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ABUNDANCES OF HEAVY ELEMENTS IN CP STARS

K. SADAKANE
Astronomical Institute, Osaka Kyoiku University
Asahigaoka, Kashiwara-shi, Osaka, Japan 582

ABSTRACT Recent determinations of abundances of heavy elements in CP stars are examined. An emphasis is placed on those elements which are found in a group of CP stars but not in others. Fragmentary data are available for most of heavy elements. Systematic surveys (especially in the UV region) using a large sample of stars are needed before we understand the physics of the apparently erratic behavior of heavy elements in CP stars.

INTRODUCTION

Heavy elements (defined as those elements with Z>40) have intrinsically low abundances in stellar atmospheres and they occasionally show surprizing anomalies in some groups of CP stars or in some specific objects. Absorption lines of these heavy elements show large variations in their strengths even among a single group of CP stars. For example, the Hg II line at 3984 Å is strong in many so-called Hg-Mn stars, while the line is absent in some stars like 53 Tauri which is considered to belong to the same group. Absorption lines of Bi II, one of the heaviest element ever found, can be seen only in two stars HR 7775 (Jacobs and Dworetsky 1982) and in HR 465 (Cowley 1987 and Fuhrmann 1989b). These erratic behaviors of heavy elements present us a puzzle, and no systematic interpretation has been established so far.

One reason for this difficulty may be the scarcity in available observational data, or incompleteness in the sampling. This is partly explained by the difficulty in deriving reliable abundances for heavy elements because of the intrinsic weakness of lines of these elements and also by the lack of accurate data of transition probabilities. In spite of these difficulties, abundances of heavy elements found on surfaces of CP stars may provide some keys or boundary conditions in our understanding of the time dependent history of stellar surfaces during the main sequence lifetime of early type stars. Thus, a systematic survey of heavy elements in CP stars is one of the important works to be done by observers of CP stars.

My interest here is focused on abundances of those heavy elements which are well known in some groups of CP stars but not yet fully explored in others. For example, the line of Hg II at 3984 Å is analyzed in many Hg-Mn stars, while the line is analyzed in only a few stars of other types such as magnetic Ap stars. On the other hand, lines of many rare-earth elements are identified in spectra of magnetic stars, while only a little is known about these elements in Hg-Mn stars. Do these reflect the true difference in abundances of heavy elements between different groups or merely a result of a selection effect? If the former interpretation is the case, it may give quantitative constraints on theories because some different groups of CP stars occupy nearly the same domain on the H-R diagram. In other words, abundances of heavy elements can play a role of test particles in testing various theories which explain the origin of abundance anomalies in CP stars.

In the following, I will summarize published data on heavy elements focusing mainly on recent results. Detections of lines of rare-earth elements in Hg-Mn stars are discussed. Finally, I will explore to some extent the abundances of Hg in magnetic stars.

SUMMARY OF PUBLISHED RESULTS

Actinides

In this section, we summarize published data on heavy elements in CP stars starting from the heaviest one. A comprehensive summary on the status of identifications of actinides in spectra of CP stars can be found in Severny (1986) and I discuss these elements only briefly. Cowley et al. (1976) analyzed high resolution optical region spectra of 51 stars including Hg-Mn, magnetic, and Am-Fm stars using the Wavelength Coincidence Statistics (WCS) method. They tried to detect lines of transuranic ($Z \geq 90$) actinides in these stars but not obtained definitely positive results. Cowley et al. (1977) examined high dispersion spectrograms of several magnetic stars and discussed lines of U II ($Z=92$) and Th II ($Z=90$) in them. Cowley and Arnold (1978) discussed the identification of U II in HR 465. They noted the feature seen at 3859.6 Å in this star at the rare-earth-maximum phase is most probably due to U II. They also noted the second candidate for the identification of U II is HD 221568 (Osawa's star). Cowley and Rice (1981) and Rice (1988) further discussed on the spectrum of HR 465 at its rare-earth-maximum phase.

