

Abundance analysis of SB2 binary stars with HgMn primaries

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Abstract. We present a short review of the abundances in the atmospheres of SB2 systems with Mercury-Manganese (HgMn) primaries. Up to now a careful study has been made for both components of 8 out of 17 known SB2 binaries with orbital periods shorter than 100 days and mass ratio ranging from 1.08 to 2.2. For all eight systems we observe a lower Mn abundance in the secondary's atmospheres than in the primary's. Significant difference in the abundances is also found for some peculiar elements such as Ga, Xe, Pt. All secondary stars with effective temperatures less than 10000 K show abundance characteristics typical of the metallic-line stars.

Key words: Stars: binaries: spectroscopic – Stars: abundances

1. Introduction

The study of abundances in atmospheres of SB2 systems with peculiar components may provide constraints on the origin of the abundance anomalies. It is natural to believe that both components in a binary system with a period less than 100 days form from the same protostellar cloud, therefore their initial abundances have to be identical. Any observed difference and its dependence on the mass and/or atmospheric parameters of the star may show us the development of abundance anomalies during stellar evolution. Among peculiar stars, the highest frequency of binary systems is observed for the non-magnetic HgMn and metallic-line (Am) stars. We give here a short review of the atmospheric abundances in SB2 binary stars with HgMn primaries.

2. The main characteristics of SB2 binary stars

There are 15 SB2 systems in Lebedev's catalogue (Lebedev 1987) whose primaries belong to the HgMn group. For two other systems, α And and κ Cnc, orbital elements are presented in poster papers of this conference. An abundance analysis of both components is carried out for eight SB2 HgMn binary stars. Their main orbital parameters are presented in Table 1, while atmospheric parameters, masses and radii are given in Table 2. Masses and radii were estimated using mass ratios and evolutionary tracks by Schaller et al. (1992).

Table 1. Orbital parameters of SB2 HgMn stars

	α And	κ Cnc	112 Her	46 Dra	ι CrB	AR Aur	HR 4072	ξ Lup
P(days)	97	6.39	6.36	9.81	35.5	4.13	11.6	15.3
e	0.53	0.14	0.12	0.20	0.56	0.01	0.26	0.00
i	105	81	16	17	3	88	40	72
m_A/m_B	2.0	2.2	1.98	1.12	1.5	1.14	1.67	1.42

Table 2. Spectroscopic parameters, masses, and radii of SB2 HgMn stars

Star	T_{eff}	$\log g$	$v \cdot \sin i$	M(M_{\odot})	R(R_{\odot})	Synchron.
α And A	13800	3.86	51.	3.8	2.7	no
B	8500	4.20	110.	1.85	1.65	no
κ Cnc A	13200	3.81	6.	4.5	5.0	subsynchron.
B	8500	4.00	40.	2.1	2.4	subsynchron.
112 Her A	13100	4.21	6.	3.9	3.3	yes
B	8500	4.20	8.	2.0	2.1	yes
46 Dra A	11700	4.11	5.	3.3	3.3	yes
B	11100	4.11	5.	2.9	2.7	yes
ι CrB A	11250	3.75	≤ 0.5	3.5	3.8	subsynchron.
B	9250	4.00	≤ 0.5	2.3	2.3	subsynchron.
AR Aur A	10950	4.33	23.	2.5	1.78	yes
B	10350	4.28	23.	2.3	1.82	yes
HR4072 A	10900	4.07	≤ 2.0	2.8	2.4	subsynchron.
B	8900	4.20	≤ 2.0	1.7	1.7	subsynchron.
ξ Lup A	10650	3.90	0.	3.0	3.2	subsynchron.
B	9200	4.20	2.	2.1	2.0	subsynchron.

The positions of the stars on a $\log g$ - T_{eff} plot are shown in Fig. 1 with evolutionary tracks overlaid. Filled circles refer to the primaries, the size of the circle being proportional to the T_{eff} of the primary.

3. Chemical abundances of the components

The reader can find a complete set of abundances in the atmospheres of the SB2 components in the following papers: ι CrB A, B (Adelman, 1989), HR 4072 A, B (Adelman, 1994), χ Lup A, B (Wahlgren et al., 1994), 112 Her A, B (Ryabchikova et al., 1996), and 46 Dra A, B (Adelman et al., 1998). For AR Aur we used equivalent widths and atmospheric parameters from Khokhlova et al. (1995), and recalculated abundances with WIDTH9. For α And A, B and for κ Cnc B we used results of the preliminary abundance analysis presented in this conference.

