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UPPER MAIN SEQUENCE STARS WITH ANOMALOUS ABUNDANCES. THE HGMN STARS HR 3273, HR 8118, HR 8567 AND HR 8937

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RESUMEN

Este trabajo es parte de un estudio para verificar posibles tendencias de las abundancias en estrellas HgMn con los parámetros estelares, rotación y edad. Presentamos un análisis de las estrellas HR 3273, HR 8118, HR 8567 y HR 8937. Utilizamos espectros echelle tomados con el telescopio de 2.1 m del CASLEO y modelos de atmósferas de ATLAS9. El He resultó por debajo del valor solar para las estrellas HgMn. El O resultó levemente sobreabundante en HR 3273 y HR 8567. MgII resultó por debajo excepto para HR 8118. El SiII resultó aproximadamente solar en HR 8118 y HR 8937, y por debajo en HR 3273 y HR 8567. El Fe resultó levemente sobreabundante en HR 8118 y HR 8937 y subabundante en HR 3273 y HR 8567. Las especies Sc, Ti, Cr, Mn, Sr, Y y Zr resultaron sobreabundantes mientras que el Ni resultó estar por debajo del valor solar.

ABSTRACT

This work is part of our current study for verifying a possible relation between abundances of HgMn stars with stellar parameters, rotation and age. We present an analysis of the stars HR 3273, HR 8118, HR 8567 and HR 8937. We used echelle spectra taken with the CASLEO 2.1 m telescope and ATLAS9 model atmospheres. HeI was underabundant for the HgMn stars. O was slightly underabundant in HR 3273 and HR 8567. MgII was underabundant except for HR 8118. SiII was close to solar in HR 8118 and HR 8937, and underabundant in HR 3273 and HR 8567. Fe was slightly underabundant in HR 3273 and HR 8567, and slightly overabundant in HR 8118 and HR 8937. The species Sc, Ti, Cr, Mn, Sr, Y and Zr were overabundant while Ni was underabundant.

Key Words: stars: chemically peculiar — stars: individual (HR 3273, HR 8118, HR 8567, HR 8937)

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1. INTRODUCTION

The mercury-manganese (HgMn) stars belong to a group of chemically peculiar (CP) stars observed in the upper main sequence. Their hydrogen spectral types are usually B7-B9 with effective temperatures between 10000 K and 15000 K. HgMn stars show typically intensified lines of Hg (up to $\sim$5 dex), Mn (up to $\sim$3 dex) and a deficiency of He. This group shows an unusually high proportion of multiple systems: more than two thirds of them are spectroscopic binaries (SBs), many of which are double-lined systems (e.g., Hubrig & Mathys 1995). They are usually slow rotators (e.g., Abt, Chaffee, & Suffolk 1972) and they show no evidence of large-scale organized magnetic fields (e.g., Auriére et al. 2007, 2010; Makaganiuk et al. 2011).

The relation of the anomalous abundances and stellar parameters is not totally clear. Some authors found no correlation between the total HgII abundance and the effective temperature (e.g., Smith 1997; Woolf & Lambert 1999), while Dolk, Wahlgren, & Hubrig (2003) found a possible correlation for a sample of 31 HgMn stars. On the other hand, Smith & Dworetsky (1993) and later Jomaron, Dworetsky,

TABLE 1

OBSERVATIONAL DATA FOR THE SAMPLE OF HGMN STARS

Parameter	HR 3273	HR 8118	HR 8567	HR 8937	References
$B-V$	−0.08	−0.08	−0.04	−0.10	R1,R6,R8
$U-B$	−0.38	−0.32	−0.37	−0.37	R1,R6
V	6.42	6.76	6.36	4.37	R1,R6,R9
$b-y$	−0.020	−0.028	−0.018	−0.046	R2
m_1	0.090	0.117	0.101	0.125	R2
c_1	0.710	0.801	0.678	0.677	R2
β	2.704	2.780	2.737	2.776	R2
J	6.515	6.848	6.410	4.477	R7
H	6.607	6.925	6.493	4.669	R7
K	6.585	6.907	6.467	4.611	R7
Sp. Type	B9p (HgMn)	B9p Hg(Mn?)	B8(Mn), HgMn	B9.5 IVp (HgMn)	R3,R4,R5 R10, R11

References: R1: Cousins & Stoy (1962), R2: Hauck & Mermilliod (1998), R3: Andersen & Nordström (1977), R4: Renson & Manfroid (2009), R5: Wolff & Wolff (1974), R6: Corben & Stoy (1968) , R7: Cutri et al. (2003), R8: Crawford (1963), R9: Corben (1971), R10: Cowley et al. (1969), R11: Houk (1982).

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& Allen (1999) found a dependence between MnI and MnII abundances and temperature. The authors suggest that difussion takes place in the atmospheres of these stars, but probably affected by other factors such as rotation and evolutionary state. This research is part of our current program for deriving elemental abundances among field CP stars and members of open clusters. The motivation of our work is to derive abundances for a sample of HgMn stars to determine possible relations with their fundamental parameters and other factors such as rotation, evolutionary state and age. In particular in this paper we report the results of four CP stars of the HgMn class, HR 3273, HR 8118, HR 8567 and HR 8937.

The star HR 3273 was classified as an HgMn star by Andersen & Nordström (1977). They studied ∼70 bright southern stars using coudé spectrograms of 20 Å/mm, taken with the ESO 1.5 m telescope at La Silla, Chile. The authors identified HR 3273 as a B9p (HgMn) star, with no definite variation in their spectra. UBV photoelectric photometry was published by Cousins & Stoy (1962). $uvby-\beta$ photometry was provided by Hauck & Mermilliod (1998), Eggen (1977) and Gronbech & Olsen (1976). JHK infrared photometry was presented by Cutri et al. (2003).

The star HR 8118 was classified as Hg(Mn?) star in the spectroscopic study of the Bright Star Catalogue by Cowley et al. (1968). They identified the line HgII $\lambda\lambda$3984 in the spectra taken at the Yerkes observatory with a dispersion of 125 Å/mm. Then the star was listed and classified as B9p Hg(Mn?) in the study of A bright stars (Cowley et al. 1969). UBV photometry was obtained by Crawford (1963) and Corben (1971). $uvby-\beta$ photometry was published by Gronbech & Olsen (1977) and Hauck & Mermilliod (1998).

The star HR 8567 was classified as HgMn star by Wolff & Wolff (1974). They studied 194 stars of types B4-B9 and identified in their sample 24 HgMn stars. The authors used UV spectrograms with a dispersion of 50 Å/mm in the region 3440–3500 Å. In this spectral range there are several strong lines of MnII. HR 8567 was classified as B8(Mn) star in the catalog of Renson & Manfroid (2009) and listed as HgMn star in the catalog of Schneider (1981). UBV photoelectric photometry was published by Rybka (1969) and Corben & Stoy (1968). $uvby-\beta$ photometry was obtained by Hauck & Mermilliod (1998), Gronbech & Olsen (1976) and Eggen (1977), and JHK infrared photometry was presented by Cutri et al. (2003).

The star HR 8937 was classified as B9p by Bertaud (1958) and then listed as B9.5 IVp (HgMn) in the Michigan Catalogue of Two Dimensional Spectral Types (Houk 1982). UBV photoelectric photometry have been provided by Abt & Golson (1962) and Irwin (1961). $uvby$ photometry was published by Crawford, Barnes, & Golson (1970) and Hauck & Mermilliod (1998), and their β photometric index were determined by Strauss & Ducati (1981).

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Table 1 presents some relevant observational data for the sample of HgMn stars, HR 3273, HR 8118, HR 8567 and HR 8937.

2. OBSERVATIONAL MATERIAL AND LINE IDENTIFICATIONS

The stellar spectra of the stars were obtained at Complejo Astrónomico El Leoncito (CASLEO) between April 21 and 23, 2004. We used the *Jorge Sahade* 2.15 m telescope that fed the EBASIM echelle spectrograph through an optical fiber. The spectra were recorded on a TEK1024 (1024 × 1024 pixels) CCD detector. The EBASIM spectrograph uses gratings as cross dispersers. We have used one grating with 226 lines mm^{-1} centered at ∼5000 Å. Three spectra of each star were obtained, covering the visual range ∼$\lambda\lambda$3800–5900 Å. The S/N ratio of the spectra is around 250 and the resolving power of the spectrograph is approximately 40000. Table 2 gives the spectral coverage of the 55 orders of the EBASIM spectrograph[1]. It contain echelle orders overlapping in ∼$\lambda\lambda$3762–5644 Å and increasing gaps of 1–4 Å for $\lambda \gtrsim 5645$ Å.

The spectra were reduced using IRAF[2] standard procedures for echelle spectra. We applied bias and flat corrections and then normalized order by order with the *continuum* task, using 7–9 order Chebyshev polynomials. We also corrected the scattered light in the spectrograph (*apscatter* task). We fitted the background with a linear function on both sides of the echelle apertures, using the task *apall*. Extensive description of the characteristics of the reduction technique and some results obtained with the observational material, have been previously published (e.g., Saffe & Levato 2009). The equivalent widths were measured by integrating the profiles across the stellar metallic lines using the *splot* task. There are no differences among the equivalent width measurements of the same lines in different spectra.

We used Gaussian profiles to fit the stellar lines. This is an interactive process in which the IRAF user marks two continuum points in the spectra and then the program fits a single line profile (splot task). IRAF uses a fixed linear continuum through the stellar line. The fitting uses an interactive algorithm based on the Levenberg-Marquardt method. The successive iterations tend to improve the fit by varying the parameters along the gradient of improvement in the χ^2 function. The final fit is overplotted on the spectrum of the star and the user decides if the fit is satisfactory or not. The center, continuum at the center, core intensity, integrated flux, equivalent width and FWHMs are printed and saved in a log file. All the parameters except the continuum are based on the fitted analytic profiles.

Pintado & Adelman (2003) compared EBASIM and DAO (Dominion Astrophysical Observatory) equivalent widths corresponding to echelle and coudé spectra, respectively. The scattered light is usually easier to measure in the latter case. They used Gaussian profiles for the EBASIM spectra and rotational profiles for the DAO spectra, due to the lower res-

TABLE 2

SPECTRAL COVERAGE FOR THE EBASIM ECHELLE SPECTROGRAPH USING THE GRATING OF 226 LINES mm^{-1}

Order	Range [Å]	Order	Range [Å]
1	3762–3798	29	4625–4670
2	3787–3823	30	4663–4708
3	3813–3849	31	4702–4748
4	3839–3875	32	4741–4788
5	3865–3902	33	4781–4828
6	3891–3929	34	4822–4869
7	3918–3956	35	4864–4911
8	3946–3984	36	4906–4954
9	3973–4012	37	4949–4998
10	4002–4041	38	4993–5042
11	4030–4070	39	5037–5087
12	4059–4099	40	5083–5133
13	4088–4129	41	5129–5180
14	4118–4159	42	5176–5227
15	4149–4190	43	5224–5276
16	4179–4221	44	5273–5325
17	4210–4252	45	5323–5375
18	4242–4284	46	5374–5426
19	4274–4317	47	5425–5478
20	4307–4350	48	5478–5533
21	4340–4383	49	5533–5588
22	4373–4417	50	5588–5644
23	4407–4451	51	5645–5701
24	4442–4486	52	5703–5760
25	4478–4522	53	5762–5820
26	4514–4558	54	5822–5881
27	4550–4594	55	5884–5943
28	4587–4632		

[1]Due to modifications in the configuration of the EBASIM spectrograph, the spectral coverage could slightly vary in different observing runs.

[2]IRAF is distributed by the National Optical Astronomical Observatories which is operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the National Science Foundation.

olution of the EBASIM data. For 170 unblended lines of the star α Sex in the region 3840–4930 Å, they obtained nearly the same scale for the equivalent widths. Then, they did not apply any additional correction to the equivalent widths of the EBASIM spectra. However, we caution that the comparison done in Pintado & Adelman (2003) needs to be extended and made more robust. The authors plan to extend it with high S/N (> 500) spectra of sharp-lined stars.

The stellar lines of the HgMn stars were identified using the same procedure of previous papers (Saffe, Levato, & López-García 2004, 2005; Saffe & Levato 2009). We used the general references of *A Multiplet Table of Astrophysical Interest* (Moore 1945) and *Wavelengths and Transition Probabilities for Atoms and Atomic Ions*, Part 1 (Reader et al. 1980) as well as the more specialized references for P II (Svendenius, Magnusson, & Zetterberg 1983), Mn II (Iglesias & Velasco 1964), Fe II (Dworetsky 1971; Johansson 1978; Guthrie 1985) and Y II (Nilsson, Johansson, & Kurucz 1991). The final line list is similar to those used in recent papers of HgMn stars (Zavala et al. 2007; Adelman & Yüce 2010).