Severny and Lyubimkov (1986) pointed out the presence of an U II line in the UV spectrum of the Ap stars 73 Dra observed with the photoelectric scanner on the Astron space station. They concluded an overabundance of U in this star. Iliev et al. (1986) verified an overabundance of U in 73 Dra analyzing the U II line in the visible spectrum, while Wahlgren et al. (1989) questioned the identification of the U II line in the UV region. The matter of detecting the absorption lines of actinides in spectra of CP star appears to be somewhat controversial still now except for a few stars.

Bi and Pb

Bi ($Z=83$) is the heaviest element definitely confirmed in stellar spectra up to now. The element was discovered by Jacobs and Dworetsky (1982) in the Hg-Mn star HR 7775 using ultraviolet high resolution spectra obtained with the *IUE* satellite. They concluded an overabundance of Bi by a factor of 10^6 in this star. Cowley (1987) and Fuhrmann (1989b) identified lines of Bi II in the magnetic star HR 465 using IUE spectra. Since then no other star has been claimed for the presence of Bi II lines. I examined IUE spectra of a dozen of Hg-Mn stars for the Bi II lines noted in Jacobs and Dworetsky (1982) but could not find any positive evidence. Thus, the Bi II lines appear only in exceptional cases.

An absorption line of the second heaviest element Pb ($Z=82$) is confirmed in the UV region (at λ 2203.53 Å) in the hot Am star α CMa (Sadakane 1991). A detailed analysis of this line showed an overabundance of Pb (+3.0 dex) in this star. Severny (1986) pointed out overabundances of Pb in 73 Dra and in the Hg-Mn star κ Cnc from analyses of the Pb II line at 2203.53 Å. Faraggiana (1989) analyzed the same line in 4

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magnetic stars and overabundances of Pb were suggested in HD 188041 and HD 201601. However, quite an incomplete survey has been done for this element so far.

Hg

The abundances of Hg (Z=80) have been analyzed in many Hg-Mn stars. Since the discoverey of the Hg II line at 3984 Å by Bidelman (1962), the line in Hg-Mn stars has been extensively analyzed (eg. Cowley and Aikman 1975 and White et al. 1976). Takada-Hidai and Jugaku (1992) analyzed the Hg II line at 6149.475 Å in the Hg-Mn star μ Lep and obtained the abundance of Hg in this star which is consistent with the abundance deduced from the 3984 Å line. The line is blended with an Fe II line at 6149.238 Å which is one of the pair of Fe II lines used in detecting a magnetic field in the Am star o Peg by Mathys and Lanz (1990). Takada-Hidai and Jugaku (1992) argued that the line pair should not be used in examining the magnetic field in Hg-Mn stars with large Hg anomalies. Leckrone (1984) analyzed the resonance lines of Hg II in the UV region in 6 Hg-Mn stars and in the magnetic star α^2 CVn using IUE spectra. Recently, Leckrone et al. (1991) carried out a detailed analysis of the resonance line of Hg II at 1942 Å in the Hg-Mn star χ Lup. They used amazingly high resolution and high S/N ratio data obtained with the Goddard High Resolution Spectrogragh (GHRS) on the Hubble Space Telescope and confirmed the isotopic anomaly of Hg in χ Lup.

Presently, the Hg II line at 3984 Å is reported in only a few magnetic stars and no data have been published for its abundance except for α^2 CVn reported in Leckrone (1984). The Hg II line at 3984 Å is identified in magnetic stars HD 192913 (Jaschek and Lopez Garcia 1966), HD 200311 (Adelman 1974) and suggested in HD 43819 (Adelman 1985b). Sadakane (1992) confirmed the Hg II line at 3984 Å in the Co type peculiar star HR 1094. This star is an interesting object because it shows lines of Cl II and Co II, which are found in only a few CP stars. The only Am star in which Hg has been confirmed is α CMa. Sadakane et al. (1988) analyzed the Hg II line at 1942 Å and concluded an overabundance of Hg (+1.3 dex) in this star.

Au and Pt

No data on the abundance of Au (Z=79) has been reported so far. Dworetsky (1971) discussed identifications of Au II lines in the optical region spectra of two Hg-Mn stars HR 4072 and χ Lup. He suggested three weak lines at λ 3804.05 Å, 4016.04 Å, and at 4052.76 Å in these two stars are most probably due to Au II. Cowley and Aikman reported the presence of at least 10 Au I and Au II lines in HR 7775 (van den Bergh 1979). Fuhrmann (1989a) discussed the identification of a Au II line at λ 1740.52 Å in IUE spectra of 3 Hg-Mn stars and 2 magnetic stars. Both optical and UV lines of Au II are quite weak and quantitative abundance analyses of these lines are difficult because of serious blends. Data of high resolution and high S/N ratio are needed to overcome the difficulty.