Table 3 gives the abundances of some elements from He to Ba and Pt-Au-Hg in the atmospheres of the primaries, while the abundance data for the

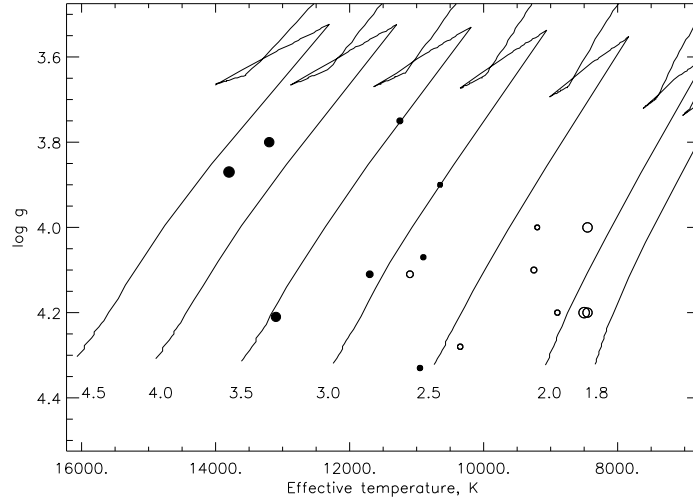


Figure 1. Position of the components of SB2 HgMn primaries (filled circles) and secondaries (open circles) on the $\log g - T_{\text{eff}}$ plot. Evolutionary tracks are shown by solid lines. The size of the circle is proportional to the T_{eff} of the primary

secondaries are shown in Table 4. As a comparison, we give abundances in the hot Am star θ Leo with $T_{\text{eff}}=9250$ K (Adelman, 1988) in the last column of Table 4. Data on Ga abundance for ι CrB A, HR 4072 A, and ξ Lup A are taken from Smith (1996), and those on Hg in HR 4072 A, ξ Lup A, and θ Leo are taken from Smith (1997). The platinum abundance was recalculated using gf-values from Dworetsky et al. (1984), and the gold abundance in the optical region was recalculated with the real (not assumed) gf-values from Rosberg & Wyart (1997).

4. Conclusions

- Abundances in the atmospheres of SB2 systems may differ significantly even when both stars have practically equal masses
- A comparison of the abundances in α And, κ Cnc, and 112 Her shows that the observed peculiarities do not correlate with the orbital periods or eccentricities
- In three hot primaries of practically equal temperatures, a violation of the odd-even effect in Mn-Fe is observed in non-synchronized systems
- The gallium abundance drops by about 1.5 dex within a narrow temperature range 11300-11600 K. It follows from the paper by Smith (1996) and it is

Table 3. Abundances in the atmospheres of SB2 primaries (log N/H)

Species	α AndA	κ Cnc A	112HerA	46 DraA	ι CrB A	AR AurA	HR4072A	χ LupA	Sun
He I	-2.00	-2.00	-2.43	-2.00	-1.82	...	-1.46	-1.68	(-1.01)
C II	-3.88	-3.97	-5.36:	-3.92	-4.07	-2.72	-3.23	-3.46	-3.43
O I	...	-3.23	-3.36:	-3.71	...	...	...	-3.48	-3.14
Mg II	-4.98	-5.00	-5.56	-4.70	-4.84	-4.46	-4.57	-4.55	-4.42
Al I	...	...	...	...	...	-6.15	-6.42	-6.18	-5.53
Al II	...	...	-6.42:	...	...	...	-6.85	...	-5.53
Si II	-4.38	-4.48	-5.05	-4.82	-4.51	-4.24	-4.53	-4.33	-4.45
P II	-4.80	-4.73	-4.71	-5.11	-5.69	...	-5.54	-5.68	-6.55
P III	-4.83	-4.77	-4.80	...	...	...	...	...	-6.55
S II	-5.48	-5.56	-5.84	...	-4.79	<-4.70	-4.64	-4.36	-4.67
Ca I	...	...	-4.55:	...	...	...	-5.24	-5.98	-5.64
Ca II	-5.00	-5.67	...	-5.49	-5.07	-6.14	-4.80	-6.78	-5.64
Sc II	...	-8.37	-9.06:	-8.89	...	<-8.50	-8.40	-10.28	-8.90
Ti II	-6.70	-6.82	-6.30	-6.73	-6.72	-6.26	-6.16	-6.54	-7.01
V II	...	-7.60	...	-7.93	-7.56	-7.76	-8.68	-8.13	-8.00
Cr II	-6.00	-6.42	-6.50	-6.38	-6.01	-5.82	-5.62	-6.18	-6.26
Mn I	...	-4.39	-4.74	-5.33	-5.14	...	-5.51	-6.78	-6.45
Mn II	-3.80	-4.10	-4.91	-5.14	-5.11	-5.08	-5.38	-6.38	-6.45
Fe I	-4.13	-4.49	-3.55	-4.08	...	-3.86	-4.00	-4.30	-4.52
Fe II	-4.18	-4.57	-3.60	-4.15	-4.44	-3.82	-4.08	-4.34	-4.52
Fe III	...	-4.44	-3.66	-3.91	-4.32	...	-3.97	...	-4.52
Ni II	...	-6.18	-6.07	-6.29	-6.62	-6.93	-6.62	-6.08	-5.75
Ga II	-4.63	-4.75	-5.27	-5.21	-7.60	...	-7.30	-7.35	-9.12
Sr II	-8.08	-8.54	-8.57:	-8.00	-7.20	-6.79	-6.49	-7.03	-9.10
Y II	-8.20:	-8.33	-8.04:	-7.91	-7.41	-7.14	-6.56	-8.08	-9.76
Zr II	-7.50:	...	-7.74	-7.58	-7.52	-7.59	-8.04	-8.88	-9.40
Xe II	-4.88	-4.75	-5.78	-5.68	...	...	...	...	(-9.77)
Ba II	...	...	...	-9.05	<-8.42	-8.97	-9.14	-8.78	...
Pt II	...	...	...	-6.93	-6.80	-4.97	-5.91	-6.23	-10.2
Au II	...	...	...	-6.80	...	...	-6.64:	-6.69	-10.99
Hg I	...	...	...	...	-6.02	...	-5.71	-5.86	(-10.91)
Hg II	-6.00:	-6.00	-6.00	-5.80	-6.01	-6.25	-5.28	-5.60	(-10.91)

