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LINE IDENTIFICATION OF THE Si STAR HD 87240

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RESUMEN

Se presentan las identificaciones de las líneas de la estrella peculiar tipo Ap Si HD 87240 ($\delta = -59^\circ\ 51'\ 00.1''$) en el intervalo espectral $\lambda\lambda$3710–5520. Este objeto es miembro del cúmulo abierto meridional NGC 3114. La comparación de este objeto con otras estrellas Ap Si del campo muestra que tienen en común muchas de las anomalías en sus líneas.

ABSTRACT

Line identifications are presented for the peculiar Ap Si star HD 87240 ($\delta = -59^\circ\ 51'\ 00.1''$) in the spectral region $\lambda\lambda$3710–5520. This object is a member of the southern open cluster NGC 3114. Comparison of this object with other field silicon stars shows that it shares many of their line anomalies.

Key Words: **STARS: CHEMICALLY PECULIAR – STARS: INDIVIDUAL: HD 87240**

1. INTRODUCTION

The identification of lines in stellar spectra is one of the basic operations in stellar spectroscopy. The main purpose of this task is to determine the element responsible for each observed spectral line. Today, complete identification studies in which one attempts to identify every absorption feature are rarely done and studies are badly needed. This research is part of our current program for producing line identification lists and elemental abundances among southern chemically peculiar (CP) stars. For this paper we selected the Si star HD 87240 (= NGC 3114 025), a member of the southern open cluster NGC 3114.

This peculiar star was classified as an B9p by Frye, Mc Connell, & Humphreys (1970), B8 IVp by Levato & Malaroda (1975), and finally as Ap by Houk, Cowley, & Smith-Moore (1975). HD 87240 is a silicon peculiar star (Levato & Malaroda 1975) or CP2 in the classification scheme of Preston (1974). *UBV* photoelectric photometry was published by Jankowitz & McCosh (1962) and Lynga (1959), *ubvy* photoelectric photometry has been provided by Houk et al. (1975) and the Hβ index was measured by Schmidt (1982). A radial valocity of 2.0 km s^{-1} has been determined by Amieux & Burnage (1981). The membership probability has been obtained to be 0.97 (Gonzalez & Lapasset 2001). HD 87240 is not an extremely low rotator. The $v \sin i$ value derived from our spectra is $\sim$ 15 km s^{-1}.

Not all of the lines of this study are fully resolved. For example, the Si I line λ3905.53 seems to be blended with the Cr II line λ3905.64. If the intensity of the line of one element is dominant, then the identification of the other line in the blend is less reliable. A line identification due purely to wavelength coincidence is not sufficient: is more trustworthy if the line is part of a multiplet where the other ionic transitions of that multiplet are also present. Conversely, if a line is the only observed component of a particular multiplet, its identification is questionable. We have found in our spectra many examples of blends.

2. OBSERVATIONAL MATERIAL

The spectra of HD 87240 were obtained by Saffe with the *Jorge Sahade* 2.15 m telescope at Complejo Astrónomico El Leoncito (CASLEO) equipped with a REOSC echelle spectrograph[5] and a TEK 1024×1024 CCD back-illuminated detector with a pixel size of 24μ × 24μ. Three spectra of the star were obtained covering the visual range $\lambda\lambda$3710–5520. The REOSC spectrograph uses gratings as

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[5] On loan from the Institut d´Astrophysique de Liege, Belgium.

TABLE 1

LINE LIST OF THE SI STAR HD 87240

λ[Å]	W_{eq}	Identification
3734.41	....	H13 34.37
48.73	.036	Cr II(11)48.68(7)
50.09	....	H12 50.15
55.58	.014	Fe II(154)55.56(4)
56.47	.011	(Sm II(44)56.41)
57.75	.038	Ti II(72)57.70(30)
58.19	.012	Fe I(21)58.23(150R)
59.36	.083	Ti II(13)59.29(12), Fe II(154)59.46(6)
61.90	.061	Ti II(107)61.88(15), Cr II(11)61.85(7)
70.62	....	H11 70.63
75.83	.038	
77.45	.030	
78.74	.046	Cr II(-)78.66(5)
79.09	.015	
79.59	.038	Fe II(23)79.58(p)
81.55	.036	Fe II(130)81.51(1)
83.40	.044	Fe II(14)83.35(4)
84.27	.015	Ce III(S)84.29(3000)
86.28	.051	Ti II(12)86.33(p)
97.93	....	H10 97.90
3813.44	.020	Ti II(12)13.39(5)
14.09	.038	Fe II(153)14.12(4)
14.60	.034	Ti II(12)14.58(6)
15.81	.032	Fe I(45)15.84(100r)
17.32	.024	
19.64	.048	Eu II(1)19.67(39000cw)
24.91	.044	Fe II(29)24.91(4)
35.33	....	H9 35.39
37.40	.058	
38.24	.039	Mg I(3)38.29(100)
48.26	.029	Mg II(5)48.29(7)
49.43	.046	(Ni II(11)49.58(2))
50.40	.019	Mg II(5)50.39(6)
52.50	.025	Gd II(2)52.45(1000)
52.62	.017	
53.64	.123	Si II(1)53.66(100h)
54.98	.023	(La II(55)54.91(30))
55.98	.207	Si II(1)56.02(500h)
62.54	.143	Si II(1)62.60(200h)
63.92	.027	Fe II(127)63.96(1), Fe II(152)63.95(1)
65.64	.056	Cr II(167)65.60(13)
66.06	.025	Cr II(130)65.99(3)
66.59	.026	Cr II(130)66.52(5)
67.21	.063	
67.93	.042	
68.50	.021	(Dy II(-)68.45(-))
69.31	.010	
69.56	.010	
72.81	.046	Fe II(29)72.76(p)

