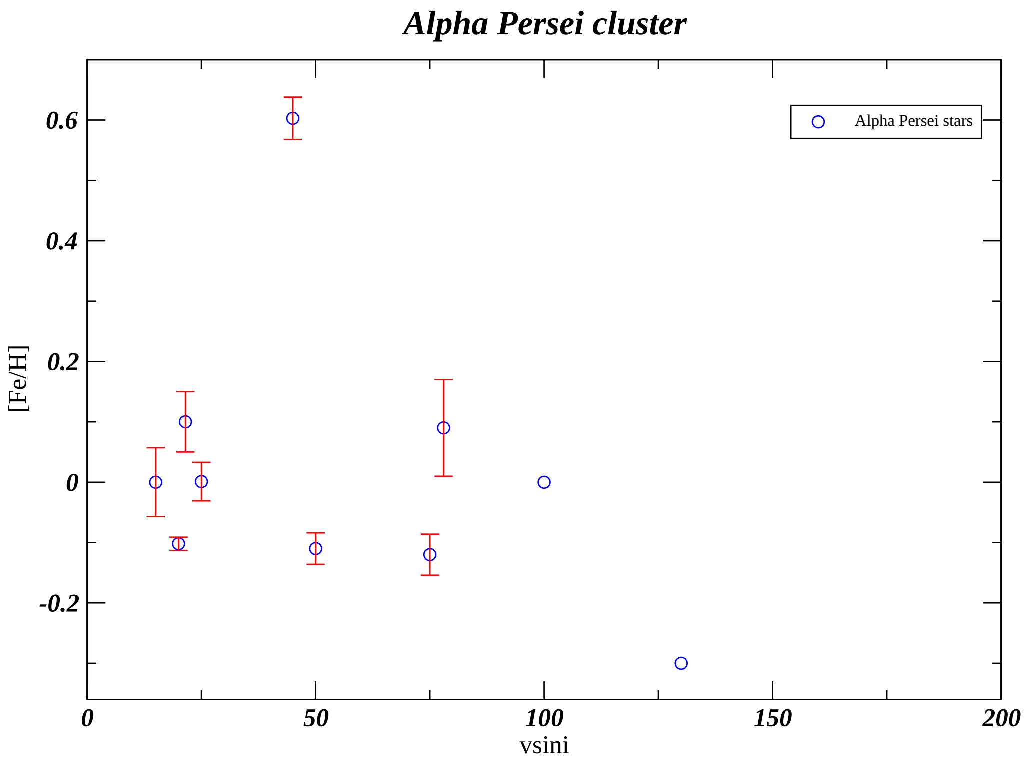


Fig. 2. Abundance of iron versus rotational velocity

3.4. Results

We note [A/B]=log(A/B)$_*$-log(A/B)$_\odot$, the stellar atmospheric abundance relative to the solar value taken from Anders & Grevesse (1989). For two stars, HD20969 and HD21092, our values of the iron abundance agree very well with those determined by Hui-Bon-Hoa et al. (1997). The errors in the elemental abundances are the standard deviations assuming a Gaussian distribution of the abundances derived from each lines:

$$\bar{x} = \frac{\sum_i x_i}{N}$$

and

$$\sigma^2 = \frac{\sum_i (x_i - \bar{x})^2}{N}$$

where $\bar{x}$ is the mean value of the abundance, N the number of line of the element and σ the standard deviation.
Table 3 represents the abundance for the 10 stars of Alpha Persei open cluster.
Figures 1 and 2 displays the abundance of iron for each star against the effective temperature and the apparent rotational velocity $v_e \sin i$. A correlation may exist between $[\frac{Fe}{H}]$ and $T_{\rm eff}$ (and between $[\frac{Fe}{H}]$ and $v_e \sin i$) but it needs to be confirmed on a much larger sample of stars. New observations of B, A and F dwarfs in the Alpha Persei cluster are foreseen in the near future.

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