supported by the abundances in 46 Dra. The only exception is HR 7775, which has $T_{\text{eff}}=10650$ K and a high gallium abundance

- There is no correlation between Hg abundance in the primaries and their atmospheric parameters, masses or orbital parameters, which supports the same conclusion made by Smith (1997)
- The detailed study of the atmospheres of HR 4072 B and 112 Her B shows that their abundance pattern is similar to abundances in Am and roAp stars. The only feature which allows to classify both secondaries as Am stars is the Co/Ni ratio: $[\text{Co}/\text{Ni}] \approx -1.0$ in HR 4072 B, 112 Her B and in Am stars, while $[\text{Co}/\text{Ni}] \approx 0.5$ in all roAp stars with detailed abundance analysis
- In view of the similarity of the abundances of the main elements in the atmospheres of the secondary stars with $T_{\text{eff}} < 10000$ K, it seems to be possible to classify them as Am stars

Table 4. Abundances in the atmospheres of SB2 secondaries (log N/H)

Species	46 DraB	AR AurB	ι CrB	χ LupB	HR4072B	112HerB	α And B	κ Cnc B	θ Leo
He I	-1.78	...	...	...	...	...	...	...	-1.22
Mg I	-4.63	...	-4.88	-4.66	-5.12	-5.04	...	...	-4.53
Mg II	-4.58	-4.35	...	-4.66	-4.64	-5.25	-4.42	-4.42	-4.66
Si I	...	...	...	-5.09	-5.37	-5.38	...	...	...
Si II	-4.55	-4.21	...	-4.56	-5.18	...	-3.91	-4.45	-4.46
Ca I	-5.47	...	...	-6.28	-6.45	-5.83	-6.26	-5.70	-5.76
Ca II	-5.55	-6.28	...	...	...	...	-5.96	-5.70	-5.57
Sc II	-9.69	...	...	-9.67	-10.07	-9.36	...	...	-9.27
Ti II	-6.48	-6.67	...	-6.93	-7.06	-6.79	-6.90	...	-6.95
Cr I	-5.88	...	-6.32	-6.29	-6.19	-5.98	-5.96	...	-6.31
Cr II	-5.95	-5.79	...	-6.09	-6.16	-5.94	-5.96	...	-6.32
Mn I	-5.68	...	...	-6.70	-6.51	-5.97	-6.10	...	-6.70
Mn II	-6.11	-5.67	...	-6.63	-5.97	-6.00	...	...	-6.31
Fe I	-4.09	-4.03	-4.41	-4.47	-4.51	-4.44	-4.20	-4.20	-4.52
Fe II	-4.20	-4.05	...	-4.51	-4.54	-4.45	-4.30	-4.20	-4.43
Co I	...	...	...	...	-7.09	-6.42	...	...	-6.95
Ni I	...	...	...	...	-5.46	-5.18	...	...	-5.35
Ni II	...	-5.16	...	-5.42	-5.45	-5.05	≤ -5.50	...	-5.34
Ga II	≤ -7.20	...	...	...	...	...	...	...	...
Ba II	-9.06	-8.05	...	-7.67	-7.45	-8.08	-8.75	-8.70	-8.50
La II	...	...	...	...	-10.13	-9.73	...	...	-9.88
Ce II	...	...	...	...	-9.37	-8.62	...	...	-9.05
Pr II	...	...	...	...	...	-9.08	...	...	...
Nd II	...	...	...	...	-9.62	-8.81	...	...	-9.62
Sm II	-8.98
Eu II	-10.49	...	-10.75	-10.45
Gd II	-9.34	-9.84
Pt II	-5.72	-5.74
Au II	-6.33
Hg I	-5.96
Hg II	-5.50	-9.50

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