ELEMENTAL ABUNDANCES OF NORMAL SHARP-LINED B AND A STARS FROM OPTICAL REGION ANALYSES

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ABSTRACT. Optical-region elemental-abundance analyses were performed for ten sharp-lined main sequence B and A stars. The derived abundances are generally in good agreement with those of the Sun. Multiple high dispersion spectrograms, fully line-blanketed solar composition model atmospheres, optical spectrophotometry, and the most accurate gf values were employed. This study provides initial parameters for studies of these stars in the ultraviolet and a consistent set of values for comparison with abundances of more exotic stars.

1. OPTICAL REGION ANALYSIS TECHNIQUES

Elemental-abundance analyses using optical region data and fully line-blanketed solar composition model atmospheres (Kurucz 1979) have been performed in a consistent manner for ten sharp-lined normal B5 through A2 type stars (see Table I) (Adelman 1984, 1985). The effective temperatures and surface gravities were determined by comparison of model predictions with optical-region spectrophotometry consistent with the Hayes-Latham (1975) calibration of Vega and Hγ profiles, respectively. For each star the equivalent widths were measured on several spectrograms, which were for the most part 4.3 Å/mm IIa0 spectrograms obtained with the 2.5-m telescope of Mt. Wilson Observatory. Least-squares relations were derived to convert values derived from other types of spectrograms to this system. Microturbulent velocities were determined by minimizing the dependence of the equivalent widths of Fe I and Fe II lines on the derived abundances. Of order 20 lines is required to determine this quantity properly for each species. Fe I gf values based primarily on those of Blackwell and his collaborators (see, e.g., Blackwell et al. 1982) and Fe II gf values chosen to be as consistent as possible with them result in derived iron abundances which are in good agreement with solar values and in microturbulent velocities between 0.0 and 2.1 km s^{-1}, which are somewhat smaller than those found by previous investigators of similar stars (Baschek and Reimers 1969). When appropriate, corrections for non-LTE effects were made to the LTE abundances.

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2. THE RESULTS

Table I contains the abundances for each star, the mean abundances of the normal stars, and solar values, consistent with the adopted gf values, from the literature. The mean abundances are in good agreement with solar values for helium, carbon, neon, magnesium, silicon, sulfur, calcium (from Ca I lines), scandium, titanium, chromium, iron, and nickel. The Ca II K line yields smaller values than the Ca I lines by an average of 0.28 dex. The average aluminum abundance is 0.28 dex less than solar, but the stars with Al I lines present show a trend of values with the hottest stars having the solar value and the coolest stars sub-solar values. The mean vanadium and strontium abundances are, respectively, 0.41 and 0.23 dex greater than solar. This suggests possible gf value scale offsets between my studies and those of the Sun. The mean offset of 0.05 dex for those stars with abundances derived from both Fe I and Fe II lines may be partially due to systematic errors in the Fe II gf values, particularly, of those lines with lower excitation potentials of several electron volts. The differences in the abundances of yttrium and zirconium between θ Leo and the Sun are difficult to interpret as Y II and Zr II lines are definitely present in only one normal star.

3. RELATED PROGRAMS

Elemental abundance analyses of two hot Am stars and three HgMn stars have also been performed in a manner consistent with this study (Adelman, Young, and Baldwin 1984, Adelman 1985). Such studies illustrate the importance of similar normal-star analyses in finding the magnitudes of the anomalous abundances. Ultraviolet region elemental abundance analyses of one hot Am and five normal stars, o Peg, π Cet, 21 Aql, 134 Tau, ν Cap, and θ Leo, using IUE data are being performed in collaboration with Dr. David S. Leckrone, NASA Goddard Space Flight Center. The use of parameters derived from the optical region studies as starting values for the ultraviolet studies is an important technique in analyzing these relatively complex spectra. In addition optical region analyses of several other B, A, and early F stars are in progress.

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TABLE I. NORMAL STAR AND SOLAR ABUNDANCES