3. ATMOSPHERIC PARAMETERS

An estimate of the effective temperature and gravity was done by Woolf & Lambert (1999), who used the Strömgren $uvby-\beta$ photometry and the calibration of Moon & Dworetsky (1985). For HR 3273, the authors derived 12350 K and 3.28 dex for $T_{\rm eff}$ and $\log g$, respectively. Glagolevskij (1994) used the Shallis-Blackwell method and derived two temperatures from the parameters Q and X (reddening free index and multicolor photometry parameter). For HR 8118 they obtained 11900 K and 11500 K, while for HR 8937 they obtained 12400 and 12300 K, using the Q and X parameters, respectively. Dolk et al. (2003) derived a temperature and gravity using *uvby* photometric data but with the calibration of Napiwotzki, Shonberner, & Wenske (1993). For HR 8567, they obtained 11977 K and 4.06 dex, while for HR 8937 they derived 12476 K and 4.13 dex for $T_{\rm eff}$ and $\log g$, respectively.

We compared the observed Hγ profiles with synthetic spectra of the Hγ region calculated with SYNTHE (Kurucz & Avrett 1981) using Kurucz ATLAS9 (Kurucz 1995, private communication) model atmospheres with [M/H]=0.0, i.e. solar abundance, which seems to be adequate for these stars. However it is difficult to obtain accurate Balmer line profiles in this region from echelle spectra covering several orders. Thus, we estimated $T_{\rm eff}$ and $\log g$ using the $uvby-\beta$ mean colors of Hauck & Mermilliod (1998) with the calibration of Napiwotzki et al. (1993), and then we corrected the $T_{\rm eff}$ values according to Adelman & Rayle (2000). These values are presented in the first two columns of Table 3. Next we adjusted the surface gravity to get ionization equilibrium from FeI and FeII. A similar strategy was applied by Adelman & Yüce (2010) in the derivation of the fundamental parameters. The final adopted values of the fundamental parameters are shown in Table 3.

TABLE 3

TEMPERATURE AND GRAVITY DERIVED FOR THE HGMN STARS

Star	$uvby-\beta$ $T_{\rm eff}$	$uvby-\beta$ $\log g$	Adopted $T_{\rm eff}$	Adopted $\log g$
HR 3273	12253	3.32	12253	3.42
HR 8118	11381	4.01	11381	4.11
HR 8567	12315	3.78	12315	3.68
HR 8937	12088	4.28	12088	4.28

We fitted a synthetic spectrum to $\sim$20 Fe lines in order to derive an estimation of the rotational velocities of the HgMn stars. We used the program SYNTHE (Kurucz & Avrett 1981) and the command *broaden* to reproduce the instrumental broadening of the EBASIM spectrograph, adopting a resolving power of $R \sim 40000$. The value of R is approximate, and thus the derived rotational velocities should be taken with caution. The final $v \sin i$ values are obtained using the average and standard deviation of the lines. We derived rotational velocities of 20 ± 2 km s^{-1}, 30 ± 1 km s^{-1}, 22 ± 1 km s^{-1} and 24 ± 2 km s^{-1} for the stars HR 3273, HR 8118, HR 8567 and HR 8937, respectively. The HgMn stars of our sample are not extremely slow rotators.

4. ABUNDANCE ANALYSES

To derive the abundances of the chemical species we used the WIDTH9 code (Kurucz 1995, private communication) and equivalent widths measured in the spectra of the stars. The program also requires the selection of a model atmosphere and the atomic data for the lines (oscillator strength, excitation potentials, damping constants, etc.). The code calculates a theoretical equivalent width for an initial input abundance (taken from the model atmosphere) and compares this value with the measured EW. WIDTH9 computes basically the line profile and the curve of growth. Then it modifies the abundance iteratively to achieve a difference between theoretical and measured equivalent width < 0.01 mÅ. The process is repeated for each measured spectral line.

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TABLE 4

DETERMINATION OF MICROTURBULENT VELOCITY FROM FEII LINES

Star	Species	n	ξ_1 km s^{-1}	$\log N/N_T$	ξ_2 km s^{-1}	$\log N/N_T$	gf-values
HR 3273	FeII	64	0.3	-4.75 ± 0.22	0.0	-4.74 ± 0.27	N4+KX+MF
		37	0.9	-4.87 ± 0.24	0.0	-4.80 ± 0.28	N4+MF
	adopted ξ:	0.3 km s^{-1}					
HR 8118	FeII	63	1.0	-4.36 ± 0.21	0.0	-4.28 ± 0.28	N4+KX+MF
		37	1.2	-4.41 ± 0.24	0.0	-4.27 ± 0.26	N4+MF
	adopted ξ:	0.5 km s^{-1}					
HR 8567	FeII	56	0.0	-4.91 ± 0.21	0.0	-4.91 ± 0.28	N4+KX+MF
		33	0.5	-4.99 ± 0.24	0.0	-4.98 ± 0.26	N4+MF
	adopted ξ:	0.1 km s^{-1}					
HR 8937	FeII	80	0.9	-4.32 ± 0.21	0.0	-4.27 ± 0.28	N4+KX+MF
		39	1.1	-4.40 ± 0.24	0.0	-4.29 ± 0.26	N4+MF
	adopted ξ:	0.5 km s^{-1}					

Note: the source of gf values are KX (Kurucz & Bell 1995), MF (Fuhr, Martin, & Wiese 1988) and N4 (Fuhr & Wiese 2006).

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The adopted metal line damping constants were the default semi-classical approximations except for those of neutral and singly-ionized Ca-Ni lines, whose values are based on the data of Kurucz & Bell (1995). For the lines of CII, multiplet 6, and MgII, multiplet 4, the adopted values for Stark broadening were based on data of Sahal-Brechot (1969), and for SiII and CaII, the damping constants are those of Lanz, Dimitrijevic, & Artru (1988), and Chapelle & Sahal-Brechot (1970) respectively. We prefer this choice of gf values to the VALD database (Piskunov 1996) to ensure homogeneity with our previous work.

To determine the abundances we need an initial estimation of the microturbulent velocity (ξ). For this estimation we have used the standard method. We computed abundances from the FeII lines for a range of possible microturbulent velocities (ξ). For determining the final values (Table 4), we looked for the conditions that the abundances of FeII were not dependent on the equivalent widths (ξ_1) or that they minimize the rms scatter of the abundances (ξ_2). Values for each species were derived using lines with gf values from 3 different sources: KX values (Kurucz & Bell 1995), MF values (Fuhr et al. 1988) and N4 values (Fuhr & Wiese 2006). The sources of gf values shown in the last column of Table 4 determine the number of lines, n. The values derived for the microturbulence using the FeII lines are 0.32 km s^{-1}, 0.55 km s^{-1}, 0.13 km s^{-1} and 0.52 km s^{-1}, for the HgMn stars HR 3273, HR 8118, HR 8567 and HR 8937, respectively. Once a ξ value has been fixed the abundances corresponding to all chemical species measured are determined using the WIDTH9 code.

In our abundance determination we did not include seriously blended lines. To give an idea of the sensitivity of our results, raising the temperature of HR 3273 by $\sim$4% (500 K) increases the average abundance by $\sim$2%, and raising the surface gravity by $\sim$15% (0.5 dex) increases the average abundance by $\sim$0.5%. Table 5 shows the sensivity of the results for the abundances to these changes.

We present in the Table 6 the He/H ratios derived comparing the observed HeI line profiles with synthetized spectra. We used the program SYNTHE under the LTE condition; the results were convolved with the rotational velocity of the star and the instrumental broadening of the spectrograph. The mean derived He/H values are 0.07, 0.09, 0.08 and 0.03, for the stars HR 3273, HR 8118, HR 8567 and HR 8937, respectively.

Previous works in literature derived the Hg abundance taking into account the isotopic and hyperfine structure, using higher resolution spectra and S/N than ours (Woolf & Lambert 1999; Dolk et al. 2003). They determined the isotopic mixture for the line HgII $\lambda\lambda$3984 using similar values of $T_{\rm eff}$ and $\log g$. We adopted the Hg abundance derived by these authors for HR 3273 (-5.25 ± 0.32 dex), HR 8567 (-5.58 ± 0.37 dex) and HR 8937 (-4.23 ± 0.43 dex). These values are comparable to those derived using the equivalent width of $\lambda\lambda$ 3984, and LTE model atmosphere, i.e. -4.83 dex, -5.39 dex and -4.06 dex,

TABLE 5

SENSITIVITY OF THE DERIVED ABUNDANCES OF HR 3273 TO CHANGES IN EFFECTIVE TEMPERATURE AND SURFACE GRAVITY

HR 3273 Element	$\log N/H$ for adopted model	$\log N/H$ for 500 K hotter model	$\log N/H$ for 0.5 dex greater model
CII	−3.61	−3.96	−3.57
OI	−3.23	−3.15	−3.27
MgI	−5.17	−4.68	−5.26
MgII	−5.11	−5.02	−5.08
AlII	−6.80	−6.83	−6.70
SiII	−4.92	−4.95	−4.89
PII	−5.97	−6.13	−5.89
SII	−4.99	−5.28	−4.91
CaII	−5.57	−5.31	−5.70
ScII	−8.03	−7.72	−8.00
TiII	−6.35	−6.06	−6.30
CrII	−5.53	−5.32	−5.45
MnI	−4.63	−4.13	−4.68
MnII	−4.68	−4.52	−4.59
FeI	−4.34	−3.93	−4.37
FeII	−4.75	−4.67	−4.65
FeIII	−4.56	−4.81	−4.38
NiII	−6.74	−6.66	−6.57
YII	−7.68	−7.37	−7.64
ZrII	−7.79	−7.46	−7.72

TABLE 6

HE/H DETERMINATION FOR THE SAMPLE OF HGMN STARS

Line	HR 3273	HR 8118	HR 8567	HR 8937
3867	0.08	—	—	—
4026	0.07	0.09	0.09	0.03
4121	0.08	—	0.09	—
4471	0.06	0.09	0.07	0.03
4713	0.06	0.09	0.08	0.03
4921	—	—	0.09	—
Average	0.07±0.01	0.09	0.08±0.01	0.03

for HR 3273, HR 8567 and HR 8937, respectively, with a mean offset of −0.23 dex. For HR 8118 we used our estimation based on the equivalent width of $\lambda\lambda$ 3984 (−5.03 dex) and then we added the mean offset (−0.23 dex), obtaining finally −5.26 dex for the Hg abundance of this star. This is not a perfect solution as some very sharp-lined HgMn stars have $\lambda\lambda$ 3984 lines with a unique distribution of Hg isotopes.