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
3889.00	....	H8 89.05
3900.54	.031	Ti II(34)00.56(12)
02.98	.013	Fe I(45)02.95(20)
03.74	.069	Fe II()3.75(0)
04.94	.048	
05.67	.072	Cr II(167)05.64(10)
06.09	.083	Fe II(173)06.04(5)
09.28	.021	Cr II(129)09.25(p)
10.57	.010	
10.84	.051	
11.51	.064	
12.28	.053	(Ni I(151)12.31(8n))
13.41	.041	Ti II(34)13.48(12)
14.52	.074	Fe II(3)14.48(2)
18.24	.058	(Ce II(12)18.28(200))
19.02	.099	C II(4)18.98(9)
20.09	.045	
20.71	.088	Fe II()20.64(0),CII(4)20.68(10)
24.83	.078	
25.61	.024	(Fe I(364)25.65(4))
25.94	.020	(Fe I(364)25.95(6))
30.36	.067	Eu II(5)30.50(32000cw)
33.69	.374	Ca II(1)33.66(400)
35.96	.040	Fe II(173)35.94(5)
38.35	.033	Fe II(3)38.29(2)
38.95	.037	Fe II(190)38.97(4)
40.32	.009	Ti II(97)40.32(p),(CeII(50)40.34(100))
40.89	.008	(Fe I(20)40.88(5)),(CoI(18)40.89(12))
42.18	.020	(Ce II()42.15(250))
45.18	.027	Fe II(3)45.21(p)
49.98	.005	Fe I(72)49.95(10)
53.67	.010	(Ce II(141)53.66(12))
54.50	.084	Si II(7.07)54.51(10)
60.84	.045	Fe II(212)60.90(3)
68.78	.057	Ca II(1)68.47(350R)
70.09	....	Hϵ 70.07
75.06	.094	Fe II(191)75.03(2)
76.58	.032	
77.78	.015	(Fe I(72)77.74(12))
79.59	.078	Cr II(183)79.52(7)
81.97	.034	Ti II(11)81.99(1)
83.09	.036	(Gd II(49)83.01(80))
83.70	.098	(Dy II()83.65(0))
83.99	.044	Hg II()83.94, Fe I(277)83.96(10)
87.68	.015	Ti II(11)87.61(5)
91.16	.011	Zr II(30)91.14(40)
94.17	.019	(Gd II()94.16(800))
94.93	.026	
95.36	.036	(Mn II(I)95.31(15H))

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
3997.36	.009	Fe I(278)97.39(15)
98.03	.036	Si II(20)98.01(10HH)
98.42	.014	
99.82	.009	
4000.48	.010	(Dy II(-)00.45(-))
02.51	.041	Cr II(166)02.48(3), Fe II(190)02.55(3)
03.38	.019	Cr II(194)03.28(9)
06.13	.033	
07.41	.014	(Nd II(-)07.43(50))
09.71	.032	Fe I(72)09.71(10)
10.77	.022	
12.51	.107	Ti II(11)12.40(15), Cr II(183)12.50(30), Fe II(126)12.47(1)
20.93	.019	(Co I(16)20.90)
21.39	.013	(Nd II(36)21.33(80))
21.92	.012	Fe I(278)21.87(12)
22.43	.032	Cr II(183)22.37(3)
26.40	.055	
24.58	.028	Fe II(127)24.55(5)
25.14	.032	Ti II(11)25.12(13)
28.35	.051	Ti II(87)28.36(12)
29.70	.025	Zr II(41)29.68(20)
30.34	.017	Cr II(19)30.34(2)
31.44	.023	Fe II(151)31.46(1)
32.93	.035	Fe II(126)32.95(3)
35.12	.018	(Sm II(33)35.11(250)
38.00	.036	Cr II(194)37.98(7)
38.62	.011	
41.64	.013	Fe II(172)41.64(p)
41.41	.011	(Mn I(5)41.36(50r))
42.56	.022	(Ce II(140)42.56(200))
43.97	.021	Fe II(172)44.01(p)
44.60	.014	(Fe I(359)44.61(6))
45.81	.034	Fe I(43)45.81(60r)
46.31	.011	
46.79	.038	Fe II(126)46.81(p)
48.71	.071	Zr II(43)48.68(25)
48.80	.046	Fe II(172)48.83(3)
49.87	.022	(Gd II(-)49.86(2000))
51.91	.031	Cr II(19)51.93(7)
53.85	.044	Ti II(87)53.83(11)
56.14	.038	Ti II(11)56.19(4), Cr II(182)56.07(4)
57.01	.072	(Si II(7.18)56.99(2h))
57.71	.056	(Fe I(729)57.66(4))
59.76	.035	(Fe I(767)69.73(3))
67.10	.054	Ni II(11)67.05(3)
69.89	.049	Fe II(188)69.88(1)
70.85	.026	Cr II(193)70.83(5)
72.67	.018	Si II(3.01)72.71(3h)
75.47	.057	Si II(3.01)75.45(20H), Cr II(19)75.62(1)
76.84	.059	Si II(3.01)76.78(15H), Cr II(19)76.85(3)