Lines of Pt II (Z=78) in the optical region spectra of Hg-Mn stars were first identified by Dworetsky (1969) in HR 4072. Dworetsky and Vaughan (1973) analyzed Pt II lines in two Hg-Mn stars HR 4072 and χ Lup and showed that Pt II lines in the former star were affected by isotopic splitting while those in the latter were not. Guthrie (1984) obtained abundances of Pt in 6 relatively cool Hg-Mn stars and upper limits in other 6 hotter stars. He pointed out that cooler Hg-Mn stars have significantly higher abundances of Pt than hotter stars. Abundances of Pt in Hg-Mn stars are also obtained by Adelman (1989) in ι CrB and HR 8349, by Adelman and Philip (1990) in χ Lup, and by Adelman (1988a) in 28 Her. Sadakane (1992) obtained the abundance of Pt in the Co type star HR

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1094. Dworetsky et al. (1984) analyzed two Pt II lines in the UV region and obtained abundances of Pt in 3 Hg-Mn stars (χ Lup, HR 4072, and HR 7775). They showed that Pt are overabundant in these stars by a factor of 10^6. Fuhrmann (1989a,b) discussed Pt II lines in the UV region spectra of Hg-Mn stars and in magnetic stars. Cowley (1977) surveyed Pt II lines in magnetic stars and concluded positive identifications in 7 stars. He noted that a Pt anomaly can occur in both the magnetic and nonmagnetic sequences. A quantitative discussion on abundances of Pt in magnetic stars is premature because no abundance data has been published.

Os and W

Lines of Os (Z=76) are found in only a few stars. Hartoog et al. (1973) demonstrated the presence of Os II in HR 465 based on a WCS analysis. Bord and Davidson (1982) pointed out the presence of Os II lines in the UV spectrum of the Hg-Mn star κ Cnc. They estimated the abundance of Os in this star to be overabundant by a factor of 10^4. Cowley (1987) discussed Os I and Os II lines in the UV spectrum of α^2 CVn.

Hensberge et al. (1986) demonstrated the presence of lines of W II (Z=74) in the UV spectrum of α^2 CVn using the WCS method. Severny (1986) concluded overabundances of W in κ Cnc and 73 Dra. Sadakane (1991) analyzed 3 lines of W II near 2000 Å in α CMa and suggested that W might be slightly underabundant in this star.

Results of recent determinations of elements heavier than W are summarized in Fig. 1. Relative abundances [X], defined as [X] = *log* X(star)/X (Sun), are plotted against the atomic number (Z).

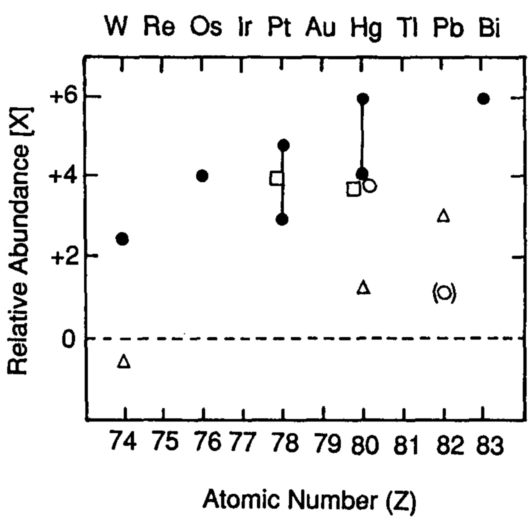

Fig. 1. Abundances of elements heavier than W. Filled circles, open circles and open triangles are for Hg-Mn stars, magnetic stars, and Am stars, respectively. Open squares represent HR 1094. The open circle in parentheses at Pb shows the suggestion by Faraggiana (1989) for two magnetic stars. For Hg-Mn stars, ranges in abundances of Pt and Hg which are given in Takada-Hidai (1991) are shown.