5. DISCUSSION

HR 3273, HR 8118, HR 8567 and HR 8937 are main sequence stars with anomalous abundances, i.e. different from solar values. The comparison of derived and solar abundances for the HgMn stars is presented in the Table 7. We included the rms of the average abundance for each species and the number of lines n involved in the average. Solar abundances have been taken from Grevesse, Noels, & Sauval

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TABLE 7

COMPARISON OF DERIVED AND SOLAR ABUNDANCES

Species	HR 3273 $\log N/N_H$	n	HR 8118 $\log N/N_H$	n	HR 8567 $\log N/N_H$	n	HR 8937 $\log N/N_H$	n	Sun $\log N/N_H$
HeI	-1.12 ± 0.06	5	-1.01 ± 0.01	3	-1.04 ± 0.05	5	-1.47 ± 0.04	3	-1.01
CII	-3.61 ± 0.11	2	-3.10 ± 0.02	2	-3.82 ± 0.27	3	-3.24 ± 0.03	2	-3.45
OI	-3.23	1	-3.71	1	-3.09	1			-3.13
MgI	-5.17	1	-4.96 ± 0.02	2	-5.14	1	-5.01 ± 0.01	2	-4.42
MgII	-5.11 ± 0.03	2	-4.54 ± 0.10	3	-4.91 ± 0.03	2	-4.73 ± 0.15	3	-4.42
AlII	-6.80	1	-5.47	1	-6.52	1			-5.53
SiII	-4.92 ± 0.22	8	-4.61 ± 0.17	6	-4.78 ± 0.20	7	-4.52 ± 0.18	8	-4.45
PII	-5.97	1					-5.37	1	-6.55
SII	-4.99 ± 0.14	7	-4.45 ± 0.19	5	-4.73 ± 0.18	7	-5.09 ± 0.09	3	-4.67
CaII	-5.57	1	-6.18	1	-5.35	1	-5.93	1	-5.64
ScII	-8.03	1	-7.02	1	-7.62	1			-8.83
TiII	-6.35 ± 0.24	34	-6.11 ± 0.22	34	-5.97 ± 0.23	32	-6.60 ± 0.23	26	-6.98
CrI			-5.20	1					-6.33
CrII	-5.53 ± 0.23	37	-5.19 ± 0.19	23	-5.34 ± 0.21	32	-5.73 ± 0.25	30	-6.33
MnI	-4.63 ± 0.22	7	-5.54 ± 0.18	3	-4.20 ± 0.26	14	-4.67 ± 0.19	11	-6.61
MnII	-4.68 ± 0.21	39	-5.26 ± 0.32	12	-4.25 ± 0.23	41	-4.46 ± 0.21	39	-6.61
FeI	-4.34 ± 0.02	2	-4.27 ± 0.35	19	-4.78 ± 0.24	3	-4.30 ± 0.40	18	-4.50
FeII	-4.75 ± 0.21	64	-4.31 ± 0.19	63	-4.91 ± 0.21	56	-4.29 ± 0.20	80	-4.50
FeIII	-4.56	1					-4.35	1	-4.50
NiII	-6.74 ± 0.30	2	-6.06 ± 0.21	2	-6.79 ± 0.25	2			-5.75
SrII			-8.43	1	-8.35	1	-6.30	1	-9.03
YII	-7.68 ± 0.26	5	-6.32 ± 0.24	9	-7.40 ± 0.16	8	-6.37 ± 0.20	11	-9.76
ZrII	-7.79 ± 0.05	2	-7.06 ± 0.16	13	-7.59 ± 0.32	2	-7.72 ± 0.14	6	-9.40
BaII			-9.17	1					-9.87
HgII	-5.25	1	-5.03	1	-5.58	1	-4.23	1	-10.83
$T_{\rm eff}$	12253		11381		12315		12088		
$\log g$	3.42		4.11		3.68		4.28		

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(1996). We also present in Tables 8–11 the line by line abundance values derived for the sample of HgMn stars. The columns shown are the code of the species, the name of the element, multiplet number, wavelength of the line, $\log gf$ value, reference for the $\log gf$ value, equivalent width and abundance of the line. In Figure 1 we show the abundance anomalies relative to solar as a function of the atomic number. The HgMn stars are presented as crosses (HR 3273), empty triangles (HR 8118), empty circles (HR 8567) and empty squares (HR 8937). For comparison purposes we show the abundances of four other HgMn stars, depicted as filled circles (HR 4817), filled triangles (π Boo), filled hexagons (μ Lep) and filled squares (28 Her). These data are taken from Adelman & Pintado (1997). From the values presented in Table 7 and Figure 1, our sample of HgMn stars shows an abundance pattern similar to other HgMn stars. However there are some differences in particular cases.

The star HR 3273 shows a relatively low abundance of SiII (8 lines) compared to other HgMn stars. In the star HR 8567, the abundance of CrII (32 lines) is relatively high compared to other HgMn stars. The CrII lines $\lambda\lambda$4588, 4634 and 5237, for instance, are intense in the spectra. The Mn and Hg abundances are similar to other HgMn stars. The abundance of CII in HR 8118 and HR 8937 is also relatively high. However, this value is based on few lines, and assumes the LTE approximation. For star HR 8937, the abundance of SrII is high compared to other HgMn stars. However, this value is derived

TABLE 8

LINE ABUNDANCES OF HR 3273

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$	Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$
6.01	C II	4	3918.97	−0.53	WF	19	−3.72	24.01	Cr II	31	4261.91	−1.53	KX	46	−5.40
6.01	C II	4	3920.68	−0.23	WF	30	−3.49	24.01	Cr II	31	4275.57	−1.70	KX	42	−5.36
8.00	O I	12	5330.73	−0.87	WF	22	−3.22	24.01	Cr II	44	4554.99	−1.38	MF	47	−5.42
12.00	Mg I	2	5183.60	−0.16	WS	6	−5.17	24.01	Cr II	39	4565.74	−2.11	MF	25	−5.36
12.01	Mg II	10	4390.57	−0.53	WS	23	−5.14	24.01	Cr II	44	4588.20	−0.63	MF	79	−5.05
12.01	Mg II	9	4427.99	−1.21	WS	6	−5.07	24.01	Cr II	44	4592.05	−1.22	MF	42	−5.72
13.01	Al II	2	4663.05	−0.28	FW	5	−6.80	24.01	Cr II	44	4616.63	−1.29	MF	43	−5.64
14.01	Si II	1	3853.66	−1.44	LA	50	−5.18	24.01	Cr II	44	4618.80	−1.11	MF	60	−5.22
14.01	Si II	1	3856.02	−0.49	LA	96	−5.10	24.01	Cr II	44	4634.07	−1.24	MF	55	−5.27
14.01	Si II	1	3862.59	−0.74	LA	90	−4.97	24.01	Cr II	30	4836.23	−2.25	MF	24	−5.31
14.01	Si II	3.01	4075.45	−1.40	SG	14	−4.85	24.01	Cr II	30	4848.23	−1.14	MF	51	−5.63
14.01	Si II	3.01	4076.78	−1.67	SG	13	−4.61	24.01	Cr II	30	4884.61	−2.08	MF	19	−5.63
14.01	Si II	3	4128.05	0.38	LA	120	−4.54	24.01	Cr II	190	4912.46	−0.95	KX	17	−5.53
14.01	Si II	3	4130.89	0.53	LA	91	−5.06	24.01	Cr II	43	5232.50	−2.09	KX	15	−5.67
14.01	Si II	5	5041.02	0.29	SG	60	−5.07	24.01	Cr II	43	5237.33	−1.16	MF	52	−5.42
15.01	P II	15	4602.07	0.74	WS	8	−5.97	24.01	Cr II	23	5246.77	−2.45	MF	20	−5.31
16.01	S II	44	4153.07	0.62	WS	11	−4.94	24.01	Cr II	23	5249.44	−2.43	KX	13	−5.54
16.01	S II	44	4162.66	0.78	WS	12	−4.99	24.01	Cr II	43	5274.96	−1.29	KX	48	−5.43
16.01	S II	9	4815.55	0.18	WM	9	−5.26	24.01	Cr II	43	5279.88	−2.10	MF	34	−5.05
16.01	S II	7	4925.34	−0.47	WS	7	−4.77	24.01	Cr II	43	5280.05	−2.01	KX	36	−5.08
16.01	S II	15	5014.04	0.03	KX	8	−4.99	24.01	Cr II	43	5308.44	−1.81	MF	25	−5.61
16.01	S II	39	5212.62	0.24	WS	6	−4.91	24.01	Cr II	43	5310.70	−2.28	MF	17	−5.39
16.01	S II	38	5320.72	0.46	WS	6	−5.08	24.01	Cr II	43	5313.59	−1.65	MF	33	−5.54
20.01	Ca II	1	3933.66	0.13	WM	212	−5.57	24.01	Cr II	43	5334.87	−1.56	KX	34	−5.59
21.01	Sc II	7	4246.82	0.24	LD	40	−8.03	25.00	Mn I	2	4030.75	−0.47	MF	15	−4.91
22.01	Ti II	34	3900.54	−0.45	MF	55	−6.38	25.00	Mn I	2	4033.06	−0.62	MF	19	−4.62
22.01	Ti II	34	3913.46	−0.53	MF	50	−6.50	25.00	Mn I	2	4034.48	−0.81	MF	9	−4.84
22.01	Ti II	31	3932.02	−1.78	MF	10	−6.49	25.00	Mn I	5	4041.35	0.29	MF	13	−4.69
22.01	Ti II	11	4012.38	−1.61	MF	35	−6.11	25.00	Mn I	28	4462.03	0.32	MF	9	−4.47
22.01	Ti II	87	4028.34	−1.00	MF	14	−6.69	25.00	Mn I	21	4762.37	0.42	MF	21	−4.19
22.01	Ti II	87	4053.82	−1.21	MF	22	−6.22	25.00	Mn I	16	4783.43	0.04	MF	7	−4.69
22.01	Ti II	105	4163.64	−0.40	MF	35	−6.34	25.01	Mn II	I	3859.21	−2.56	KX	11	−4.91
22.01	Ti II	20	4287.87	−2.02	MF	19	−5.91	25.01	Mn II	I	3878.99	−1.71	KX	40	−4.73
22.01	Ti II	19	4294.09	−1.11	MF	37	−6.33	25.01	Mn II	I	3917.32	−1.15	KX	29	−4.97
22.01	Ti II	41	4300.04	−0.77	MF	58	−5.97	25.01	Mn II	I	3930.95	−2.15	KX	13	−4.68
22.01	Ti II	41	4301.92	−1.16	MF	20	−6.70	25.01	Mn II	I	3952.42	−1.50	KX	12	−4.78
22.01	Ti II	41	4312.86	−1.16	MF	27	−6.49	25.01	Mn II	I	3986.58	−2.60	KX	14	−4.70
22.01	Ti II	41	4320.95	−1.87	MF	17	−6.07	25.01	Mn II	I	4000.05	−1.21	KX	26	−4.58
22.01	Ti II	51	4394.06	−1.59	MF	6	−6.86	25.01	Mn II	I	4081.44	−2.24	KX	28	−4.27
22.01	Ti II	19	4395.03	−0.66	MF	49	−6.41	25.01	Mn II	I	4087.91	−2.91	KX	7	−4.81
22.01	Ti II	61	4395.84	−2.17	MF	8	−6.14	25.01	Mn II	I	4136.90	−1.29	KX	59	−4.21
22.01	Ti II	61	4409.24	−2.64	KX	5	−5.90	25.01	Mn II	I	4140.44	−2.46	KX	17	−4.67
22.01	Ti II	115	4411.07	−1.06	MF	10	−6.25	25.01	Mn II	2	4174.32	−3.55	KX	44	−4.62
22.01	Ti II	40	4417.71	−1.43	MF	21	−6.39	25.01	Mn II	I	4184.45	−1.95	KX	22	−4.72
22.01	Ti II	19	4443.80	−0.70	MF	45	−6.50	25.01	Mn II	I	4200.27	−1.74	KX	32	−4.64
22.01	Ti II	19	4450.48	−1.45	MF	16	−6.58	25.01	Mn II	2	4205.38	−3.38	KX	51	−4.54
22.01	Ti II	31	4468.49	−0.60	MF	44	−6.60	25.01	Mn II	I	4240.39	−2.07	KX	25	−4.51
22.01	Ti II	115	4488.32	−0.82	MF	17	−6.18	25.01	Mn II	7	4244.25	−2.39	KX	33	−4.34
22.01	Ti II	31	4501.27	−0.75	MF	41	−6.56	25.01	Mn II	I	4251.73	−1.06	KX	52	−4.68
22.01	Ti II	50	4533.96	−0.77	MF	57	−5.97	25.01	Mn II	2	4260.46	−4.25	KX	15	−4.77
22.01	Ti II	41	4563.76	−0.96	MF	35	−6.46	25.01	Mn II	I	4377.74	−2.14	KX	20	−4.95
22.01	Ti II	82	4571.97	−0.53	MF	53	−6.19	25.01	Mn II	I	4393.38	−2.32	KX	15	−4.94
22.01	Ti II	59	4657.20	−2.15	MF	7	−6.23	25.01	Mn II	I	4403.51	−1.80	KX	11	−5.08
22.01	Ti II	92	4779.98	−1.37	MF	13	−6.28	25.01	Mn II	I	4478.64	−0.95	KX	40	−4.92
22.01	Ti II	82	4805.09	−1.10	MF	17	−6.39	25.01	Mn II	I	4497.94	−2.59	KX	9	−4.98
22.01	Ti II	14	4911.20	−0.34	MF	17	−6.65	25.01	Mn II	I	4503.20	−2.16	KX	15	−4.82
22.01	Ti II	86	5129.16	−1.39	MF	9	−6.53	25.01	Mn II	I	4689.55	−2.54	KX	11	−4.56
22.01	Ti II	86	5185.90	−1.35	MF	17	−6.24	25.01	Mn II	I	4702.73	−2.34	KX	10	−4.78
22.01	Ti II	7	5188.69	−1.21	MF	17	−6.52	25.01	Mn II	I	4717.26	−1.86	KX	15	−4.86
24.01	Cr II	167	3865.60	−0.78	KX	32	−5.84	25.01	Mn II	I	4730.40	−2.15	KX	40	−4.33
24.01	Cr II	130	3866.52	−2.07	KX	4	−5.86	25.01	Mn II	I	4749.11	−2.00	KX	16	−4.85
24.01	Cr II	129	3911.32	−2.06	KX	9	−5.56	25.01	Mn II	I	4764.73	−1.35	KX	62	−4.37
24.01	Cr II	183	3979.50	−0.73	KX	30	−5.79	25.01	Mn II	I	4791.78	−1.72	KX	29	−4.69
24.01	Cr II	183	4012.50	−0.89	KX	37	−5.44	25.01	Mn II	I	4806.82	−1.56	KX	46	−4.72
24.01	Cr II	19	4051.93	−2.19	KX	22	−5.80	25.01	Mn II	I	4830.06	−1.85	KX	25	−4.70
24.01	Cr II	19	4054.08	−2.48	KX	24	−5.46	25.01	Mn II	I	4839.74	−1.86	KX	19	−4.87
24.01	Cr II	26	4072.56	−2.41	KX	10	−5.76	25.01	Mn II	I	4842.32	−2.01	KX	25	−4.53
24.01	Cr II	165	4082.28	−1.23	KX	13	−5.99	25.01	Mn II	I	5102.52	−1.93	KX	27	−4.63
24.01	Cr II	26	4086.13	−2.42	KX	8	−5.83	25.01	Mn II	I	5177.65	−1.77	KX	44	−4.24
24.01	Cr II	26	4132.42	−2.35	KX	11	−5.73	25.01	Mn II	I	3902.36	−2.72	KX	13	−4.57
24.01	Cr II	162	4145.78	−1.16	KX	25	−5.66	26.00	Fe I	43	4132.06	−0.68	N4	4	−4.31
24.01	Cr II	26	4179.42	−1.77	KX	23	−5.84	26.00	Fe I	1146	5383.37	0.65	N4	3	−4.36