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4077.70	.049	Sr II(1)77.71(400r)
82.32	.022	Cr II(165)82.30(6)
4101.73	....	Hδ 01.74
11.04	.036	Cr II(18,26)11.01(6)
11.90	.024	Fe II(188)11.88(1)
13.24	.016	Cr II(18)13.24(5)
16.71	.018	Cr II(181)16.66(2)
17.05	.011	
19.50	.034	Fe II(21)19.53(p)
20.99	.024	Fe III(118)20.97(8)
21.48	.023	
22.59	.069	Fe II(28)22.64(4)
25.65	.016	
28.10	.151	Si II(3)28.07(300H)
30.84	.144	Si II(3)30.88(500H)
32.45	.040	Cl II(29)32.48(200), Cr II(26)32.41(7)
36.54	.020	
38.38	.016	Fe II(39)38.40(p)
43.46	.098	Fe I(523)43.42(15)
45.77	.057	Cr II(162)45.80(11)
47.38	.021	(Fe I(693)47.34(p))
48.06	.009	
49.22	.035	Zr II(41)49.22(75)
50.94	.032	Zr II(42)50.97(10)
51.05	.021	Cr II(163)51.00(5)
52.27	.044	
53.06	.022	S II(44)53.10(10)
53.91	.012	Fe I(695)53.91(10n)
54.52	.042	
55.25	.027	Sm II(8,50)55.21(100)
56.29	.018	Zr II(29)56.24(15)
61.05	.013	Cr II(162)61.08(2)
61.47	.020	Ti II(21)61.53(11)
61.83	.016	Sr II(3)61.80(30)
62.65	.013	S II(44,65)62.70(10)
63.65	.045	Ti II(105)63.64(19)
64.78	.017	Fe III(118)64.73(20)
65.08	.014	
67.01	.033	
70.80	.016	Cr II(181)70.84(2)
71.93	.045	Ti II(105)71.92(19), Cr II(18)71.91(3)
73.50	.070	Fe II(27)73.45(8), Ti II(21)73.53(13)
73.99	.019	S II(64)74.00(19), Ti II(105)74.05(13)
75.84	.028	
77.65	.059	Fe II(21)77.70(p)
78.90	.082	Fe II(28)78.86(8)
79.48	.038	Cr II(26)79.45(10)
80.71	.026	
81.00	.015	Fe II(148)80.97(p)
83.36	.037	Si II(7.26)83.34(10h)
....	....	...

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4184.30	.034	Ti II(21)84.33(9)
87.08	.049	Fe I(152)87.04(20)
87.55	.012	
87.79	.047	Fe I(152)87.79(20)
88.95	.016	Ti II(H)88.98(10)
90.04	.041	
90.73	.056	Si II(7.26)90.72(100h)
92.05	.010	Ni II(10)92.07(1)
95.35	.023	(Cr II(10)95.42(5)), (Fe I(693)95.34(5))
96.02	.029	
96.62	.008	Ti II(21)96.64(p)
98.17	.047	Si II(7.26)98.13(50)
4200.62	.120	Si II(7.06).66(30)
00.88	.101	Si II(7.06)00.89(40)
02.03	.026	Fe I(42)02.03(30)
05.00	.040	Eu II(1)05.05(6000cw)
05.52	.055	Fe II(22)05.48(p)
06.36	.011	Mn II(-)6.37(200)
13.50	.045	(S II(44)13.50(0))
13.07	.057	
15.50	.053	Sr II(1)15.52(300r)
18.16	.020	Ti II(33)18.18(p)
22.19	.023	Fe I(152)22.22(12)
23.03	.010	(Pr II()22.93(38000))
24.83	.022	Cr II(162)24.89(9)
24.49	.037	(Fe I(689)24.51(3n))
25.95	.024	
33.21	.090	Cr II(31)33.27(11), Fe II(27)33.17(11)
35.46	.023	Cl II(71)35.49(25)
36.71	.024	
42.40	.056	Mn II(-)42.33(100), Cr II(31)42.40(13)
43.32	.013	
46.42	.018	Cr II(31)46.41(2)
47.25	.016	
51.70	.036	Mn II(-)51.74(150), Gd II(15)51.73(1700)
52.62	.039	Cr II(31)52.65(7)
56.15	.029	Cr II(192)56.12(3)
59.34	.014	
61.92	.052	Cr II(31)61.92(6), Gd II(44)62.09(1600)
63.88	.043	Fe II(J)63.90(1)
67.18	.086	C II(6)67.27(20), C II(6)67.02(19)
68.97	.033	Cr II(192)68.88(2)
69.60	.037	
69.32	.010	Cr II(31)69.28(6)
71.78	.077	Fe I(42)71.76(35)
73.27	.054	Fe II(27)73.32(3)
75.53	.022	Cr II(31)75.60(10)
76.46	.031	
77.41	.022	(Zr II(40)77.37(4))
78.05	.036	Cr II(161)78.12(1)

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4282.46	.018	Fe I(71)82.41(12)
77.37	.039	
78.11	.056	Cr II(161)78.12(1), Fe II(32)78.13(1)
79.98	.037	
82.59	.014	S II(49)82.60(18)
84.23	.077	Cr II(31)84.21(9)
85.40	.033	
86.29	.046	Fe II(J)86.31(1)
87.85	.021	Ti II(20)87.89(13)
88.16	.030	
88.32	.017	
89.49	.035	(Ce II(135)89.45)
90.20	.072	Ti II(41)90.22(18)
94.08	.028	Ti II(20)94.09(19), Fe I(41)94.13(15)
94.43	.014	(S II(49)94.43)
95.37	.023	Cr II(37)95.37
96.56	.062	Fe II(28)96.57(6)
4300.09	.037	Ti II(41).06(19)
01.89	.046	Ti II(41)01.93(17)
03.19	.094	Fe II(27)03.17(8)
04.18	.053	
05.48	.023	Sr II(3)5.45(40)
07.71	.054	
12.22	.015	
12.88	.076	Ti II(41)12.87(17)
14.29	.052	Fe II(32)14.29(4)
15.03	.046	Ti II(41)14.96(17)
18.24	.012	Fe II(220)18.22(0N)
19.73	.024	Fe II(220)19.68(1n)
25.51	.031	(Gd II(103)25.57(200))
25.80	.066	Fe I(42)25.76(35), (Sc II(15)25.76(40))
26.68	.045	Mn II(-)26.63(500)
28.14	.017	
40.47	....	Hγ 40.47
51.77	.076	Fe II(27)51.76(9)
54.36	.049	Fe II(213)54.34(2n)
55.09	.054	
56.57	.082	(Mn II(-)56.62(80))
57.53	.052	Fe II(J)57.57(4)
61.31	.056	Fe II(-)61.25(2)
62.08	.029	Ni II(9)62.10(1)
69.39	.030	Fe II(28)69.40(2)
70.96	.027	(Zr II(79)70.96(8))
72.20	.020	Fe II(33)72.22(p)
73.57	.016	(Fe I(214)73.56(2))
74.89	.051	Ti II(93)74.84(14), Y II(13)74.94(300)
75.37	.015	Ti II(104)75.35(p)
76.79	.021	
....	....	...
....	....	...