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Rare Earths

There are many review articles on abundances of rare-earth elements (REEs) in CP stars (Jaschek and Jaschek 1974, Hack 1976 and 1981, Bonsack and Wolff 1980, and Wolff 1983). Cowley (1984) extensively discussed the observed abundance patterns and gave element by element summaries for lanthanides. Here, I mention only a few recent results on REEs. It has been often supposed that Am stars have lower abundances of the REEs than in magnetic stars (Fig. 5 in Cowley 1984). Magazzu and Cowley (1986) determined abundances of 6 REEs in two cool magnetic stars γ Equ and 10 Aql and in an Am star 32 Aqr. They found that abundances of lantanides in these cool magnetic stars are comparable with those in 32 Aqr. Abundances of REEs in the Am star HR 178 were determined by van't Veer et al. (1988). Adelman (1984a) reanalyzed the cool Ap star HD 8441 and found considerably lower abundances of REEs compared to those obtained in his earlier work (Adelman 1973). Ryabchikova and Ptitsyn (1986) derived abundances of Eu in 3 magnetic stars HD 2453, HD 8441, and HD 192913.

Identification works of the third spectra of REEs are carried out mainly in the UV region. Hensberge et al. (1986) identified Yb III (Z=70) lines in the UV spectrum of α^2 CVn. Cowley and Greenberg (1987) discussed the presence of Er III lines in the UV spectrum of HR 465 observed with the IUE satellite. Cowley and Greenberg (1988) also surveyed lines of doubly ionized REEs in UV spectra of 5 magnetic stars. The severe blending in the UV region and the limited resolution hamper quantitative analyses of faint lines of these interesting ions. In the optical region, Muthsam and Cowley (1984) identified lines of Nd III in HD 168733 and Mathys and Cowley (1992) discovered lines of Pr III in many magnetic stars.

Only a few data of abundances of REEs in Hg-Mn stars are available. Guthrie (1985) examined high resolution optical region spectra of 8 Hg-Mn stars and found lines of Pr II (Z=59) and Nd II (Z=60) in HR 7775. He noted that no lines of REEs could be found in other 7 stars. Adelman et al. (1984) and Adelman (1984b) obtained abundances of Yb in Hg-Mn stars ν Cnc and υ Her, respectively. Adelman (1989) obtained abundances of La in the Hg-Mn star ι CrB and those of Gd in HR 8349, ι CrB, and in ν Cnc. Adelman (1991) obtained abundances of REEs in 2 A-type stars θ Leo and o Peg.

Recent determinations of abundances of REEs in CP stars are summarized in Fig. 2. Data of magnetic stars are taken from Magazzu and Cowley (1986), Adelman (1984a), and from Ryabchikova and Ptitsyn (1986). Those of Am stars are taken from Magazzu and Cowley (1986) and van't Veer et al. (1988). Data of Hg-Mn stars are from Adelman et al. (1984), Adelman (1984b), and Adelman (1989). When the range of abundances of each REEs given in Adelman (1973) (magnetic stars) and in Smith (1971) (Am stars) are overplotted on this figure, we notice that the degree of overabundance reduced significantly in both groups. These changes are caused by improvements in the effective temperature scale and also in the quality of observational data.

Fig. 3 shows a comparison in the frequency of detection for each REE in magnetic stars and in Hg-Mn stars. The sample of magnetic stars contains 26 objects which are taken from Adelman (1974 and 1984a), Cowley (1976), Cowley et al. (1977) (HD 101065), and from Magazzu and Cowley (1986). Data of Hg-Mn stars (total 17 stars) are taken from Guthrie (1985), Adelman (1984b, 1987, 1988b, and 1989), and from Adelman et al. (1984). We can see that the frequencies of detection are much lower in Hg-Mn stars than in magnetic stars. This apparent difference can be partly explained by the difference in effective temperatures between the two groups. As an example, expected strengths (in mÅ) of the La II line at 3988.52 Å are plotted against the effective temperature for four