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TABLE 8 (CONTINUED)

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	W_{eq}	$\log(N/N_T)$	Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	W_{eq}	$\log(N/N_T)$
26.01	Fe II	38	3935.96	−1.86	N4	18	−4.78	26.01	Fe II	J	5018.44	−1.22	MF	88	−4.44
26.01	Fe II	3	3938.29	−4.07	N4	11	−4.72	26.01	Fe II	J	5021.59	−0.30	KX	11	−4.37
26.01	Fe II	190	3938.97	−1.85	N4	16	−4.71	26.01	Fe II	J	5022.79	−0.02	KX	12	−4.60
26.01	Fe II	127	4024.55	−2.44	N4	11	−4.99	26.01	Fe II	J	5035.71	0.61	KX	27	−4.63
26.01	Fe II	172	4048.83	−2.14	N4	23	−4.34	26.01	Fe II	J	5061.72	0.22	KX	11	−4.88
26.01	Fe II	28	4122.67	−3.38	N4	15	−4.82	26.01	Fe II	J	5070.90	0.24	KX	11	−4.88
26.01	Fe II	27	4233.17	−1.81	N4	77	−4.36	26.01	Fe II	J	5075.76	0.28	KX	12	−4.78
26.01	Fe II	27	4273.33	−3.34	N4	11	−4.95	26.01	Fe II	J	5093.58	0.11	KX	12	−4.65
26.01	Fe II	28	4296.57	−3.01	N4	24	−4.81	26.01	Fe II	J	5097.27	0.31	KX	25	−4.37
26.01	Fe II	27	4303.18	−2.61	N4	51	−4.38	26.01	Fe II	J	5106.11	−0.28	KX	10	−4.38
26.01	Fe II	27	4351.77	−2.08	N4	44	−5.16	26.01	Fe II	J	5145.77	−0.40	KX	8	−4.33
26.01	Fe II	J	4357.58	−2.10	KX	11	−4.59	26.01	Fe II	J	5150.49	−0.12	KX	11	−4.46
26.01	Fe II	27	4385.39	−2.57	N4	34	−4.92	26.01	Fe II	J	5169.03	−0.87	MF	90	−4.72
26.01	Fe II	27	4416.83	−2.60	N4	33	−4.92	26.01	Fe II	J	5199.12	0.10	KX	7	−4.92
26.01	Fe II	37	4489.18	−2.97	N4	23	−4.83	26.01	Fe II	J	5216.85	0.81	KX	19	−5.01
26.01	Fe II	37	4491.40	−2.70	N4	24	−5.04	26.01	Fe II	J	5228.90	−0.30	KX	7	−4.49
26.01	Fe II	38	4508.29	−2.21	N4	42	−4.99	26.01	Fe II	J	5232.79	−0.06	KX	14	−4.37
26.01	Fe II	37	4515.34	−2.48	N4	34	−4.99	26.01	Fe II	J	5234.62	−2.05	MF	45	−4.84
26.01	Fe II	37	4520.22	−2.60	N4	33	−4.91	26.01	Fe II	J	5247.95	0.55	N4	18	−4.74
26.01	Fe II	38	4522.63	−2.03	N4	47	−5.03	26.01	Fe II	J	5254.93	−3.23	KX	11	−4.79
26.01	Fe II	38	4541.52	−3.05	N4	17	−4.92	26.01	Fe II	J	5257.12	0.03	KX	9	−4.66
26.01	Fe II	37	4555.89	−2.29	N4	42	−4.94	26.01	Fe II	J	5260.25	1.07	KX	33	−4.82
26.01	Fe II	38	4576.34	−3.04	N4	17	−4.93	26.01	Fe II	J	5272.40	−2.03	MF	16	−4.44
26.01	Fe II	37	4582.84	−3.10	N4	15	−4.94	26.01	Fe II	J	5276.00	−1.94	MF	45	−4.96
26.01	Fe II	38	4583.84	−2.02	N4	60	−4.62	26.01	Fe II	J	5291.67	0.58	KX	17	−4.86
26.01	Fe II	D	4596.02	−1.84	N4	12	−4.69	26.01	Fe II	J	5339.59	0.54	KX	17	−4.80
26.01	Fe II	38	4620.52	−3.28	N4	15	−4.76	26.02	Fe III	4	4419.60	−2.22	KX	7	−4.56
26.01	Fe II	37	4629.34	−2.37	N4	38	−4.98	28.01	Ni II	12	4015.47	−2.42	KX	4	−6.44
26.01	Fe II	186	4635.32	−1.65	N4	22	−4.65	28.01	Ni II	11	4067.03	−1.29	KX	12	−7.03
26.01	Fe II	28	4666.76	−3.33	N4	11	−4.90	39.01	Y II	6	3950.35	−0.49	HL	12	−7.90
26.01	Fe II	43	4731.45	−3.13	N4	17	−4.82	39.01	Y II	6	3982.59	−0.49	HL	11	−7.96
26.01	Fe II	J	4913.29	0.01	KX	11	−4.69	39.01	Y II	14	4124.90	−1.50	HL	4	−7.25
26.01	Fe II	J	4951.58	0.18	KX	14	−4.69	39.01	Y II	22	4900.12	−0.09	HL	14	−7.74
26.01	Fe II	J	4977.04	0.04	KX	11	−4.65	39.01	Y II	20	5205.72	−0.34	HL	12	−7.57
26.01	Fe II	J	4990.51	0.18	KX	13	−4.72	40.01	Zr II	16	3998.95	−0.67	GB	6	−7.84
26.01	Fe II	J	4993.36	−3.65	MF	6	−4.88	40.01	Zr II	30	4045.64	−0.60	KX	8	−7.74
26.01	Fe II	J	5001.96	0.90	KX	30	−4.86	80.01	Hg II	–	3983.94	−1.73	DW	83	−4.83
26.01	Fe II	J	5004.20	0.50	KX	18	−4.85								

from one line and should be taken with caution. For HR 8937 we adopted the Hg abundance derived by Dolk et al. (2003). They found an abundance of -4.23 ± 0.43 dex, i.e., a relatively high value. We compared this value with an estimation using the equivalent width of $\lambda\lambda$3984 and derived -4.06 dex, i.e. also a high abundance for HgII in this star.

For star HR 8118, the abundances of CII, AlII and ScII seem to be relatively high compared to other HgMn stars. However, these values are based on the measurement of few lines (2, 1 and 1, respectively) and should be taken with caution. On the other hand, the abundances of CrII, YII and ZrII are also relatively high, from a greater number of lines (23, 9 and 13, respectively). We caution that this star has the highest $v \sin i$ in our sample (30 ± 1 km s^{-1}) which suggest that high abundance values in different species might be due to blends with another lines. However this effect is not clearly seen in the FeII abundances (63 lines), and thus the CrII abundance could be real. A comparison of higher resolution spectra with synthetic spectra is needed to verify the abundance of Cr, Y and Zr in this star.

HeI was slightly underabundant for the sample of HgMn stars and underabundantin HR 8937. O was slightly underabundant in the stars HR 3273 and HR 8567. MgII was underabundant, except for HR 8118 (which is close to the solar value). SiII was close to solar in HR 8118 and HR 8937, and underabundant in HR 3273 and HR 8567. Fe was slightly underabundant in HR 3273 and HR 8567, and slightly overabundant in HR 8118 and HR 8937. The species Sc, Ti, Cr, Mn, Sr, Y and Zr were overabundant while Ni was underabundant.

As we said in the Introduction, our purpose is to discuss the possible trend of the abundances of the critical elements in HgMn stars with stellar parameters. Papers in the literature show that the abundances of some elements seem to correlate with the effective temperature (e.g., Smith & Dworetsky 1993; Smith 1997; Woolf & Lambert 1999; Jomaron et al. 1999; Dolk et al. 2003). However, it is not clear (for instance) how the abundances are corre-

