THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 123:283–293, 1999 July

LIBRARY OF MEDIUM-RESOLUTION FIBER OPTIC ECHELLE SPECTRA OF F, G, K, AND M FIELD DWARFS TO GIANT STARS

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Received 1998 August 20; accepted 1999 February 20

ABSTRACT

We present a library of Penn State Fiber Optic Echelle (FOE) observations of a sample of field stars with spectral types F to M and luminosity classes V to I. The spectral coverage is from 3800 to 10000 Å with a nominal resolving power of 12,000. These spectra include many of the spectral lines most widely used as optical and near-infrared indicators of chromospheric activity such as the Balmer lines (Hα to Hϵ), Ca II H & K, the Mg I b triplet, Na I D_1, D_2, He I D_3, and Ca II IRT lines. There are also a large number of photospheric lines, which can also be affected by chromospheric activity, and temperature-sensitive photospheric features such as TiO bands. The spectra have been compiled with the goal of providing a set of standards observed at medium resolution. We have extensively used such data for the study of active chromosphere stars by applying a spectral subtraction technique. However, the data set presented here can also be utilized in a wide variety of ways ranging from radial velocity templates to study of variable stars and stellar population synthesis. This library can also be used for spectral classification purposes and determination of atmospheric parameters ($T_{\rm eff}$, log g, [Fe/H]). A digital version of all the fully reduced spectra is available via ftp and the World Wide Web (WWW) in FITS format.

Subject headings: atlases — stars: activity — stars: chromospheres — stars: late-type

1. INTRODUCTION

Spectral libraries of late-type stars with medium to high resolution and large spectral coverage are an essential tool for the study of the chromospheric activity in multiwavelength optical observations using the spectral subtraction technique (see Barden 1985; Huenemoerder & Ramsey 1987; Hall & Ramsey 1992; Montes et al. 1995a, 1995b, 1995c, 1996a, 1996b, 1997a, 1998). Furthermore, these libraries are also very useful in many areas of astrophysics such as the stellar spectral classification, determination of atmospheric parameters ($T_{\rm eff}$, log g, [Fe/H]), modeling stellar atmospheres, spectral synthesis applied to composite systems, and spectral synthesis of the stellar population of galaxies.

In previous work, Montes et al. (1997b, hereafter Paper I) presented a library of high- and mid-resolution (3–0.2 Å) spectra in the Ca II H & K, Hα, Hβ, Na I D_1, D_2, and He I D_3 line regions of F, G, K, and M field stars. A library of echelle spectra of a sample of F, G, K, and M field dwarf stars is presented in Montes & Martín (1998, hereafter Paper II), which is an extension of Paper I to higher spectral resolution (0.19–0.09 Å) covering a large spectral range (4800–10600 Å).

The spectral library presented here expands upon the data set in Papers I and II. This library consists of echelle spectra of a sample of F, G, K, and M field stars, mainly dwarfs (V), subgiant (IV), and giants (III) but also some supergiants (II, I). The spectral resolving power is intermediate, nominally $R = 12{,}000$ ($\approx$0.5 Å in Hα), but the spectra have a nearly complete optical region coverage (from 3900 to 9000 Å). These regions include most of the spectral lines widely used as optical and near-infrared indicators of chromospheric activity such as the Balmer lines (Hα to Hϵ), Ca II H & K, the Mg I b triplet, Na I D_1, D_2, He I D_3, and Ca II IRT lines, as well as temperature-sensitive photospheric features such as TiO bands.

Recently, Pickles (1998) has taken available published spectra and combined them into a uniform stellar spectral flux library. This library has a wide wavelength, spectral type, and luminosity class coverage, but a low spectral resolution ($R = 500$), and their main purpose is the synthesis and modeling of the integrated light from composite populations. However, for other purposes such as detailed studies of chromospheric activity, stellar spectral classification, and determination of atmospheric parameters, libraries of higher resolution, such as those presented in Papers I and II, Soubiran, Katz, & Cayrel (1998), and the library presented here, are needed.

In § 2 we report the details of our observations and data reduction. The library is presented in § 3.