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4377.30	.075	
81.75	.023	Fe II(9)81.79(p)
82.58	.045	
85.39	.101	Fe II(27)85.38(7)
86.87	.030	Ti II(104)86.85(13)
88.03	.046	(Ce II(5)88.01(8))
90.61	.040	Mg II(10)90.58(10)
91.04	.016	Ti II(61)91.04(10)
95.04	.071	Ti II(19)95.00(19)
95.81	.062	Ti II(61)95.83(11)
96.43	.009	
99.78	.042	Ti II(51)99.79(15)
4400.68	.016	Ti II(93)00.63(0)
01.44	.026	
02.92	.037	Fe II(-)2.88(p)
04.74	.060	Fe I(41)04.75(30)
06.88	.034	
08.44	.032	
09.46	.025	Ti II(61)09.51(8)
10.06	.024	
11.08	.039	Ti II(115)11.10(14)
13.63	.014	Fe II(32)13.60(0)
16.84	.061	Fe II(27)16.82(7)
17.67	.030	Ti II(40)17.72(17)
19.03	.020	Fe II(D)18.98(p)
19.54	.044	Fe III(4)19.59(10)
20.77	.020	Fe II(9)20.75(p)
21.95	.018	Ti II(93)21.95(1)
22.52	.017	(Fe I(350)22.57(6))
25.66	.017	
30.94	.024	Fe III(4)30.95(7)
31.69	.016	Fe II(222)31.63(1n)
35.20	.023	
37.58	.036	
41.95	.037	(Mn II(-)41.99(30))
43.78	.076	Ti II(19)43.78(16)
49.72	.030	Fe II(222)49.66(1n)
50.29	.058	
50.73	.053	Ce II(3)50.73(75)
51.54	.025	Fe II(J)51.54(4)
52.65	.020	
54.62	.021	
55.30	.064	Fe II(J)55.26(3)
55.88	.024	Fe II(140)55.85(p)
56.60	.043	Ti II(115)56.63(8
64.52	.037	Ti II(40)64.46(11)
65.39	.022	(Y II(81)65.40(10n))
66.52	.025	Fe I(350)66.55(12)
68.52	.076	Ti II(31)68.52(19)
71.72	.069	···

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4473.09	.076	
74.20	.028	Fe II(171)74.19(0n)
81.28	.083	Mg II(4)81.13,.33(100)
83.40	.017	S II()83.43(19)
84.22	.013	
85.17	.029	
86.62	.019	S II()86.64(16)
86.96	.017	(Ce II(57)86.91(150))
87.70	.009	
88.28	.035	Ti II(115)88.34(17)
89.21	.064	Fe II(37)89.18(4)
90.09	.007	
91.41	.056	Fe II(37)91.40(5)
93.57	.048	Ti II(18)93.53(5), Fe II(222)93.58(1n)
94.30	.017	
99.45	.023	(Sm II(23)99.47(0))
4501.21	.056	Ti II(31)01.27(15)
03.07	.032	
07.15	.017	Fe II(J)07.13(0n), Fe II(213)07.20(0)
08.31	.079	Fe II(38)08.28(8), Fe II(222)08.26(p)
11.83	.012	Cr II(191)11.82(p)
12.23	.011	
14.77	.015	
14.18	.047	
15.29	.089	Fe II(37)15.34(7)
18.34	.020	Ti II(18)18.35(6)
20.30	.087	(Fe II(37)20.22(7))
22.62	.094	Fe II(38)22.63(9), Eu II(4)22.57(3000)
24.91	.025	(S II(40)24.95(21))
26.55	.030	Fe II(171)26.58(p)
29.42	.062	Ti II(82)29.48(9)
30.56	.030	(La II(73)30.54)
33.92	.072	Ti II(50)33.97(15), Fe II(37)34.16(2)
40.91	.030	
41.48	.079	Fe II(38)41.52(4)
47.98	.027	
48.75	.020	
49.59	.092	Ti II(82)49.61(15), Fe II(38)49.47(10)
52.65	.100	Si III(2)52.62(9)
54.99	.048	Cr II(44)54.94(13)
55.92	.078	Fe II(37)55.89(8)
58.66	.072	Cr II(44)58.64(17)
63.76	.058	Ti II(50)63.77(16)
64.95	.012	
65.72	.035	Cr II(39)65.68(8)
66.62	.039	
71.91	.077	Ti II(82)71.96(19)
72.88	.027	
74.79	.031	Si III(2)74.77(4)
....	....	···

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4576.29	.063	Fe II(38)76.33(4)
77.77	.036	Fe II(54)77.78(p)
78.51	.018	
79.49	.059	Fe II(J)79.52(1)
80.20	.025	
82.84	.056	Fe II(37)82.84(3)
84.02	.095	Fe II(26)83.99(p)
87.29	.017	Cr II(J)87.26(2)
88.23	.089	Cr II(44)88.19(15)
89.88	.036	Ti II(50)89.92(15), Cr II(44)89.89(5)
91.10	.028	
92.07	.069	Cr II(44)92.05(10)
93.94	.025	Ce II(6)93.93(200)
96.00	.033	Fe II(J)96.02(10)
98.58	.028	Fe II(219)98.53(1n)
4601.47	.016	
06.45	.039	(Ce II(6)6.40(50))
18.85	.065	Cr II(44)18.78(10)
20.55	.059	Fe II(38)20.51(3)
21.55	.135	Si II(7.05)21.42,.72((100,150))
29.34	.075	Fe II(37)29.34(7)
31.93	.029	Fe II(219)31.90(0n)
32.68	.033	
34.12	.053	Cr II(44)34.11(12)
35.37	.054	Fe II(186)35.33(5)
36.67	.031	
38.11	.034	Fe II(J)38.11(p)
47.65	.036	
48.99	.018	Fe II(25)48.94(0)
49.82	.023	
62.69	.015	Ti II(38)62.74(p)
63.67	.033	Fe II(44)63.70(0)
65.79	.020	Fe II(26)65.80(p)
66.72	.047	Fe II(37)66.75(2)
73.24	.097	Si II(7.15)73.27(20)
78.84	.013	(Fe I(821)78.85(7))
80.44	.009	(Ce II(2)80.46(2))
96.10	.023	(Ce II(153)96.12(p))
97.25	.018	
4702.98	.049	Mg I(11)2.99(40)
14.11	.072	
15.08	.032	Cr II(178)15.12(1)
16.23	.064	S II(9)16.27(20)
31.39	.054	Fe II(43)31.44(3)
33.48	.021	
39.57	.043	Mg II(18)39.59(5)
55.69	.055	Mn II(-)55.73(200)
61.54	.026	
63.82	.021	Ti II(48)63.84(1)
64.57	.015	Ti II(48)64.54(1)