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TABLE 9

LINE ABUNDANCES OF HR 8118

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$
6.01	C II	4	3918.97	−0.53	WF	16	−3.12
6.01	C II	4	3920.68	−0.23	WF	23	−3.09
12.00	Mg I	2	5172.68	−0.38	WS	28	−4.98
12.00	Mg I	2	5183.60	−0.16	WS	41	−4.93
12.01	Mg II	5	3848.21	−1.59	WS	31	−4.42
12.01	Mg II	10	4390.57	−0.53	WS	50	−4.65
12.01	Mg II	9	4427.99	−1.21	WS	18	−4.55
13.01	Al II	2	4663.05	−0.28	FW	25	−5.47
14.01	Si II	1	3853.66	−1.44	LA	64	−4.66
14.01	Si II	1	3856.02	−0.49	LA	120	−4.78
14.01	Si II	1	3862.59	−0.74	LA	95	−4.85
14.01	Si II	3.01	4075.45	−1.40	SG	19	−4.38
14.01	Si II	3	4130.89	0.53	LA	123	−4.54
14.01	Si II	5	5041.02	0.29	SG	81	−4.47
16.01	S II	44	4145.06	0.23	KX	6	−4.33
16.01	S II	44	4153.07	0.62	WS	8	−4.51
16.01	S II	44	4162.66	0.78	WS	13	−4.31
16.01	S II	9	4815.55	0.18	WM	6	−4.78
16.01	S II	7	5032.43	0.18	WS	12	−4.30
20.01	Ca II	1	3933.66	0.13	WM	249	−6.18
21.01	Sc II	7	4246.82	0.24	LD	89	−7.03
22.01	Ti II	34	3900.54	−0.45	MF	75	−6.13
22.01	Ti II	34	3913.46	−0.53	MF	75	−6.07
22.01	Ti II	31	3932.02	−1.78	MF	33	−6.08
22.01	Ti II	87	4028.34	−1.00	MF	42	−6.25
22.01	Ti II	105	4163.64	−0.40	MF	57	−6.05
22.01	Ti II	33	4227.33	−2.36	KX	11	−6.20
22.01	Ti II	20	4287.87	−2.02	MF	26	−6.05
22.01	Ti II	41	4290.22	−1.12	MF	72	−5.62
22.01	Ti II	19	4294.09	−1.11	MF	66	−5.85
22.01	Ti II	41	4300.04	−0.77	MF	78	−5.77
22.01	Ti II	41	4301.92	−1.16	MF	51	−6.24
22.01	Ti II	41	4307.87	−1.29	MF	57	−5.92
22.01	Ti II	41	4312.86	−1.16	MF	50	−6.25
22.01	Ti II	104	4386.85	−1.26	MF	28	−5.95
22.01	Ti II	51	4394.06	−1.59	MF	20	−6.58
22.01	Ti II	19	4395.03	−0.66	MF	73	−6.07
22.01	Ti II	61	4395.84	−2.17	MF	14	−6.19
22.01	Ti II	61	4409.52	−2.57	KX	12	−5.89
22.01	Ti II	115	4411.07	−1.06	MF	20	−6.11
22.01	Ti II	40	4417.71	−1.43	MF	46	−6.10
22.01	Ti II	19	4450.48	−1.45	MF	32	−6.46
22.01	Ti II	31	4468.49	−0.60	MF	68	−6.28
22.01	Ti II	31	4501.27	−0.75	MF	65	−6.25
22.01	Ti II	50	4533.96	−0.77	MF	80	−5.63
22.01	Ti II	41	4563.76	−0.96	MF	64	−6.02
22.01	Ti II	82	4571.97	−0.53	MF	73	−5.95
22.01	Ti II	59	4657.20	−2.15	MF	18	−6.07
22.01	Ti II	92	4779.98	−1.37	MF	26	−6.20
22.01	Ti II	82	4805.09	−1.10	MF	40	−6.11
22.01	Ti II	114	4874.01	−0.79	MF	18	−6.45
22.01	Ti II	114	4911.20	−0.34	MF	29	−6.57
22.01	Ti II	86	5129.16	−1.39	MF	26	−6.25
22.01	Ti II	86	5185.90	−1.35	MF	36	−6.04
22.01	Ti II	7	5188.69	−1.21	MF	43	−6.16
24.00	Cr I	7	5208.43	0.16	MF	21	−5.20
24.01	Cr II	129	3911.32	−2.06	KX	17	−5.18
24.01	Cr II	183	3979.50	−0.73	KX	44	−5.40
24.01	Cr II	19	4051.93	−2.19	KX	41	−5.34
24.01	Cr II	26	4072.56	−2.41	KX	36	−4.94
24.01	Cr II	165	4082.28	−1.23	KX	25	−5.60
24.01	Cr II	26	4132.42	−2.35	KX	13	−5.64
24.01	Cr II	162	4145.78	−1.16	KX	45	−5.09
24.01	Cr II	26	4179.42	−1.77	KX	39	−5.44
24.01	Cr II	31	4275.57	−1.70	KX	56	−4.98
24.01	Cr II	44	4554.99	−1.38	MF	62	−5.01
24.01	Cr II	44	4588.20	−0.63	MF	87	−4.97
24.01	Cr II	44	4592.05	−1.22	MF	63	−5.14
24.01	Cr II	44	4616.63	−1.29	MF	63	−5.08
24.01	Cr II	178	4697.60	−1.88	MF	15	−5.07
24.01	Cr II	30	4812.34	−1.80	MF	42	−5.29
24.01	Cr II	30	4848.23	−1.14	MF	65	−5.26
24.01	Cr II	30	4884.61	−2.08	MF	35	−5.20
24.01	Cr II	190	4901.62	−0.83	KX	28	−5.28
24.01	Cr II	43	5232.50	−2.09	KX	34	−5.08
24.01	Cr II	23	5246.77	−2.45	MF	25	−5.14
24.01	Cr II	23	5249.44	−2.43	KX	25	−5.16
24.01	Cr II	43	5308.44	−1.81	MF	46	−5.02
24.01	Cr II	43	5310.70	−2.28	MF	29	−5.03
25.00	Mn I	2	4033.06	−0.62	MF	24	−5.29
25.00	Mn I	2	4034.48	−0.81	MF	9	−5.63
25.00	Mn I	16	4754.04	−0.09	MF	3	−5.69
25.01	Mn II	I	4136.90	−1.29	KX	17	−5.49
25.01	Mn II	I	4184.45	−1.95	KX	12	−5.01
25.01	Mn II	7	4244.25	−2.39	KX	9	−5.11
25.01	Mn II	I	4251.73	−1.06	KX	17	−5.69
25.01	Mn II	2	4260.46	−4.25	KX	11	−4.94
25.01	Mn II	I	4478.64	−0.95	KX	14	−5.69
25.01	Mn II	I	4702.73	−2.34	KX	9	−4.72
25.01	Mn II	I	4730.40	−2.15	KX	13	−5.13
25.01	Mn II	I	4755.72	−1.24	KX	37	−5.27
25.01	Mn II	I	4806.82	−1.56	KX	13	−5.69
25.01	Mn II	I	5177.65	−1.77	KX	18	−4.97
25.01	Mn II	I	4238.79	−3.63	KX	14	−5.43
26.00	Fe I	45	3815.84	0.23	N4	31	−4.79
26.00	Fe I	4	3859.91	−0.71	N4	27	−4.73
26.00	Fe I	43	4132.06	−0.68	N4	26	−3.96
26.00	Fe I	152	4187.04	−0.55	N4	19	−3.87
26.00	Fe I	152	4187.80	−0.55	N4	12	−4.13
26.00	Fe I	152	4198.30	−0.72	N4	7	−4.21
26.00	Fe I	522	4199.10	0.16	N4	29	−3.97
26.00	Fe I	152	4222.21	−0.97	N4	9	−3.85
26.00	Fe I	693	4227.43	0.27	N4	12	−4.50
26.00	Fe I	152	4250.12	−0.41	N4	17	−4.07
26.00	Fe I	42	4250.79	−0.71	N4	15	−4.28
26.00	Fe I	42	4271.76	−0.16	N4	17	−4.80
26.00	Fe I	41	4383.54	0.20	N4	30	−4.79
26.00	Fe I	41	4404.75	−0.14	N4	22	−4.64
26.00	Fe I	554	4736.77	−0.75	N4	6	−3.84
26.00	Fe I	318	4920.50	0.07	N4	13	−4.47
26.00	Fe I	383	5232.94	−0.06	N4	24	−3.93
26.00	Fe I	1146	5383.37	0.65	N4	11	−4.39
26.00	Fe I	686	5586.76	−0.14	N4	15	−3.89
26.01	Fe II	127	3845.18	−2.29	KX	17	−4.73
26.01	Fe II	29	3872.77	−3.32	KX	31	−4.18
26.01	Fe II	173	3906.04	−1.83	N4	32	−4.22
26.01	Fe II	38	3935.96	−1.86	N4	36	−4.05
26.01	Fe II	3	3938.29	−4.07	N4	21	−4.24
26.01	Fe II	190	3938.97	−1.85	N4	24	−4.26
26.01	Fe II	28	4122.67	−3.38	N4	25	−4.36
26.01	Fe II	27	4233.17	−1.81	N4	87	−4.05
26.01	Fe II	27	4273.33	−3.34	N4	37	−3.98
26.01	Fe II	28	4296.57	−3.01	N4	46	−4.06
26.01	Fe II	27	4303.18	−2.61	N4	53	−4.27
26.01	Fe II	27	4351.77	−2.08	N4	58	−4.64
26.01	Fe II	J	4357.58	−2.10	KX	8	−4.52
26.01	Fe II	27	4385.39	−2.57	N4	52	−4.28
26.01	Fe II	27	4416.83	−2.60	N4	43	−4.52
26.01	Fe II	37	4489.18	−2.97	N4	40	−4.20
26.01	Fe II	37	4491.40	−2.70	N4	39	−4.49
26.01	Fe II	38	4508.29	−2.21	N4	52	−4.60
26.01	Fe II	37	4515.34	−2.48	N4	55	−4.23
26.01	Fe II	37	4520.22	−2.60	N4	41	−4.55
26.01	Fe II	38	4522.63	−2.03	N4	58	−4.60
26.01	Fe II	38	4541.52	−3.05	N4	29	−4.41
26.01	Fe II	37	4555.89	−2.29	N4	52	−4.52
26.01	Fe II	38	4576.34	−3.04	N4	30	−4.41
26.01	Fe II	37	4582.84	−3.10	N4	22	−4.56
26.01	Fe II	38	4583.84	−2.02	N4	75	−4.11
26.01	Fe II	D	4596.02	−1.84	N4	18	−4.25
26.01	Fe II	38	4620.52	−3.28	N4	22	−4.38
26.01	Fe II	37	4629.34	−2.37	N4	66	−4.01
26.01	Fe II	186	4635.32	−1.65	N4	32	−4.12
26.01	Fe II	28	4666.76	−3.33	N4	18	−4.47

TABLE 9 (CONTINUED)

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$
26.01	Fe II	43	4731.45	−3.13	N4	27	−4.37
26.01	Fe II	J	4826.68	−0.44	KX	5	−4.40
26.01	Fe II	J	4951.58	0.18	KX	14	−4.44
26.01	Fe II	J	4984.47	0.01	KX	12	−4.32
26.01	Fe II	J	4990.51	0.18	KX	15	−4.35
26.01	Fe II	J	4993.36	−3.65	MF	10	−4.49
26.01	Fe II	J	5001.96	0.90	KX	39	−4.34
26.01	Fe II	J	5004.20	0.50	KX	22	−4.43
26.01	Fe II	J	5018.44	−1.22	MF	106	−4.04
26.01	Fe II	J	5035.71	0.61	KX	28	−4.34
26.01	Fe II	J	5045.11	−0.13	KX	8	−4.40
26.01	Fe II	J	5061.72	0.22	KX	12	−4.52
26.01	Fe II	J	5070.90	0.24	KX	13	−4.50
26.01	Fe II	J	5075.76	0.28	KX	17	−4.29
26.01	Fe II	J	5082.23	−0.10	KX	9	−4.33
26.01	Fe II	J	5093.58	0.11	KX	21	−4.00
26.01	Fe II	J	5097.27	0.31	KX	32	−3.85
26.01	Fe II	J	5145.77	−0.40	KX	10	−3.93
26.01	Fe II	J	5149.46	0.40	KX	25	−4.12
26.01	Fe II	J	5160.84	−2.64	KX	10	−4.05
26.01	Fe II	J	5169.03	−0.87	MF	111	−4.31
26.01	Fe II	J	5216.85	0.81	KX	22	−4.57
26.01	Fe II	J	5234.62	−2.05	MF	58	−4.34
26.01	Fe II	J	5247.95	0.55	N4	18	−4.44
26.01	Fe II	J	5251.23	0.42	N4	21	−4.22
26.01	Fe II	J	5254.93	−3.23	KX	19	−4.28
26.01	Fe II	J	5257.12	0.03	KX	12	−4.20
26.01	Fe II	J	5260.25	1.07	KX	39	−4.38
26.01	Fe II	J	5272.40	−2.03	MF	14	−4.27
26.01	Fe II	J	5276.00	−1.94	MF	58	−4.45
26.01	Fe II	J	5291.67	0.58	KX	22	−4.37
26.01	Fe II	J	5339.59	0.54	KX	25	−4.22
28.01	Ni II	11	3849.55	−1.88	KX	21	−5.85
28.01	Ni II	11	4067.03	−1.29	KX	26	−6.27
38.01	Sr II	1	4215.52	−0.17	WM	35	−8.43
39.01	Y II	6	3950.35	−0.49	HL	65	−6.35
39.01	Y II	6	3982.59	−0.49	HL	62	−6.47
39.01	Y II	14	4124.90	−1.50	HL	42	−6.20
39.01	Y II	5	4422.58	−1.27	HL	53	−6.13
39.01	Y II	22	4854.86	−0.38	HL	48	−6.80
39.01	Y II	22	4900.12	−0.09	HL	74	−5.99
39.01	Y II	20	4982.13	−1.29	HL	30	−6.51
39.01	Y II	20	5200.41	−0.57	HL	59	−6.10
39.01	Y II	20	5289.82	−1.85	HL	20	−6.30
40.01	Zr II	17	3915.96	−0.82	KX	28	−7.22
40.01	Zr II	16	3958.23	−0.31	KX	44	−7.14
40.01	Zr II	30	3991.15	−0.25	KX	45	−7.07
40.01	Zr II	16	3998.95	−0.67	GB	41	−6.90
40.01	Zr II	54	4018.37	−0.99	KX	12	−7.41
40.01	Zr II	42	4034.10	−1.55	BG	8	−7.17
40.01	Zr II	29	4090.53	−1.10	GB	18	−7.15
40.01	Zr II	41	4149.22	−0.03	BG	52	−6.94
40.01	Zr II	29	4156.28	−0.71	GB	32	−7.13
40.01	Zr II	97	4186.67	−0.58	KX	20	−7.10
40.01	Zr II	99	4231.67	−1.02	KX	13	−6.91
40.01	Zr II	130	4494.42	−0.48	KX	20	−6.85
40.01	Zr II	129	4661.78	−0.80	KX	12	−6.83
56.01	Ba II	1	4934.07	0.00	WM	10	−9.17
80.01	Hg II	–	3983.94	−1.73	DW	59	−5.03