2. OBSERVATIONS AND DATA REDUCTION

The echelle spectra presented here were obtained during several observing runs with the Penn State Fiber Optic Echelle (FOE) at the 0.9 m and 2.1 m telescopes of the Kitt Peak National Observatory (KPNO). The FOE is a fiber-fed prism cross-dispersed echelle medium-resolution spectrograph and is described in more detail in Ramsey & Huenemoerder (1986). It was designed specifically to obtain in a single exposure a wide spectral range encompassing all the visible chromospheric activity sensitive features. Typical data and performance of the FOE for the different observing runs are discussed in Ramsey et al. (1987), Huenemoerder, Buzasi, & Ramsey (1989), Newmark et al. (1990),

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TABLE 1

SUMMARY OF OBSERVATIONS

Code Number	Date (yyyy/mm)	CCD Detector	Number of Echelle Orders	λ_i–λ_f	Dispersion Range (Å pixel^{-1})
1	1994/12	T1KA (1024 × 1024)	34	3875–9400	0.123–0.296
2	1994/05	T1KA (1024 × 1024)	33	3875–9000	0.124–0.284
3	1993/12	T1KA (1024 × 1024)	34	3875–9400	0.121–0.288
4	1992/11	T2KB (2048 × 2048)	36	3700–9050	0.113–0.276
5	1991/09	TI3 (800 × 800)	34	3810–8950	0.077–0.180
6	1991/05	TEK2 (512 × 512)	32	3950–8975	0.152–0.310
7	1990/10	RCA1 (512 × 512)	40	3690–10700	0.130–0.378
8	1989/12	TI2 (800 × 800)	15	7250–9000	0.130–0.158
9	1989/04	RCA3 (512 × 512)	34	3890–9350	0.151–0.359
10	1988/09	RCA3 (512 × 512)	33	3880–8950	0.150–0.344
11	1987/03	RCA1 (512 × 512)	33	3880–8950	0.151–0.346

Hall et al. (1990), Buzasi, Huenemoerder, & Ramsey (1991), Hall & Ramsey (1992), Welty & Ramsey (1995), and Welty (1995).

In Table 1 we give a summary of observations. For each observing run we list the date, the CCD detector used, the number of echelle orders included, the wavelength range covered (λ_i–λ_f), and the range of reciprocal dispersion achieved (Å pixel^{-1}) from the first to the last echelle orders. The Å pixel^{-1} value for each order can be found in the header of the spectra. The spectral resolution, determined by the FWHM of the arc comparison lines, ranges from 2.0 to 2.2 pixels. The signal-to-noise ratio is larger than 100 in all cases. Table 2 gives for each observing run the spectral lines of interest in each echelle order.

TABLE 2

LINES INCLUDED IN FOE SPECTRAL ORDERS IN EACH OBSERVING RUN

Order Number	1, 2, 3, 10, 11	4, 7	5	6	9	8
1	Ca II K			Ca II H		
2	Ca II H					
3			Ca II H	Hδ	Ca II IRT	
4	Hδ	Ca II K				
5		Ca II H	Hδ			
6				Hγ		
7	Hγ	Hδ				
8			Hγ			
9						
10		Hγ			Li I	
11				Hβ	Hα	
12	Hβ					Ca II IRT
13			Hβ			Ca II IRT
14				Mg I b		
15	Mg I b	Hβ			Na I D	
16			Mg I b			
17						
18		Mg I b				
19				Na I D		
20	Na I D				Mg I b	
21			Na I D			
22						
23		Na I D		Hα	Hβ	
24	Hα			Li I		
25	Li I		Hα			
26			Li I			
27		Hα				
28		LiI			Hγ	
29						
30						
31				Ca II IRT	Hδ	
32	Ca II IRT					
33			Ca II IRT		Ca II H	
34					Ca II K	
35		Ca II IRT				
36						