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4765.52	.028	
76.22	.013	Si II(25)76.20(3h)
79.98	.043	Ti II(92)79.98(1)
88.45	.026	
94.57	.028	Cl II(1)94.54(250)
98.29	.011	
98.58	.037	Ti II(17)98.53(7)
99.91	.048	(V II(29)99.94)
4805.11	.040	Ti II(92)05.09(13)
10.03	.086	Cl II(1)10.06(225)
12.32	.058	Cr II(30)12.36(6)
15.58	.027	S II(9)15.55(22)
17.74	.035	
19.78	.058	Si III(9)19.74(3n)
21.00	.060	Ti II(29)21.01(p)
24.15	.076	Cr II(30)24.12(12)
36.25	.052	Cr II(30)36.24(7)
40.50	.037	
45.60	.021	
46.42	.064	Fe II(25)46.47(p)
48.29	.062	Cr II(30)48.28(12)
61.32	....	Hβ 61.33
74.06	.021	Ti II(114)74.00(12)
76.38	.080	Cr II(30)76.43(12)
83.23	.037	Si II(24)83.20(15h), Fe II(J)83.28(4w)
84.55	.028	Cr II(30)84.57(10)
85.67	.013	S II(15)85.65(17)
88.02	.020	
4901.64	.023	Cr II(190)01.65(7)
03.30	.024	
04.73	.034	Cl II(17)04.76(135)
08.23	.044	Si II(34)08.18(5h)
11.16	.047	Ti II(114)11.18(14)
13.21	.063	
13.99	.035	(Ni I(132)13.97(3))
22.17	.058	
23.90	.093	Fe II(42)23.92(20)
25.27	.034	S II(7)25.35(19)
26.16	.028	
27.47	.045	(Fe IIII(43)27.56(0))
32.79	.091	Si II(33)32.80(20h)
42.48	.058	S II(7)42.47(16)
57.62	.035	
70.63	.040	
77.06	.089	Fe II(J)77.03(10)
77.91	.092	Fe II(J)77.92(4)
84.53	.066	Fe II(J)84.49(10)
90.54	.060	Fe II(J)90.50(11)
91.52	.048	...

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
4993.32	.044	Fe II(J)93.35(8)
95.86	.034	Ti II(71)95.89( )
5001.87	.075	Fe II(J)01.92(18w)
07.44	.045	Fe II(J)07.45(6)
16.16	.025	
18.05	.062	
20.98	.027	Fe II(J)20.01(4)
22.87	.027	Fe II(J)22.79(10)
23.77	.093	
27.50	.018	
28.14	.063	
31.03	.048	
30.60	.020	Fe II(J)30.64(11)
32.68	.072	Fe II(J)32.71(10)
34.00	.013	Fe II(J)33.96(4w)
36.90	.040	Fe II(36)36.92(2)
38.84	.015	
41.03	.152	Si II(5)41.03(1000)
50.85	.069	(Gd II(114)50.88(300))
52.97	.040	
54.60	.035	
55.97	.268	Si II(5)55.98(1000)
56.32	.080	Si II(5)56.31(30)
60.23	.039	Fe II(J)60.26(6)
61.74	.064	Fe II(J)61.72(9)
75.73	.084	Fe II(J)75.76(10)
77.78	.016	
78.27	.044	Cl II(16)78.25(150)
80.93	.024	
81.39	.023	
82.24	.050	Fe II(J)82.23(9)
86.30	.055	Fe II(J)86.31(7)
87.23	.031	Fe II(J)87.26(9w)
89.19	.052	Fe II(J)89.22(9)
90.79	.017	
93.59	.059	Fe II(J)93.56(9)
97.26	.074	Cr II(24)97.29(7), Fe II(J)97.27(10)
98.89	.034	
5100.68	.114	Fe II(J)00.73(18w)
06.16	.051	Fe II(J)06.11(8)
07.68	.065	
10.04	.022	
10.47	.036	Cr II(199)10.43(-)
12.19	.018	Fe II(J)12.17(4)
13.01	.053	Fe II(J)12.99(7)
15.10	.036	Fe II(J)15.06(6)
16.02	.011	Cr II(24)16.06(2)
17.02	.038	Fe II(J)17.03(9)
19.36	.018	Fe II(J)19.34(4)