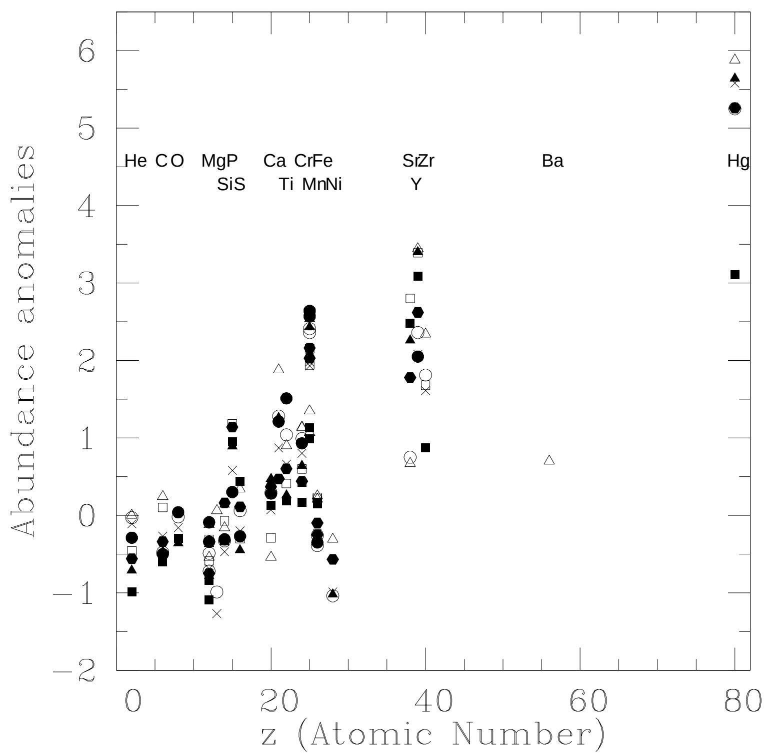

Fig. 1. Abundance anomalies relative to solar as a function of the atomic number. The HgMn stars are presented as crosses (HR 3273), empty triangles (HR 8118), empty circles (HR 8567) and empty squares (HR 8937). For comparison purposes we show the abundances of four other HgMn stars, depicted as filled circles (HR 4817), filled triangles (π Boo), filled hexagons (μ Lep) and filled squares (28 Her). Data taken from Adelman & Pintado (1997).

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TABLE 10

LINE ABUNDANCES OF HR 8567

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$	Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$
6.01	C II	4	3918.97	−0.53	WF	15	−3.76	24.01	Cr II	44	4616.63	−1.29	MF	50	−5.34
6.01	C II	4	3920.68	−0.23	WF	26	−3.53	24.01	Cr II	44	4634.07	−1.24	MF	62	−4.96
6.01	C II	6	4267.26	0.72	WF	15	−4.19	24.01	Cr II	178	4697.60	−1.88	MF	9	−5.31
8.00	O I	12	5330.73	−0.87	WF	28	−3.09	24.01	Cr II	30	4812.34	−1.80	MF	30	−5.53
12.00	Mg I	2	5183.60	−0.16	WS	8	−5.14	24.01	Cr II	30	4836.23	−2.25	MF	31	−5.06
12.01	Mg II	10	4390.57	−0.53	WS	31	−4.95	24.01	Cr II	30	4848.23	−1.14	MF	54	−5.46
12.01	Mg II	9	4427.99	−1.21	WS	10	−4.88	24.01	Cr II	30	4884.61	−2.08	MF	24	−5.43
13.01	Al II	2	4663.05	−0.28	FW	8	−6.52	24.01	Cr II	190	4912.46	−0.95	KX	19	−5.43
14.01	Si II	1	3853.66	−1.44	LA	56	−4.99	24.01	Cr II	43	5232.50	−2.09	KX	21	−5.42
14.01	Si II	1	3856.02	−0.49	LA	107	−4.89	24.01	Cr II	43	5237.33	−1.16	MF	59	−5.11
14.01	Si II	1	3862.59	−0.74	LA	88	−4.98	24.01	Cr II	23	5249.44	−2.43	KX	16	−5.40
14.01	Si II	3.01	4075.45	−1.40	SG	16	−4.72	24.01	Cr II	43	5274.96	−1.29	KX	49	−5.35
14.01	Si II	3.01	4076.78	−1.67	SG	19	−4.35	24.01	Cr II	43	5308.44	−1.81	MF	37	−5.19
14.01	Si II	3	4130.89	0.53	LA	114	−4.73	24.01	Cr II	43	5310.70	−2.28	MF	20	−5.25
14.01	Si II	5	5041.02	0.29	SG	73	−4.77	24.01	Cr II	43	5313.59	−1.65	MF	43	−5.18
16.01	S II	44	4153.07	0.62	WS	12	−4.79	24.01	Cr II	43	5334.87	−1.56	KX	40	−5.37
16.01	S II	44	4162.66	0.78	WS	14	−4.82	25.00	Mn I	2	4030.75	−0.47	MF	31	−4.50
16.01	S II	9	4815.55	0.18	WM	13	−4.93	25.00	Mn I	2	4033.06	−0.62	MF	49	−3.76
16.01	S II	1	4991.97	−0.65	WS	7	−4.45	25.00	Mn I	2	4034.48	−0.81	MF	16	−4.63
16.01	S II	15	5014.04	0.03	KX	14	−4.47	25.00	Mn I	5	4035.72	−0.19	KX	12	−4.33
16.01	S II	7	5032.43	0.18	WS	15	−4.71	25.00	Mn I	5	4041.35	0.29	MF	30	−4.25
16.01	S II	39	5212.62	0.24	WS	4	−4.93	25.00	Mn I	5	4058.93	−0.45	MF	8	−4.25
20.01	Ca II	1	3933.66	0.13	WM	280	−5.35	25.00	Mn I	23	4235.14	−0.26	KX	14	−3.81
21.01	Sc II	7	4246.82	0.24	LD	54	−7.61	25.00	Mn I	28	4455.01	−0.39	KX	11	−3.76
22.01	Ti II	34	3900.54	−0.45	MF	66	−5.97	25.00	Mn I	28	4462.03	0.32	MF	11	−4.46
22.01	Ti II	34	3913.46	−0.53	MF	70	−5.78	25.00	Mn I	22	4470.14	−0.44	MF	5	−4.16
22.01	Ti II	31	3932.02	−1.78	MF	23	−5.99	25.00	Mn I	21	4709.71	−0.34	MF	6	−4.14
22.01	Ti II	87	4028.34	−1.00	MF	31	−6.19	25.00	Mn I	16	4754.04	−0.09	MF	14	−4.32
22.01	Ti II	105	4163.64	−0.40	MF	48	−5.96	25.00	Mn I	21	4761.51	−0.14	MF	8	−4.20
22.01	Ti II	41	4290.22	−1.12	MF	54	−5.74	25.00	Mn I	16	4783.43	0.04	MF	17	−4.30
22.01	Ti II	19	4294.09	−1.11	MF	61	−5.55	25.01	Mn II	I	3878.99	−1.71	KX	55	−4.16
22.01	Ti II	41	4301.92	−1.16	MF	35	−6.28	25.01	Mn II	I	3917.32	−1.15	KX	43	−4.47
22.01	Ti II	41	4312.86	−1.16	MF	43	−6.04	25.01	Mn II	I	3930.95	−2.15	KX	23	−4.29
22.01	Ti II	94	4316.79	−1.42	MF	11	−6.31	25.01	Mn II	I	3952.42	−1.50	KX	23	−4.35
22.01	Ti II	41	4320.95	−1.87	MF	38	−5.49	25.01	Mn II	I	3986.58	−2.60	KX	28	−4.20
22.01	Ti II	104	4386.85	−1.26	MF	29	−5.62	25.01	Mn II	I	3995.31	−2.44	KX	24	−4.52
22.01	Ti II	19	4395.03	−0.66	MF	65	−5.83	25.01	Mn II	I	4000.05	−1.21	KX	40	−4.11
22.01	Ti II	61	4395.84	−2.17	MF	14	−5.86	25.01	Mn II	I	4081.44	−2.24	KX	41	−3.83
22.01	Ti II	115	4411.07	−1.06	MF	20	−5.84	25.01	Mn II	I	4087.91	−2.91	KX	12	−4.47
22.01	Ti II	40	4417.71	−1.43	MF	40	−5.88	25.01	Mn II	I	4140.44	−2.46	KX	26	−4.35
22.01	Ti II	19	4443.80	−0.70	MF	58	−6.06	25.01	Mn II	2	4174.32	−3.55	KX	58	−4.08
22.01	Ti II	19	4450.48	−1.45	MF	25	−6.29	25.01	Mn II	I	4180.06	−2.83	KX	13	−4.46
22.01	Ti II	31	4468.49	−0.60	MF	61	−6.04	25.01	Mn II	I	4184.45	−1.95	KX	38	−4.18
22.01	Ti II	115	4488.32	−0.82	MF	24	−5.94	25.01	Mn II	I	4200.27	−1.74	KX	48	−4.06
22.01	Ti II	50	4533.96	−0.77	MF	65	−5.67	25.01	Mn II	2	4205.38	−3.38	KX	66	−3.92
22.01	Ti II	41	4563.76	−0.96	MF	54	−5.86	25.01	Mn II	I	4240.39	−2.07	KX	40	−4.01
22.01	Ti II	59	4657.20	−2.15	MF	11	−5.98	25.01	Mn II	7	4244.25	−2.39	KX	44	−3.95
22.01	Ti II	92	4779.98	−1.37	MF	27	−5.84	25.01	Mn II	I	4251.73	−1.06	KX	61	−4.29
22.01	Ti II	82	4805.09	−1.10	MF	32	−5.97	25.01	Mn II	2	4260.46	−4.25	KX	25	−4.41
22.01	Ti II	114	4874.01	−0.79	MF	12	−6.38	25.01	Mn II	I	4377.74	−2.14	KX	29	−4.64
22.01	Ti II	114	4911.20	−0.34	MF	27	−6.32	25.01	Mn II	I	4391.96	−2.89	KX	12	−4.45
22.01	Ti II	113	5072.29	−0.75	MF	11	−6.44	25.01	Mn II	I	4393.38	−2.32	KX	31	−4.36
22.01	Ti II	86	5129.16	−1.39	MF	21	−6.06	25.01	Mn II	I	4403.51	−1.80	KX	23	−4.59
22.01	Ti II	86	5185.90	−1.35	MF	30	−5.84	25.01	Mn II	I	4478.64	−0.95	KX	56	−4.34
22.01	Ti II	7	5188.69	−1.21	MF	35	−5.99	25.01	Mn II	I	4497.94	−2.59	KX	16	−4.59
22.01	Ti II	70	5226.54	−1.30	MF	26	−6.15	25.01	Mn II	I	4503.20	−2.16	KX	26	−4.43
24.01	Cr II	167	3865.60	−0.78	KX	50	−5.26	25.01	Mn II	I	4509.22	−3.60	KX	8	−3.97
24.01	Cr II	129	3911.32	−2.06	KX	13	−5.32	25.01	Mn II	17	4510.21	−0.72	KX	17	−3.98
24.01	Cr II	183	3979.50	−0.73	KX	36	−5.58	25.01	Mn II	I	4689.55	−2.54	KX	24	−4.02
24.01	Cr II	19	4051.93	−2.19	KX	30	−5.55	25.01	Mn II	I	4702.73	−2.34	KX	15	−4.50
24.01	Cr II	26	4072.56	−2.41	KX	25	−5.16	25.01	Mn II	I	4717.26	−1.86	KX	27	−4.43
24.01	Cr II	165	4082.28	−1.23	KX	16	−5.83	25.01	Mn II	I	4730.40	−2.15	KX	52	−3.90
24.01	Cr II	26	4086.13	−2.42	KX	15	−5.48	25.01	Mn II	I	4749.11	−2.00	KX	23	−4.57
24.01	Cr II	181	4127.06	−1.77	KX	10	−5.40	25.01	Mn II	I	4791.78	−1.72	KX	41	−4.28
24.01	Cr II	26	4132.42	−2.35	KX	15	−5.54	25.01	Mn II	I	4806.82	−1.56	KX	66	−3.93
24.01	Cr II	26	4179.42	−1.77	KX	29	−5.63	25.01	Mn II	I	4830.06	−1.85	KX	39	−4.23
24.01	Cr II	31	4275.57	−1.70	KX	51	−5.02	25.01	Mn II	I	4839.74	−1.86	KX	32	−4.43
24.01	Cr II	191	4465.73	−1.18	KX	9	−5.65	25.01	Mn II	I	4842.32	−2.01	KX	39	−4.05
24.01	Cr II	44	4554.99	−1.38	MF	50	−5.25	25.01	Mn II	I	5102.52	−1.93	KX	48	−3.91
24.01	Cr II	39	4565.74	−2.11	MF	33	−5.08	25.01	Mn II	I	5307.35	−2.07	KX	17	−4.25
24.01	Cr II	44	4588.20	−0.63	MF	80	−4.96	25.01	Mn II	I	3902.36	−2.72	KX	13	−4.53
24.01	Cr II	44	4592.05	−1.22	MF	54	−5.28	26.00	Fe I	4	3859.91	−0.71	N4	10	−4.68