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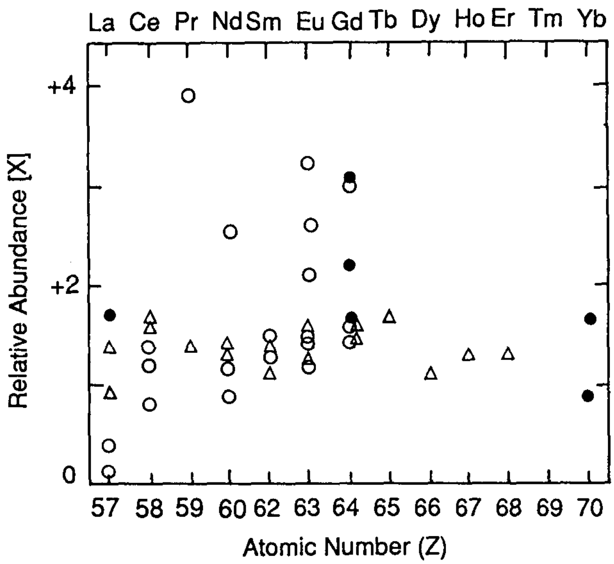

Fig. 2. Abundances of rare earth elements. Only recent results are shown. Symbols are the same as in Fig. 1.

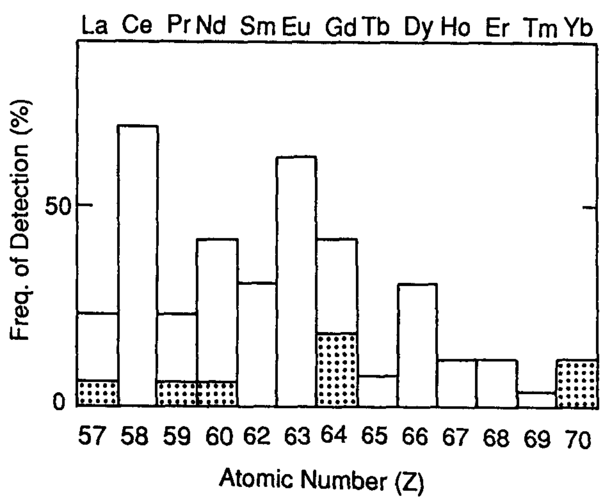

Fig. 3. Frequency of detection of lines of REEs. Data of magnetic stars are shown by white columns and those of Hg-Mn stars are shown by shaded columns.

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abundances of La in Fig. 4. The line weakens very rapidly as the temperature becomes higher. When we assume rather arbitrarily the limit of detection to be at 5 mÅ, the line can be detected at 9000 K for the solar abundance of La. While at 12000 K, the line can be detected only when La is overabundant by 2.3 dex or more. Nearly the same dependence on the temperature can be found for lines of other REEs, too. Thus, it is extremely difficult to measure equivalent widths of REEs lines even in the coolest Hg-Mn stars unless these elements are overabundant by more than 2 dex. The upper limit of the equivalent width of the La II line in α CMa measured on the spectral atlas published by Kurucz and Furenlid (1979) is plotted on Fig. 4. The equivalent width in o Peg taken from Adelman (1988a) is also plotted. Overabundances of La are suggested in these hot Am stars.

In addition to the effective temperature, several factors such as the rotational velocity, $v \sin i$, spectral resolution and S/N ratio affect the frequency of detection for weak lines. Thus it is necessary to compare high quality spectra of the coolest Hg-Mn stars and magnetic stars which have nearly the same effective temperatures at around 10,000 K before we have quantitative conclusions.

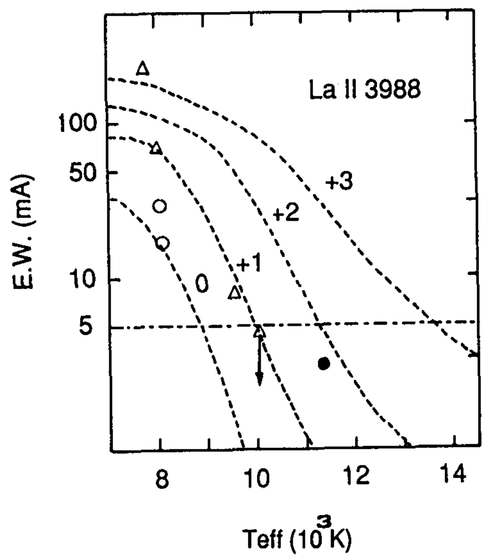

Fig. 4. Comparison of measured and computed equivalent width of the La II line at 3988 Å. Equivalent widths are plotted against the effective temperature. Computations are carried out using log $g = 4.0$ model atmospheres for 4 abundances of La (+3.0, +2.0, +1.0, and the solar abundance). Several recent measurements are shown by the same symbols as in Fig. 1. The open triangle with a downward arrow shows the upper limit for α CMa.