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
5128.76	.101	Fe II(J)28.77(3)
29.14	.042	Ti II(86)29.14(14)
32.63	.026	Fe II(35)32.66(4)
37.31	.020	(C II(16)37.26(0))
39.29	.047	
44.37	.090	Fe II(J)44.36(11)
45.78	.067	Fe II(J)45.78(9w)
48.93	.086	Fe II(J)48.97(8)
49.45	.040	Fe II(J)49.46(12)
50.51	.042	Fe II(J)50.49(7)
52.67	.093	Fe II(J)52.71(5)
54.46	.087	
56.13	.045	Fe II(RC)56.12(12)
57.24	.043	Fe II(J)57.28(8)
58.07	.011	Fe II(J)58.07(8)
59.89	.008	Fe II(J)59.91(4)
60.88	.031	Fe II(J)60.85(6)
61.15	.025	Fe II(35)61.18(p)
63.54	.011	Fe II(J)63.58(5)
65.42	.025	
66.30	.017	
68.98	.082	Fe II(J)69.00(30)
72.97	.044	Fe II(185)73.00(0)
75.71	.045	
77.41	.083	Fe II(J)77.39(6)
80.56	.047	Fe II(35)80.53(p)
81.94	.035	Si II(23)81.90(100)
83.58	.037	Mg I(2)83.60(125)
85.57	.112	Si II(7.14)85.53(100)
88.73	.051	Ti II(70)88.69(15)
92.88	.096	Si II(23)92.86(200h)
93.72	.043	
94.95	.060	Fe II(J)94.89(6w)
97.57	.083	Fe II(49)97.56(6)
99.02	.045	Fe II(J)99.12(10)
99.74	.035	(V II(55)99.68(0))
5200.78	.057	Fe II(J)00.81(7)
01.33	.045	S II(39)01.32(15)
02.45	.060	Si II(23)02.41(500h)
03.82	.087	
05.73	.030	Y II(20)05.73(80)
08.37	.047	
13.94	.081	Fe II(J)13.99(9w)
15.28	.093	Fe II(J)15.34(7)
16.84	.095	Fe II(J)16.85(18w)
18.53	.074	
21.35	.036	Cl II(3)21.34(75)
27.47	.086	Fe II(J)27.49(13)
27.88	.073	Ti II(103)27.87(p)
31.88	.036	···

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
5232.74	.100	Fe II(J)32.78(4)
34.65	.082	Fe II(49)34.62(7)
35.63	.029	Fe III(G)35.66(10)
37.36	.024	Cr II(43)37.34(25)
37.94	.034	Fe II(J)37.95(9)
39.85	.080	
46.71	.035	Cr II(23)46.75(-)
47.91	.083	Fe II(J)47.95(13)
49.40	.061	Cr II(23)49.40(10)
51.24	.092	Fe II(J)51.23(13)
54.93	.092	Fe II(J)54.92(9)
57.11	.073	Fe II(J)57.11(7)
59.07	.075	
60.28	.096	Fe II(J)60.26(18)
62.13	.054	Ti II(70)62.10(0)
64.81	.058	Fe II(J)64.80(12)
64.18	.086	Fe II(J)64.18(11)
70.99	.039	
72.41	.077	Fe II(J)72.39(11)
75.97	.105	Fe II(J)75.99(18)
75.00	.055	Cr II(43)74.99(2)
77.34	.032	
78.24	.045	Fe II(J)78.20(6)
78.98	.045	Fe II(J)78.94(6), Fe II(184)78.94(0)
79.90	.040	Cr II(43)79.92(15)
81.39	.030	
84.10	.090	Fe II(J)84.10(11), Fe II(41)84.09(3)
98.37	.037	
98.76	.053	Fe II(J)98.84(8w)
99.91	.030	Fe III(G)99.93(12)
5305.85	.081	Cr II(24)05.85(25)
08.25	.036	
10.67	.045	Cr II(43)10.70(12)
18.01	.029	Fe II(J)18.06(10)
18.61	.013	(V II(53)18.61())
25.60	.089	Fe II(49)25.56(2)
34.82	.038	
37.74	.049	Fe II(J)37.73(8)
39.42	.069	
45.67	.027	S II(38)45.72(22)
46.07	.049	Cr II(24)46.12(p)
47.18	.068	Fe II(J)47.18(6)
49.76	.013	

TABLE 1 (CONTINUED)

λ[Å]	W_{eq}	Identification
5354.62	.047	Cr II(29)54.66(p)
55.47	.077	Fe II(J)55.42(6)
58.88	.043	Fe II(J)58.87(7)
60.52	.026	Fe II(J)60.49(5)
62.90	.089	Fe II(J)62.87(18)
75.94	.043	...
80.97	.024	Ti II(69)81.02(12)
82.57	.013	Fe II(184)82.52(p)
83.35	.040	
87.06	.060	Fe II(J)87.06(14)
89.41	.032	
93.64	.070	Fe II(J)93.59(5)
95.89	.083	Fe II(J)95.86(12)
97.60	.081	
5402.10	.097	Fe II(J)02.06(15)
05.08	.033	Fe II(J)05.09(8)
07.62	.033	Cr II(23)07.62(10)
08.94	.020	
10.41	.032	Cr II(29)10.39(p)
50.07	.034	Fe II(J)50.10(6)
51.15	.036	Si II(30)51.18(0h)
55.79	.082	Cr II(50)55.80(3)
57.45	.045	Cl II(2)57.47(30)
60.83	.025	
61.95	.037	
66.41	.189	Si II(7.03)66.43(500H)
69.19	.067	Si II(32)69.21(100h)
72.82	.033	Fe II(J)72.86(5)
75.84	.042	Fe II(J)75.83(9)
78.31	.057	Cr II(50)78.35(15)
79.36	.033	Fe II(J)79.41(8)
81.14	.049	
82.29	.053	Fe II(J)82.31(16)
87.66	.076	Fe II(J)87.62(14)
5502.06	.016	Cr II(50)02.05(12)
03.17	.054	Fe II(J)03.22(10), (Cr II(50)03.18)
03.88	.021	Fe II(J)03.89(5)
06.16	.088	Fe II(J)06.19(18)
07.13	.025	Fe II(J)07.06(5)
10.73	.073	Cr II(23)10.68(7), Fe II(J)10.78(12)
12.36	.028	...

cross dispersers. We have used one grating with 400 lines mm^{-1}. The S/N ratio of the spectra is around 200 and they have been obtained from April 22 to 25, 2000. The resolution is approximately 12,500.