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TABLE 10 (CONTINUED)

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$
26.00	Fe I	20	3872.50	−0.93	N4	3	−4.54
26.00	Fe I	41	4383.54	0.20	N4	6	−5.10
26.01	Fe II	127	3845.18	−2.29	KX	8	−5.24
26.01	Fe II	38	3935.96	−1.86	N4	12	−4.96
26.01	Fe II	190	3938.97	−1.85	N4	11	−4.88
26.01	Fe II	28	4122.67	−3.38	N4	9	−4.99
26.01	Fe II	27	4273.33	−3.34	N4	8	−5.02
26.01	Fe II	28	4296.57	−3.01	N4	15	−5.03
26.01	Fe II	27	4303.18	−2.61	N4	46	−4.47
26.01	Fe II	27	4351.77	−2.08	N4	35	−5.35
26.01	Fe II	27	4385.39	−2.57	N4	28	−5.03
26.01	Fe II	27	4416.83	−2.60	N4	26	−5.05
26.01	Fe II	37	4489.18	−2.97	N4	18	−4.89
26.01	Fe II	37	4491.40	−2.70	N4	18	−5.16
26.01	Fe II	38	4508.29	−2.21	N4	32	−5.23
26.01	Fe II	37	4515.34	−2.48	N4	26	−5.14
26.01	Fe II	37	4520.22	−2.60	N4	22	−5.15
26.01	Fe II	38	4522.63	−2.03	N4	40	−5.17
26.01	Fe II	38	4541.52	−3.05	N4	13	−4.98
26.01	Fe II	37	4555.89	−2.29	N4	34	−5.10
26.01	Fe II	38	4576.34	−3.04	N4	13	−5.00
26.01	Fe II	37	4582.84	−3.10	N4	11	−5.07
26.01	Fe II	38	4583.84	−2.02	N4	51	−4.83
26.01	Fe II	D	4596.02	−1.84	N4	8	−4.84
26.01	Fe II	38	4620.52	−3.28	N4	8	−5.03
26.01	Fe II	37	4629.34	−2.37	N4	31	−5.10
26.01	Fe II	186	4635.32	−1.65	N4	17	−4.77
26.01	Fe II	28	4666.76	−3.33	N4	10	−4.90
26.01	Fe II	43	4731.45	−3.13	N4	10	−5.05
26.01	Fe II	J	4908.15	−0.30	KX	8	−4.50
26.01	Fe II	J	4951.58	0.18	KX	12	−4.76
26.01	Fe II	J	4984.47	0.01	KX	6	−4.92
26.01	Fe II	J	4990.51	0.18	KX	8	−4.94
26.01	Fe II	J	4993.36	−3.65	MF	4	−4.95
26.01	Fe II	J	5001.96	0.90	KX	28	−4.85
26.01	Fe II	J	5004.20	0.50	KX	14	−4.96
26.01	Fe II	J	5018.44	−1.22	MF	77	−4.68
26.01	Fe II	J	5022.79	−0.02	KX	8	−4.78
26.01	Fe II	J	5032.71	0.11	KX	14	−4.52
26.01	Fe II	J	5035.71	0.61	KX	21	−4.79
26.01	Fe II	J	5061.72	0.22	KX	7	−5.06
26.01	Fe II	J	5070.90	0.24	KX	6	−5.16
26.01	Fe II	J	5075.76	0.28	KX	8	−4.95
26.01	Fe II	J	5082.23	−0.10	KX	5	−4.80
26.01	Fe II	J	5093.58	0.11	KX	11	−4.64
26.01	Fe II	J	5145.77	−0.40	KX	5	−4.49
26.01	Fe II	J	5149.46	0.40	KX	14	−4.76
26.01	Fe II	J	5150.49	−0.12	KX	9	−4.50
26.01	Fe II	J	5169.03	−0.87	MF	81	−4.89
26.01	Fe II	J	5199.12	0.10	KX	5	−5.08
26.01	Fe II	J	5203.64	−0.05	KX	6	−4.81
26.01	Fe II	J	5216.85	0.81	KX	17	−5.00
26.01	Fe II	J	5234.62	−2.05	MF	37	−5.02
26.01	Fe II	J	5247.95	0.55	N4	22	−4.55
26.01	Fe II	J	5260.25	1.07	KX	30	−4.84
26.01	Fe II	J	5272.40	−2.03	MF	14	−4.46
26.01	Fe II	J	5276.00	−1.94	MF	34	−5.21
26.01	Fe II	J	5291.67	0.58	KX	13	−4.94
28.01	Ni II	11	3849.55	−1.88	KX	9	−6.54
28.01	Ni II	11	4067.03	−1.29	KX	11	−7.03
38.01	Sr II	1	4215.52	−0.17	WM	21	−8.35
39.01	Y II	6	3950.35	−0.49	HL	21	−7.55
39.01	Y II	6	3982.59	−0.49	HL	19	−7.62
39.01	Y II	5	4422.58	−1.27	HL	7	−7.43
39.01	Y II	22	4854.86	−0.38	HL	12	−7.59
39.01	Y II	22	4900.12	−0.09	HL	24	−7.38
39.01	Y II	20	5119.11	−1.36	HL	4	−7.14
39.01	Y II	20	5200.41	−0.57	HL	14	−7.28
39.01	Y II	20	5205.72	−0.34	HL	20	−7.24
40.01	Zr II	16	3998.95	−0.67	GB	5	−7.91
40.01	Zr II	42	4161.21	−0.72	BG	15	−7.26
80.01	Hg II	–	3983.94	−1.73	DW	50	−5.39

lated with stellar rotation. If difussion is operating in the atmospheres, probably one should expect that abundance anomalies should decrease with increasing rotational velocity. In fact, CP stars are rarely found having rotational velocities larger than $\sim$120 km s^{-1}. Finding a trend or its absence will be important in the context of the diffusion theory, which is the best explanation today for the spectroscopic characteristics of CP stars.

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TABLE 11

LINE ABUNDANCES OF HR 8937

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$	Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	$W_{\rm eq}$	$\log(N/N_T)$
6.01	C II	4	3918.97	−0.53	WF	19	−3.21	24.01	Cr II	43	5308.44	−1.81	MF	20	−5.61
6.01	C II	4	3920.68	−0.23	WF	24	−3.27	24.01	Cr II	43	5310.70	−2.28	MF	8	−5.63
12.00	Mg I	2	5172.68	−0.38	WS	15	−5.01	24.01	Cr II	43	5313.59	−1.65	MF	19	−5.82
12.00	Mg I	2	5183.60	−0.16	WS	22	−5.02	24.01	Cr II	43	5334.87	−1.56	KX	19	−5.90
12.01	Mg II	5	3848.21	−1.59	WS	25	−4.51	25.00	Mn I	2	4030.75	−0.47	MF	27	−4.98
12.01	Mg II	10	4390.57	−0.53	WS	35	−4.88	25.00	Mn I	2	4033.06	−0.62	MF	47	−4.26
12.01	Mg II	9	4427.99	−1.21	WS	11	−4.80	25.00	Mn I	2	4034.48	−0.81	MF	19	−4.86
14.01	Si II	1	3853.66	−1.44	LA	69	−4.59	25.00	Mn I	5	4035.72	−0.19	KX	10	−4.80
14.01	Si II	1	3856.02	−0.49	LA	122	−4.76	25.00	Mn I	5	4041.35	0.29	MF	26	−4.71
14.01	Si II	1	3862.59	−0.74	LA	103	−4.76	25.00	Mn I	22	4414.89	−0.29	MF	7	−4.51
14.01	Si II	3.01	4075.45	−1.40	SG	17	−4.52	25.00	Mn I	16	4754.04	−0.09	MF	12	−4.72
14.01	Si II	3.01	4076.78	−1.67	SG	17	−4.23	25.00	Mn I	21	4761.51	−0.14	MF	5	−4.74
14.01	Si II	3	4128.05	0.38	LA	145	−4.27	25.00	Mn I	21	4765.85	−0.08	MF	11	−4.45
14.01	Si II	3	4130.89	0.53	LA	128	−4.56	25.00	Mn I	21	4766.42	0.10	MF	11	−4.62
14.01	Si II	5	5041.02	0.29	SG	90	−4.44	25.00	Mn I	16	4783.43	0.04	MF	15	−4.72
15.01	P II	15	4602.07	0.74	WS	11	−5.37	25.01	Mn II	I	3859.21	−2.56	KX	10	−4.80
16.01	S II	44	4153.07	0.62	WS	4	−5.13	25.01	Mn II	I	3878.99	−1.71	KX	40	−4.61
16.01	S II	44	4162.66	0.78	WS	7	−4.96	25.01	Mn II	I	3917.32	−1.15	KX	35	−4.65
16.01	S II	9	4815.55	0.18	WM	5	−5.17	25.01	Mn II	I	3952.42	−1.50	KX	15	−4.53
20.01	Ca II	1	3933.66	0.13	WM	232	−5.93	25.01	Mn II	I	3986.58	−2.60	KX	18	−4.41
22.01	Ti II	34	3900.54	−0.45	MF	47	−6.76	25.01	Mn II	I	3995.31	−2.44	KX	17	−4.65
22.01	Ti II	34	3913.46	−0.53	MF	49	−6.65	25.01	Mn II	I	4000.05	−1.21	KX	31	−4.31
22.01	Ti II	87	4028.34	−1.00	MF	16	−6.70	25.01	Mn II	I	4081.44	−2.24	KX	32	−4.02
22.01	Ti II	105	4163.64	−0.40	MF	30	−6.55	25.01	Mn II	I	4087.91	−2.91	KX	9	−4.51
22.01	Ti II	19	4294.09	−1.11	MF	36	−6.44	25.01	Mn II	I	4110.62	−1.51	KX	34	−4.68
22.01	Ti II	41	4300.04	−0.77	MF	54	−6.22	25.01	Mn II	I	4140.44	−2.46	KX	18	−4.50
22.01	Ti II	41	4301.92	−1.16	MF	16	−6.90	25.01	Mn II	I	4184.45	−1.95	KX	28	−4.38
22.01	Ti II	41	4312.86	−1.16	MF	26	−6.58	25.01	Mn II	I	4200.27	−1.74	KX	39	−4.28
22.01	Ti II	19	4395.03	−0.66	MF	47	−6.58	25.01	Mn II	2	4205.38	−3.38	KX	57	−4.25
22.01	Ti II	61	4395.84	−2.17	MF	6	−6.34	25.01	Mn II	I	4240.39	−2.07	KX	29	−4.25
22.01	Ti II	51	4399.77	−1.27	MF	16	−6.75	25.01	Mn II	7	4244.25	−2.39	KX	37	−4.10
22.01	Ti II	40	4417.71	−1.43	MF	16	−6.62	25.01	Mn II	2	4260.46	−4.25	KX	19	−4.49
22.01	Ti II	19	4443.80	−0.70	MF	37	−6.81	25.01	Mn II	I	4377.74	−2.14	KX	22	−4.73
22.01	Ti II	19	4450.48	−1.45	MF	13	−6.76	25.01	Mn II	I	4391.96	−2.89	KX	7	−4.58
22.01	Ti II	31	4468.49	−0.60	MF	37	−6.89	25.01	Mn II	I	4393.38	−2.32	KX	20	−4.61
22.01	Ti II	115	4488.32	−0.82	MF	11	−6.48	25.01	Mn II	I	4403.51	−1.80	KX	20	−4.58
22.01	Ti II	31	4501.27	−0.75	MF	33	−6.85	25.01	Mn II	I	4478.64	−0.95	KX	49	−4.51
22.01	Ti II	50	4533.96	−0.77	MF	51	−6.28	25.01	Mn II	I	4497.94	−2.59	KX	10	−4.74
22.01	Ti II	41	4563.76	−0.96	MF	31	−6.63	25.01	Mn II	I	4500.54	−2.07	KX	15	−4.77
22.01	Ti II	82	4571.97	−0.53	MF	47	−6.47	25.01	Mn II	I	4503.20	−2.16	KX	19	−4.55
22.01	Ti II	59	4657.20	−2.15	MF	9	−6.17	25.01	Mn II	I	4689.55	−2.54	KX	15	−4.22
22.01	Ti II	92	4779.98	−1.37	MF	9	−6.53	25.01	Mn II	I	4702.73	−2.34	KX	13	−4.49
22.01	Ti II	82	4805.09	−1.10	MF	13	−6.61	25.01	Mn II	I	4717.26	−1.86	KX	19	−4.56
22.01	Ti II	114	4911.20	−0.34	MF	9	−7.05	25.01	Mn II	I	4730.40	−2.15	KX	46	−4.03
22.01	Ti II	86	5185.90	−1.35	MF	22	−6.14	25.01	Mn II	I	4749.11	−2.00	KX	17	−4.64
22.01	Ti II	7	5188.69	−1.21	MF	14	−6.72	25.01	Mn II	I	4791.78	−1.72	KX	29	−4.56
24.01	Cr II	167	3865.60	−0.78	KX	25	−5.92	25.01	Mn II	I	4806.82	−1.56	KX	55	−4.30
24.01	Cr II	167	3905.64	−0.90	KX	43	−5.30	25.01	Mn II	I	4830.06	−1.85	KX	30	−4.41
24.01	Cr II	129	3911.32	−2.06	KX	9	−5.43	25.01	Mn II	I	4839.74	−1.86	KX	21	−4.65
24.01	Cr II	183	3979.50	−0.73	KX	15	−6.15	25.01	Mn II	I	4842.32	−2.01	KX	25	−4.38
24.01	Cr II	19	4051.93	−2.19	KX	9	−6.16	25.01	Mn II	I	5102.52	−1.93	KX	40	−4.08
24.01	Cr II	26	4072.56	−2.41	KX	11	−5.57	25.01	Mn II	I	5307.35	−2.07	KX	11	−4.39
24.01	Cr II	162	4145.78	−1.16	KX	16	−5.85	25.01	Mn II	I	3902.36	−2.72	KX	10	−4.59
24.01	Cr II	31	4261.91	−1.53	KX	46	−5.31	25.01	Mn II	I	3926.11	−2.42	KX	26	−4.08
24.01	Cr II	31	4275.57	−1.70	KX	28	−5.64	26.00	Fe I	45	3815.84	0.23	N4	19	−4.80
24.01	Cr II	44	4554.99	−1.38	MF	31	−5.76	26.00	Fe I	20	3825.88	−0.04	N4	20	−4.80
24.01	Cr II	44	4558.65	−0.66	MF	64	−5.51	26.00	Fe I	4	3859.91	−0.71	N4	14	−4.79
24.01	Cr II	39	4565.74	−2.11	MF	13	−5.63	26.00	Fe I	20	3865.52	−0.98	N4	18	−3.88
24.01	Cr II	44	4588.20	−0.63	MF	65	−5.50	26.00	Fe I	20	3872.50	−0.93	N4	12	−4.17
24.01	Cr II	44	4592.05	−1.22	MF	30	−5.94	26.00	Fe I	43	4071.74	−0.02	N4	12	−4.78
24.01	Cr II	44	4616.63	−1.29	MF	24	−6.06	26.00	Fe I	152	4198.30	−0.72	N4	8	−3.89
24.01	Cr II	44	4618.80	−1.11	MF	45	−5.65	26.00	Fe I	522	4199.10	0.16	N4	18	−4.01
24.01	Cr II	44	4634.07	−1.24	MF	39	−5.68	26.00	Fe I	42	4271.76	−0.16	N4	11	−4.74
24.01	Cr II	30	4812.34	−1.80	MF	11	−6.11	26.00	Fe I	41	4383.54	0.20	N4	19	−4.79
24.01	Cr II	30	4824.13	−1.22	MF	48	−5.55	26.00	Fe I	41	4404.75	−0.14	N4	16	−4.51
24.01	Cr II	30	4836.23	−2.25	MF	12	−5.61	26.00	Fe I	318	4920.50	0.07	N4	22	−3.90
24.01	Cr II	30	4848.23	−1.14	MF	31	−6.11	26.00	Fe I	289	4957.30	−0.41	N4	9	−3.90
24.01	Cr II	105	4876.40	−1.46	KX	35	−5.68	26.00	Fe I	318	4957.60	0.23	N4	9	−4.58
24.01	Cr II	30	4884.61	−2.08	MF	8	−5.94	26.00	Fe I	325	5192.34	−0.42	N4	8	−3.86
24.01	Cr II	43	5232.50	−2.09	KX	15	−5.50	26.00	Fe I	383	5232.94	−0.06	N4	17	−3.86
24.01	Cr II	23	5246.77	−2.45	MF	16	−5.29	26.00	Fe I	1146	5383.37	0.65	N4	12	−4.10
24.01	Cr II	43	5274.96	−1.29	KX	24	−6.01	26.00	Fe I	686	5586.76	−0.14	N4	8	−3.96