Ba and Lighter Elements

Cowley (1976) carried out an extensive survey of the resonance line of Ba II (Z=56)

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at 4554.03 Å for 29 magnetic and Am stars. He pointed out that the resonance line is absent in some hot magnetic stars and the abundances of Ba are highly variable among CP stars. Ryabchikova and Ptitsyn (1986) and Ryabchikova and Piskunov (1988) determined abundances of Ba in two magnetic stars HD 2453 and HD 8441 and in the Hg-Mn star ϕ Her, respectively. Adelman (1989) obtained upper limits of Ba abundances in 6 Hg-Mn stars.

There has been a wide void in our knowledge of abundances for those elements with Z smaller than 55 and only very fragmentary data are available. Abundances of Xe (Z=54) are obtained in 3 Hg-Mn stars. Heacox (1979) analyzed Xe II lines in 3 stars (κ Cnc, HR 7245, and HR 7361) and concluded large (from +4.3 to + 5.0 dex) overabundances of Xe in them. Adelman (1987) and Ryabchikova and Smirnov (1988) analyzed Xe II lines in κ Cnc, and overabundances of Xe by 4.5 dex and 4.0 dex, respectively, were obtained.

Sadakane (1991) analyzed UV lines of Cd II (Z=48) and Mo II (Z=42) in α CMa and suggested over- and underabundances of Cd and Mo, respectively. However, the reliability of available data of transition probability has to be checked before we have convincing conclusions. Guthrie (1982) discussed the variability of lines of REEs and Mo II and Nb II (Z=41) in the extreme Ap star HR 465. Lines of these elements were very strong in the visual spectrum of this star in 1960. Quite recently, Leckrone et al. (1992) reported an identification of lines of Ru II (Z= 44) in the UV spectrum of the Hg-Mn star χ Lup using high resolution data obtained with the HST. They obtained an overabundance (+2.3 dex) of Ru in this star. It is very important to obtain high resolution spectroscopic data in the satellite UV region to fill the gap between Z = 41 and 55.

THE HG II LINE AT 1942 Å IN MAGNETIC STARS

As noted above, the abundance of Hg has been determined only in one magnetic star (α^2 CVn). While the Hg II line at 3984 Å has been detected in several magnetic stars, no abundance data has been derived from this line. This is due to the weakness of the line and further because the line is seriously affected by blending lines in magnetic stars. Here, I report some preliminary results on a survey of the resonance line of Hg II at 1942 Å in magnetic stars. The region around 1942 Å in 13 magnetic stars are examined using IUE data. As an illustration, data of two magnetic stars (α^2 CVn and HD 125248) are compared with those of Hg-Mn stars (HR 2844 and HR 4072) and normal stars (π Cet (B7V) and ν Cap (B9V)) in Fig. 5. Features seen at 1942.3 Å in these magnetic stars are slightly weaker than in Hg-Mn stars but they are definitely stronger than the corresponding features in normal stars. Similar strengths of the 1942.3 Å feature can be found in 9 out of the 13 magnetic stars examined. In order to obtain quantitative estimations, measured equivalent widths of the 1942.3 Å feature in magnetic stars are compared with those in Hg-Mn stars and in normal stars in Fig. 6. Only upper limits can be given for some magnetic stars and for normal stars. Logarithmic equivalent widths (in Å) are plotted against the effective temperature. Effective temperatures of Hg-Mn stars and of normal stars are the same as those used in Takada-Hidai et al. (1986). For magnetic stars, we use averaged effective temperatures obtained in the optical region given in Adelman (1985a), Adelman (1982) (HD 192913), and Adelman (1983) (HD 215441). The effective temperature of α^2 CVn is taken from Leckrone (1984). Equivalent widths of the Hg II resonance line are computed for 5 abundances of Hg relative to the solar system value using line-blanketed model atmospheres with log g = 4.0.