Species	τ Her log N/H	HR 2154 log N/H	HR 5780 log N/H	π Cet log N/H	21 Aql log N/H	5 Aqr log N/H	14 Cyg log N/H	134 Tau log N/H	ν Cap log N/H	θ Leo log N/H	Stellar log N/H	Mean n	The Sun log N/H
He I	-1.04	-1.12	-0.98	-1.09	-1.13	-1.12	-0.99	-1.13	-1.26	-1.00	-1.09	10	-1.07
C II	-3.48	-3.55	-3.59	-3.45	-3.61	-2.86	-3.26	-3.43	-3.40	...	-3.40	9	-3.33
N II	...	...	-3.40:	-3.87	-3.64	...	...	...	...	...	...	...	-4.01
O I	-2.71:	-3.17	...	-3.50	-3.27	...	...	-3.31	-3.04	-3.25	-3.26	6	-3.08
Ne I	-3.91	-4.06	...	...	-4.23	...	...	...	...	...	-4.07	3	-4.15
Na I	...	...	...	...	...	...	...	...	-5.12	-4.59	...	..	-5.68
Mg I	...	...	...	...	...	...	...	-4.13	-4.13	-4.42	-4.23	3	-4.38
Mg II	-4.15	-4.28	-4.15	-4.31	-4.34	-4.19	-4.29	-4.39	-4.11	-4.40	-4.26	10	-4.38
Al II	...	...	...	...	...	-5.57	-5.71	-5.88	-5.86	-5.91	-5.79	5	-5.51
Si II	-4.59	-4.52	-4.38	-4.40	-4.39	-4.08	-4.14	-4.59	-4.42	-4.28	-4.38	10	-4.37
Si III	-4.80	-4.48	-4.28	-4.05	...	...	...	...	...	...	-4.40	4	-4.37
S II	-4.67	-4.73	-4.58	-4.72	-4.71	...	...	...	...	...	-4.68	5	-4.77
Ca I	...	...	...	...	...	...	...	...	-5.76	-5.57	-5.66	2	-5.66
Ca II	-6.03	-5.68	-5.78	-5.93	-5.69	-5.87	-6.07	-6.09	-6.17	-6.12	-5.94	10	-5.66
Sc II	...	...	...	...	...	...	...	-9.20	-9.14	-8.98	-9.11	3	-8.96
Ti II	...	-5.92:	-6.87	-7.15	-7.19	-6.99	-6.89	-6.99	-6.82	-6.85	-6.97	8	-7.02
V II	...	...	...	...	...	...	...	-7.26	-7.54	-7.35	-7.38	3	-7.79
Cr I	...	...	...	...	...	...	...	-5.80	-6.02	-6.26	-6.03	3	-5.88
Cr II	...	...	-5.48	-5.72	-6.12	-5.60	-5.74	-5.83	-5.60	-5.82	-5.78	7	-5.88
Mn I	...	...	...	...	...	...	...	...	...	-6.59	...	..	-7.16
Mn II	...	...	...	...	...	...	...	...	...	-6.49	...	..	-7.16
Fe I	...	...	...	...	...	-4.30	-4.16	-4.29	-4.34	-4.25	-4.27	5	-4.37
Fe II	-4.60	-4.79	-4.56	-4.45	-4.46	-4.22	-4.38	-4.50	-4.23	-4.21	-4.38	8	-4.37
Ni I	...	...	...	...	...	...	...	...	...	-5.55	...	...	-6.70
Ni II	...	...	-6.80	-6.82	-6.99	-6.32	-6.39	-6.68	-6.39	-6.19	-6.57	8	-6.70
Sr II	...	...	...	...	...	...	-8.91	-9.20	-8.88	-8.49	-8.87	4	-9.10
Y II	...	...	...	...	...	...	-8.39:	...	...	-9.50	...	...	-9.76
Zr II	...	...	...	...	...	...	...	...	...	-8.57	...	...	-9.44
Ba II	...	...	...	...	...	...	...	...	-9.44	-8.99	...	...	-9.91

DISCUSSION

ADELMAN: The normal stars being analyzed in addition to those in this paper are HR 6559 and Eta Lep. The latter star is classified FO IV. Some of the offset in the average abundance of the ten normal stars and that of the Sun may be due to small systematic errors in the gf values. One way to demonstrate such a hypothesis would be to perform a differential analysis of Eta Lep and the Sun.

HEINTZE: How do your new effective temperatures agree with others?

ADELMAN: They agree rather well with the scale by Code and his collaborators.

JASCHEK: I am happy to see that someone is doing a whole series of stars along the main sequence, and I hope you will publish the line identifications.

ADELMAN: Although I am not publishing complete line identifications with these stars, I am publishing the equivalent widths of all the lines used in the analysis as well as those of other unblended lines for which at present good gf values do not exist. I am planning to include some normal stars in my current program of HgMn stars at Dominion Astrophysical Observatory.

SEGGEWISS: Could you briefly summarize the most important abundance differences between "normal" A and Am stars as deduced from your studies?

ADELMAN: The hot Am stars are 2-3 times solar iron-rich. Most of the major anomalies occur for elements heavier than the iron peak. Adelman, Young and Baldwin (1984 Mon. Not. R. Astron. Soc. 206, 649) give the analysis of these stars.