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TABLE 11 (CONTINUED)

Code	Species	Mult.	λ(Å)	$\log gf$	Ref.	W_{eq}	$\log(N/N_T)$
26.01	Fe II	127	3845.18	−2.29	KX	13	−4.82
26.01	Fe II	173	3906.04	−1.83	N4	28	−4.29
26.01	Fe II	38	3935.96	−1.86	N4	24	−4.37
26.01	Fe II	3	3938.29	−4.07	N4	13	−4.39
26.01	Fe II	90	3938.97	−1.85	N4	20	−4.34
26.01	Fe II	28	4122.67	−3.38	N4	20	−4.41
26.01	Fe II	27	4233.17	−1.81	N4	83	−4.02
26.01	Fe II	27	4273.33	−3.34	N4	20	−4.36
26.01	Fe II	28	4296.57	−3.01	N4	33	−4.32
26.01	Fe II	27	4303.18	−2.61	N4	57	−4.01
26.01	Fe II	27	4351.77	−2.08	N4	50	−4.74
26.01	Fe II	J	4357.58	−2.10	KX	9	−4.45
26.01	Fe II	27	4385.39	−2.57	N4	45	−4.37
26.01	Fe II	27	4416.83	−2.60	N4	40	−4.49
26.01	Fe II	37	4472.93	−3.53	N4	13	−4.38
26.01	Fe II	37	4489.18	−2.97	N4	31	−4.34
26.01	Fe II	37	4491.40	−2.70	N4	36	−4.46
26.01	Fe II	38	4508.29	−2.21	N4	50	−4.53
26.01	Fe II	37	4515.34	−2.48	N4	42	−4.51
26.01	Fe II	37	4520.22	−2.60	N4	38	−4.54
26.01	Fe II	38	4522.63	−2.03	N4	56	−4.55
26.01	Fe II	38	4541.52	−3.05	N4	28	−4.35
26.01	Fe II	37	4555.89	−2.29	N4	51	−4.44
26.01	Fe II	38	4576.34	−3.04	N4	26	−4.40
26.01	Fe II	37	4582.84	−3.10	N4	22	−4.48
26.01	Fe II	38	4583.84	−2.02	N4	69	−4.15
26.01	Fe II	D	4596.02	−1.84	N4	18	−4.24
26.01	Fe II	38	4620.52	−3.28	N4	20	−4.35
26.01	Fe II	37	4629.34	−2.37	N4	50	−4.39
26.01	Fe II	186	4635.32	−1.65	N4	29	−4.20
26.01	Fe II	28	4666.76	−3.33	N4	18	−4.37
26.01	Fe II	43	4731.45	−3.13	N4	22	−4.41
26.01	Fe II	J	4908.15	−0.30	KX	10	−4.17
26.01	Fe II	J	4913.29	0.01	KX	14	−4.32
26.01	Fe II	J	4951.58	0.18	KX	18	−4.32
26.01	Fe II	J	4977.04	0.04	KX	17	−4.16
26.01	Fe II	J	4984.47	0.01	KX	12	−4.33
26.01	Fe II	J	4990.51	0.18	KX	15	−4.41
26.01	Fe II	J	4993.36	−3.65	MF	7	−4.55
26.01	Fe II	J	5001.96	0.90	KX	44	−4.25
26.01	Fe II	J	5004.20	0.50	KX	24	−4.43
26.01	Fe II	J	5015.75	−0.05	KX	24	−3.86
26.01	Fe II	J	5018.44	−1.22	MF	102	−3.99
26.01	Fe II	J	5021.59	−0.30	KX	6	−4.44
26.01	Fe II	J	5022.79	−0.02	KX	19	−4.17
26.01	Fe II	J	5030.63	0.40	KX	21	−4.44
26.01	Fe II	J	5035.71	0.61	KX	31	−4.32
26.01	Fe II	J	5045.11	−0.13	KX	9	−4.38
26.01	Fe II	J	5061.72	0.22	KX	16	−4.41
26.01	Fe II	J	5067.89	−0.20	KX	8	−4.35
26.01	Fe II	J	5070.90	0.24	KX	18	−4.36
26.01	Fe II	J	5075.76	0.28	KX	15	−4.44
26.01	Fe II	J	5082.23	−0.10	KX	9	−4.39
26.01	Fe II	J	5093.58	0.11	KX	22	−4.01
26.01	Fe II	J	5097.27	0.31	KX	31	−3.95
26.01	Fe II	J	5106.11	−0.28	KX	13	−4.02
26.01	Fe II	J	5117.03	−0.13	KX	8	−4.41
26.01	Fe II	J	5145.77	−0.40	KX	12	−3.92
26.01	Fe II	J	5149.46	0.40	KX	28	−4.09
26.01	Fe II	J	5150.49	−0.12	KX	12	−4.18
26.01	Fe II	J	5160.84	−2.64	KX	10	−4.03
26.01	Fe II	J	5169.03	−0.87	MF	106	−4.26
26.01	Fe II	J	5180.31	0.04	KX	5	−4.77
26.01	Fe II	J	5199.12	0.10	KX	21	−4.03
26.01	Fe II	J	5203.64	−0.05	KX	16	−4.07
26.01	Fe II	J	5216.85	0.81	KX	28	−4.45
26.01	Fe II	J	5223.26	−0.41	KX	7	−4.17
26.01	Fe II	J	5228.90	−0.30	KX	12	−3.99
26.01	Fe II	J	5232.79	−0.06	KX	16	−4.07
26.01	Fe II	J	5234.62	−2.05	MF	57	−4.22
26.01	Fe II	J	5247.95	0.55	N4	31	−4.08
26.01	Fe II	J	5251.23	0.42	N4	30	−3.98
26.01	Fe II	J	5254.93	−3.23	KX	13	−4.44
26.01	Fe II	J	5257.12	0.03	KX	12	−4.30
26.01	Fe II	J	5260.25	1.07	KX	46	−4.25
26.01	Fe II	J	5272.40	−2.03	MF	18	−4.09
26.01	Fe II	J	5276.00	−1.94	MF	52	−4.51
26.01	Fe II	J	5291.67	0.58	KX	37	−3.95
26.01	Fe II	J	5306.18	0.09	N4	23	−3.87
26.01	Fe II	J	5339.59	0.54	KX	30	−4.11
26.02	Fe III	4	4419.60	−2.22	KX	3	−4.35
38.01	Sr II	1	4215.52	−0.17	WM	81	−6.30
39.01	Y II	6	3950.35	−0.49	HL	52	−6.51
39.01	Y II	6	3982.59	−0.49	HL	54	−6.45
39.01	Y II	14	4124.90	−1.50	HL	29	−6.29
39.01	Y II	5	4235.73	−1.50	HL	34	−6.26
39.01	Y II	5	4422.58	−1.27	HL	35	−6.49
39.01	Y II	22	4854.86	−0.38	HL	37	−6.81
39.01	Y II	22	4900.12	−0.09	HL	59	−6.18
39.01	Y II	20	4982.13	−1.29	HL	19	−6.53
39.01	Y II	20	5200.41	−0.57	HL	48	−6.15
39.01	Y II	20	5205.72	−0.34	HL	54	−6.10
39.01	Y II	20	5289.82	−1.85	HL	10	−6.35
40.01	Zr II	17	3915.96	−0.82	KX	6	−7.86
40.01	Zr II	16	3958.23	−0.31	KX	15	−7.85
40.01	Zr II	30	3991.15	−0.25	KX	16	−7.77
40.01	Zr II	16	3998.95	−0.67	GB	16	−7.45
40.01	Zr II	41	4149.22	−0.03	BG	24	−7.69
40.01	Zr II	41	4208.98	−0.46	BG	13	−7.70
80.01	Hg II	–	3983.94	−1.73	DW	128	−4.06

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