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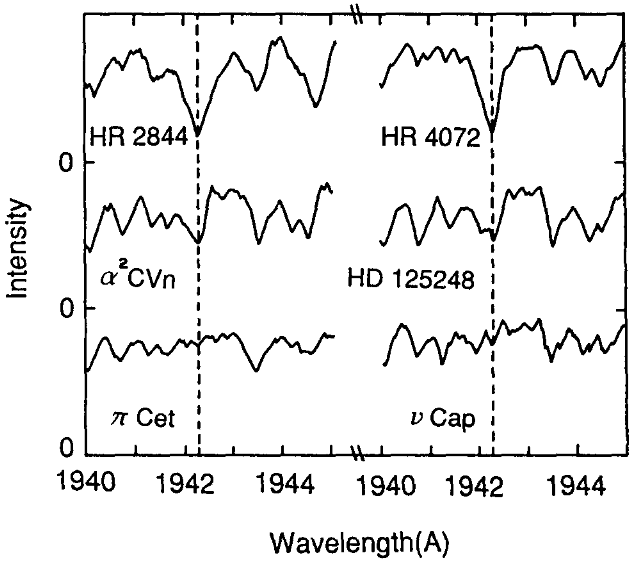

Fig. 5. Comparison of the feature at 1942.3 Å. Spectra of two magnetic stars (middle) are compared with Hg-Mn stars (top) and normal stars (bottom). Left and right panels compare stars having nearly the same effective temperatures. Vertical broken lines show the position of the Hg II resonance line at 1942.28 Å.

Although the line consists of 11 isotopic components (Leckrone 1984), it is treated as a single line here for simplicity. The data of transition probability (log gf = -0.31) for the Hg II line is taken from Dworetsky (1980). We assume the classical damping constant and use the microturbulent velocity, $\xi = 2$ km s^{-1}. Expected equivalent widths for each abundance are plotted on Fig. 6 by broken lines.

We can guess preliminary abundances of Hg in our target stars from this diagram. Results obtained from this figure are compared in TABLE I with the abundances in 6 stars given by Leckrone (1984). His results are based on spectrum synthesis analyses of individual stars and include isotopic components explicitly. We can find a fairly good agreement for 5 Hg-Mn stars and the abundances of Hg deduced from Fig. 6 for these stars are slightly (0.2 dex on the average) less than those given in Leckrone (1984). On the other hand, we find an overabundance of Hg which is larger by 1.1 dex than that found by Leckrone for α^2 CVn. This difference most probably can be accounted for by the omission of blending lines in measureing the equivalent width in this star. Most of these blending lines are due to ionized iron peak elements which are known to be overabundant in magnetic stars (Leckrone 1984). Thus, abundances of Hg in magnetic stars obtained from Fig. 6 might be overestimated by around 1.0 dex. Exact evaluations

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of blending components to the feature in individual stars are beyond the scope of the present discussion because data of abundances for blending species are unavailable for most of the magnetic stars. However, we can conclude from Figures 5 and 6 that Hg is overabundant in many magnetic stars. Quantitatively, the degree of overabundances in magnetic stars is less enhanced than in Hg-Mn stars. We estimate Hg is overabundant by around 2 dex in magnetic stars on the average, taking the effect of blending lines into account. Detailed analyses of the feature using the spectrum synthesis technique are needed to obtain accurate abundances in individual stars. The expected equivalent width of the Hg II line at 3984 Å for +2.0 dex is smaller than 1 mÅ and is well below the detection limit. It is natural that virtually no data of abundance of Hg in magnetic stars has been obtained from the line.