There is no more than a 20% difference among the equivalent width measurements of the same lines in different orders of the echelle spectra. The spectra were reduced by Saffe using IRAF[6] standard procedures for echelle spectra, and were normalized order by order with the *continuum* task of the same package. The dispersion of the spectra is 0.17 Å/px. Extensive description of the observational material obtained with the same equipment, and results derived from them, have been published by López-García, Adelman, & Pintado (2001).

3. LINE IDENTIFICATIONS

The line identification techniques have been extensively reviewed by Cowley & Adelman (1990) and by Gulliver & Stadel (1990). More recently the subject was addressed by Cowley (1995). Cowley & Adelman, in particular, compare the results of the classical technique for line identification with the wavelength coincidence statistics (WCS). As HD 87240 is an early type CP star we have used the classical technique for line identification based on the following precautions: (a) we use the highest S/N ratio spectra on hand; (b) we try to identify all the possible lines in the wavelength range; (c) we pay attention to the strongest laboratory lines of each atomic specie to be present. The stellar lines were identified using the general compilation by Moore (1945) as well as the more specialized references for Si II (Shenstone 1961), S II (Pettersson 1983), Ti II (Huldt et al. 1982), Mn II (Iglesias & Velasco 1964), Fe II (Johansson 1978), and Gd II (Meggers, Corliss, & Scribner 1961). We have used a $\Delta\lambda$ interval of 0.25 Å to search for the possible contributors to each spectral feature. We already mentioned that the $v \sin i$ value derived from our REOSC spectra is around 15 km s^{-1}.

Table 1 lists the line identifications. The first column shows the mean wavelength λ in Å as measured on HD 87240 and corrected by Doppler shift to the laboratory frame. The second column lists the equivalent width in Å measured in our spectra. They are averages of two spectra. Column three lists the line identification, the multiplet number between parentheses, the rest wavelenght and the relative intensity of the line, taken from the sources indicated in the literature. The intensities are for the line center referred to the local continuum. In the vicinity of the Balmer lines, the intensities for the metal lines are measured with respect to the hydrogen line wings. The Balmer lines were identified, but their observed wavelengths are only estimates. The identifications given between parentheses are tentative. Those multiplets without number are denoted as (), for example Cr II()3778.69(6). Atomic species with lines in the region studied which are not discussed in the section were not identified. Let us comment next on the results for each atomic species:

[6]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.

H I (Moore 1945): The last Balmer line listed in Table 1 is H12. Examination of the spectra shows that there is also evidence for H13 and H14.

He I (Moore 1945): Lines such as λ4471.48 or λ4026.19 are not present. For positive identification of this atomic species strong lines such as λ5875 and λ6678 must be present.

C II (Moore 1945): Lines of multiplets 4 and 6 are present.

Mg I (Moore 1945): Examination of the spectra indicate that the strongest lines of multiplets 2 and 3 are present, and multiplet 11 might be in blend.

Mg II (Moore 1945): The blend at λ4481.23 is present, as well as lines belonging to multiplets 5, 10, and 18.

Si I (Moore 1945): The strong line λ3905.53 is probably present but in blend with Cr II(167)3905.64.

Si II (Shenstone 1961): The stronger lines are easily seen, as well as many higher excitation lines of multiplets 3.01, 7.06, 7.07, 7.14, 7.15, 7.16, 7.17, 7.18 and 7.26.

Si III (Moore 1945): The strongest line λ4552.62 is present; λ4574.77 is also present but λ4567.87 is absent.

S II (Pettersson 1983): Strongest lines of multiplets 7, 9 and 44 are present but weaker members are absent.

Cl II (Moore 1945): Strongest lines of multiplets 1, 16, 17 and 29 are present but weaker members are absent.

Ca II (Moore 1945): The line λ3933 is present and λ3968 might be.

Ti II (Huldt et al. 1982): Many strong, moderately strong and weak lines are seen. The wavelengths and intensities are from the additional source whenever possible.

Cr II (Moore 1945): Many strong, moderately strong and weak lines are seen, as well as higher excitation lines.

TABLE 2

COMPARISON OF HD 87240 WITH OTHER FIELD AP Si STARS[a]

Atomic Species	HD 87240	HD 200311	HD 192913	HD 133029	HD 43819	Atomic Species	HD 87240	HD 200311	HD 192913	HD 133029	HD 43819
He I	Abs	Abs	Abs	Abs	Pres	Fe III	Pres	Pres	Pres	Abs	Poss
C II	Pres	Pres	Pres	Abs	Pres	Co I,II	Abs	Pres	Abs	Abs	Abs
N II	Abs	Pres	Abs	Abs	Abs	Ni II	Pres	Pres	Abs	Pres	Pres
O II	Abs	Poss	Abs	Abs	Abs	Ga II	Abs	Pres	Abs	Abs	Abs
Mg I	Pres	Abs	Abs	Abs	Pres	Sr II	Pres	Pres	Pres	Pres	Pres
Mg II	Pres	Pres	Pres	Pres	Pres	Y II	**Poss**	Pres	Pres	Abs	Abs
Al I	Abs	Abs	Pres	Abs	Abs	Zr II	Pres	Abs	Pres	Pres	Pres
Al II	Ab	Abs	Abs	Pres	Abs	Ba II	Abs	Abs	Abs	Abs	Pres
Si II	Pres	Pres	Pres	Pres	Pres	La II	Abs	Abs	Abs	Pres	Abs
Si III	Pres	Pres	Abs	Pres	Abs	Ce II	Abs	Pres	Abs	Pres	Pres
S II	Pres	Pres	Abs	Abs	Pres	Ce III	Abs	Pres	Abs	Abs	Prob
Ca II	Pres	Pres	Pres	Pres	Pres	Pr II	Abs	Pres	Abs	Pres	Abs
Cl II	Pres	Pres	Abs	Abs	Abs	Nd II	Abs	Poss	Abs	Pres	Pres
Sc II	Abs	Pres	Pres	Abs	Pres	Sm II	Abs	Prob	Abs	Pres	Abs
Ti II	Pres	Pres	Pres	Pres	Pres	Eu II	Pres	Pres	Pres	Pres	Pres
Cr I	Abs	Abs	Pres	Pres	Pres	Gd II	Poss	Pres	Pres	Pres	Abs
Cr II	Pres	Pres	Pres	Pres	Pres	Dy II	Abs	Abs	Abs	Pres	Abs
Mn II	Poss	Pres	Pres	Pres	Pres	Er III	Abs	Pres	Abs	Abs	Abs
Fe I	Pres	Pres	Pres	Pres	Pres	Pt II	Abs	Pres	Abs	Abs	Abs
Fe II	Pres	Pres	Pres	Pres	Pres	Hg II	Pres	Pres	Pres	Abs	Pres
$T_{\rm eff}$	12500	13000	10900	11200	11300	$T_{\rm eff}$	12500	13000	10900	11200	11300

[a]Notes: Abs = Absent, Pres = Present, Prob = Probable, Poss = Possible. Effective temperatures were obtained from López-García & Adelman (1999) for HD 192913 and HD 133029, and López-García & Adelman (1994) for HD 43819. In the case of HD 87240 and HD 200311, we roughly estimate their $T_{\rm eff}$ from their $B-V$ and $U-B$ colors.

Mn II (Iglesias & Velasco 1964): The strongest line in the region studied λ4326 is blended. The line λ4343 falls in Balmer Hγ wing and is possibly present. The identification of Mn II is uncertain.

Fe I (Moore 1945): Many strong and moderately strong lines are seen. The strongest lines of multiplets 42, 43, 45, 71, and 72 are present and probably 2, 20, 21, and 41.

Fe II (Moore 1945; Johansson 1978): Many strong, moderately strong and weak lines are seen. The wavelengths and intensity are from the additional source whenever possible.

Fe III (Moore 1945): The strongest line λ4419.59 is present. Some of the strongest lines of multiplets 4, 113, 118, and 121 are present, but weaker lines are absent.

Ni II (Moore 1945): The strongest lines in the region studied λ3849 and λ4067 are present.

Sr II (Moore 1945): Multiplets 1 and 3 are present.

Y II (Moore 1945): The strong line λ4374 is present and λ3710 is probably present. The strongest lines of multiplets 13 and 20 are present but weaker lines are absent. We consider that this is a possible but not a definite identification.

Zr II (Moore 1945): The strongest lines λ3991 and λ4149 are present. Some of the strongest lines of multiplets 29, 30, and 43 are also present.

Eu II (Meggers et al. 1975): The lines λ4205 and λ3819 are present. The line λ4129 is probably present, weakened between two strong Si II lines λ4128 and λ4130.

Gd II (Meggers et al. 1961): The lines λ4251, λ4325, and λ4049 are probably present but blended. There is no evidence for other lines with similar intensities. The identification is uncertain.

Hg II (Moore 1945): The strongest line λ3983.96 is present but might be due to Fe I(277)3983.96. This feature has been identified in other studies of hot peculiar A-type stars as a Hg II line.

Thus, H I, C II, Mg I, Mg II, Si II, S II, Cl II, Ca II, Ti II, Cr II, Fe I, Fe II, Fe III, Ni II, Sr II, Y II, Zr II,Eu II, and Hg II are present. In addition Si I, Mn II, and Gd II may be present. There are a number of unidentified lines. These are likely to be lines of atomic species which have already been identified.

4. COMPARISON WITH OTHER FIELD AP STARS AND COMMENTS

The star HD 87240 ($B-V=-0.07$ mag, $U-B=-0.44$ mag) (Lynga 1959) is a member of the south open cluster NGC 3114. This cluster contains at least five Ap stars (three Ap Si stars) and other CP stars. Line identification lists have been published for several other silicon stars, in particular field Ap stars. In Table 2, the atomic species present in the HD 87240 photographic region spectrum are compared with those of field stars of similar colors HD 200311 ($B-V=-0.11$ mag, $U-B=-0.50$ mag) (Adelman 1974a), HD 192913 ($B-V=-0.07$ mag, $U-B=-0.24$ mag) (Jaschek & García 1966; López-García & Adelman 1999), HD 133029 ($B-V=-0.11$ mag, $U-B=-0.25$ mag) (Burbidge & Burbidge 1955; López-García & Adelman 1999), and HD 43819 ($B-V=-0.07$ mag, $U-B=-0.30$ mag) (Adelman 1985; López-García & Adelman 1994).

HD 87240 does not appear to be identical to any of the other stars in Table 2 although it shares many of their anomalies. Many of the atomic species which are present are represented by only a few lines. Differences in the magnetic field strength and configuration, apparent rotational velocity, effective temperature, surface gravity, elemental distributions on the stellar surface, and the exact wavelength region studied may well hide some of the underlying similarities. For example, Catanzaro, Leone, & Catalano (1999) have been reported He I λ5876 variability in the Ap Si star HD 43819. We do not identify this species in HD 87240.

There is no evidence in the HD 87240 spectra of doubly ionized rare-earth lines. This lack of identifications may be due to the choice of the region studied (Adelman 1974a). We note that Dy III is possibly present in HD 133029 (Burbidge & Burbidge 1955; Adelman 1974a), Ce III, Pr III, and Er III are present in HD 200311 (Adelman 1974a). In HD 192913, Ce III, Nd III, Sm III, Dy III, Ho III, and Yb III have been identified, while Pr III, Gd III, Er III, and Tm III are probably present (Riabchikova, Davidova, & Adelman 1990). Doubly ionized rare-earth lines have also been identified in other magnetic Ap stars (Cohen, Deutsch, & Greenstein 1969; Adelman 1974b).

Within the former limitations, HD 87240 is not unique in any atomic species in comparison with the other Ap Si stars (see Table 2). The only probable exception is Mn II, whose identification is uncertain. The major similarity occurs between HD 87240 and HD 192913, sharing almost the same anomalies for species heavier than Fe I. Also HD 87240 shares with HD 43819 the same species for elements lighter than S II. We conclude that HD 87240 appears to be an Ap Si star.

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