TABLE I Abundances of Hg from the 1942 A line

star	T_{eff} (10^3 K)	W_λ (A)	[X][1]	[X][2]
κ Cnc	13.3	0.20	+4.7	+4.9
μ Lep	12.8	0.25	+4.9	+5.2
ι CrB	11.0	0.20	+4.5	+4.7
χ Lup	10.7	0.24	+4.7	+5.0
HR 4072	10.5	0.41	+5.1	+5.2
α^2 CVn	12.1	0.12	+4.0	+2.9
21 Per	10.4	0.14	+4.1	
41 Tau	13.5	0.06	+2.6	
HD 32633	13.1	0.21	+4.7	
HR 1732	15.8	<0.02	<+1.3	
53 Cam	9.4	0.10	+3.4	
15 Cnc	10.4	0.09	+3.3	
HD 125248	10.0	0.11	+3.5	
HR 5597	11.4	0.08	+3.2	
4 Cyg	12.8	<0.02	<+1.0	
HD 192913	10.6	0.10	+3.5	
HD 215441	17.0	0.14	+4.7	
108 Aqr	13.3	0.05	+2.2	

1 Abundance of Hg obtained from Fig. 6 relative to the solar system value.

2 Relative abundance of Hg determined by Leckrone (1984) using the spectrum synthesis technique.

Finally, I want to make a brief comment on the 1942 Å feature in 3 stars 53 Tau, 20 Tau, and HR 2676. These stars are included in the group of Mn stars and usually discussed together with Hg-Mn stars. We can find a very weak feature at 1942.3 Å in these stars and only upper limits can be given (15 mÅ). Then, estimated upper limits of the abundances of Hg in them are around +1.0 dex, which are comparable to those

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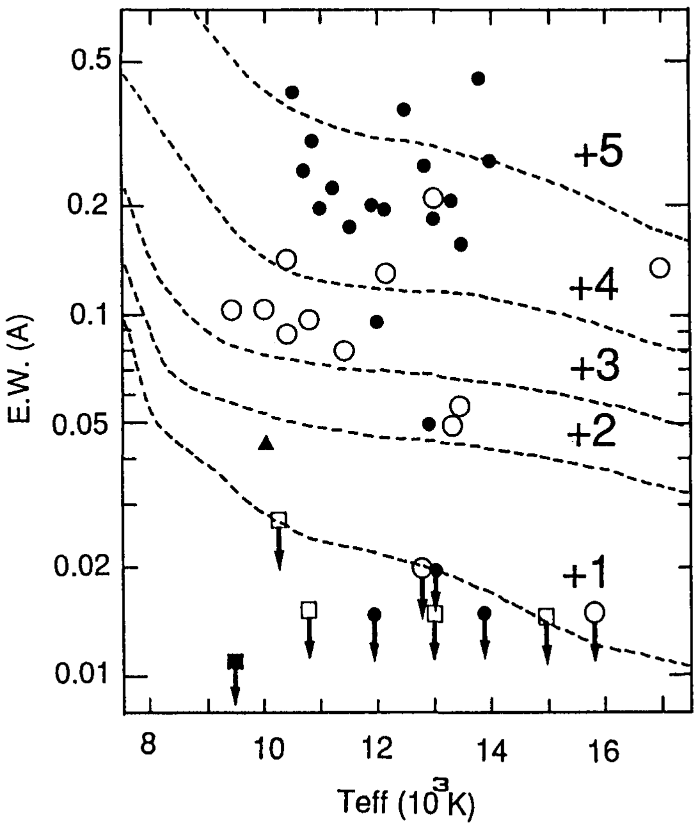

Fig. 6. Comparison of measured and computed equivalent widths of the Hg II resonance line at 1942.3 Å. Equivalent widths are plotted against the effective temperature. Computations were carried out for 5 (+5.0, +4.0, +3.0, +2.0 and +1.0) abundances of Hg with respect to to solar system value. Filled and open circles are for Hg-Mn stars and for magnetic stars, respectively. Open squares show normal stars. Data of α CMa and α Lyr are shown with a filled triangle and a filled square, respectively. Downward arrows show upper limits.

obtained in normal stars. This upper limit is smaller than that deduced from upper limits (5mÅ) of the Hg II line at 3984 Å by around 2.0 dex. For example, no detection of the the Hg II line at 3984 Å in 53 Tau (Adelman 1987) implies an upper limit of +2.9 dex in this star. The range in the abundance of Hg in the group of B-type non-magnetic stars (Hg-Mn and Mn group) is certainly larger than that given in Takada-Hidai (1991). To improve further the accuracy in the lower boundary in the Hg abundance among CP stars, high resolution spectroscopic data which can be obtained with the HST are urgently needed.

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