TABLE 3

STARS

HD (1)	HR (2)	GJ (3)	Name (4)	T_{sp} [a] (5)	MK (6)	[Fe/H] (dex) (7)	P_{rot} (days) (8)	$v \sin i$ (km s^{-1}) (9)	S (10)	Observing Run (11)	Papers I and II (12)
						F Stars					
58946	2852	274 A	ρ Gem	F0 V (SB?)	MK	...	...	68	...	8	
15257	717	...	12 Tri	F0 III		...	...	78	...	8	
1457	...	...	SAO 11104	F0 Iab		...	...	...	...	3, 8	
128167	5447	557	σ Boo	F2 V	MK	−0.387	...	7.8	0.190	11	
210027	8430	848	ι Peg	F5 V (SB1)	MK	−0.079	...	...	...	5	
87141	3954	...	BD +54 1348	F5 V		0.047	...	10	...	8	
55052	2706	...	48 Gem	F5 III–IV		...	...	74	...	11	
20902	1017	...	α Per	F5 Ib:	MK*	...	...	18	...	8	
76572	3563	...	61 Cnc	F6 V		...	...	<10	0.148	11	
11443	544	78.1	α Tri	F6 IV (SB)		0.000	...	93	0.275	5	
8992	...	...	SAO 22328	F6 Ib		...	...	...	...	3	
187013	7534	767.1 A	17 Cyg	F7 V		−0.109	...	10.0	0.154	2, 11(2)	I
222368	8969	904	ι Psc	F7 V (SB?)	MK	−0.127	...	5.6	0.153	4	
187691	7560	768.1 A	o Aql	F8 V		0.059	...	3.1	0.148	1, 2, 3, 6(2), 7, 11(2)	I
142373	5914	602	χ Her	F8 V		−0.431	...	2.4	0.147	6, 11	I, II
9826	458	61	υ And	F8 V		−0.14	...	8	0.154	5	II
45067	2313	...	BD −00 1287	F8 V		−0.16	...	<15	0.141	11	I
107213	4688	...	9 Com	F8 V		0.154	...	10.0	0.135	11	I
122563	5270	...	BD +10 2617	F8 IV		−2.74	...	...	...	6	
102870	4540	449	β Vir	F9 V (SB?)	MK	0.180	...	4.5	...	11	
22484	1101	147	10 Tau	F9 IV–V (SB?)		−0.106	...	2.8	0.147	4, 8	
114710	4983	502	β Com	F9.5 V	MK	0.135	12.35	4.3	0.201	2, 11(2)	I, II
						G Stars					
39587	2047	222 AB	χ^1 Ori	G0− V (SB1)	MK	−0.084	5.36	8.6	0.325	10(6)	I, II
143761	5968	606.2	ρ CrB	G0+ Va	MK	−0.185	...	5.0	0.150	11	I
13974	660	92	δ Tri	G0.5 V (SB2)	MK	−0.444	...	10.0	0.232	1(2), 3, 4, 5, 10	I
26630	1303	...	μ Per	G0 Ib (SB)	MK	−0.32	...	14	0.362	8	
126053	5384	547	BD +01 2920	G1 V		...	...	1	0.165	6, 11	
95128	4277	407	47 UMa	G1− V	MK	0.026	...	<3	0.165	8	
67228	3176	...	μ^2 Cnc	G1 IVb		0.052	...	3.0	0.138	1(2), 6, 11	
84441	3873	...	ϵ Leo	G1 II		0.17	...	<17	...	9(6), 11(2)	
185758	7479	...	α Sge	G1 II	MK	−0.15	...	6.0	...	2(2)	
...	...	...	Sun	G2 V		0.00	25.72	<1.7	0.179	1	I
1835	88	17.3	9 Cet	G2.5 V	MK	0.050	7.7	6	0.349	1, 3, 4(2), 5	
221170	...	...	BD +29 4940	G2 IV		−1.96	...	...	0.106	2, 3, 5	
196755	7896	...	κ Del	G2 IV	MK	−0.02	...	2.7	0.152	1, 2(2), 3, 4, 5	
218658	8819	...	π Cep	G2 III (SB)		0.01	...	22	0.237	1, 2	
161239	6608	...	84 Her	G2 IIIb	MK	...	...	6.0	0.138	11(2)	
11544	...	...	SAO 22740	G2 Ib		...	...	...	...	1, 3	
223047	9003	...	ψ And	G3 Ib–II		0.10	...	<19	0.385	8	
117176	5072	512.1	70 Vir	G4 V	MK	−0.035	...	1.2	0.142	6, 11(2)	
123	5	4.1 A	V640 Cas	G5 V		...	...	...	...	3, 5, 11	

TABLE 3—*Continued*

HD (1)	HR (2)	GJ (3)	Name (4)	T_{sp} [a] (5)	MK (6)	[Fe/H] (dex) (7)	P_{rot} (days) (8)	$v \sin i$ (km s^{-1}) (9)	S (10)	Observing Run (11)	Papers I and II (12)
20630	996	137	κ^1 Cet	G5 V (SB?)	MK*	0.133	9.24	3.9	0.366	1(3), 4, 7	I, II
59058	…	…	BD +38 1771	G5 V		…	…	…	…	8	
86873	…	…	BD +32 1970	G5		…	…	…	…	8	
161797	6623	695 A	μ Her A	G5 IV	MK*	0.242	…	1.2	0.136	5, 6	
71369	3323	…	o UMa	G5 III		−0.21	…	3.4	0.120	1	
…	…	…	κ Her	G5 III		…	…	…	…	2	
20825	…	…	62 Ari	G5 III		−0.14	…	…	…	4, 5	
190360	7670	777 A	BD +29 3872	G6 IV+M6 V		0.308	…	…	0.146	5, 6	I
221115	8923	…	70 Peg	G7+ III		−0.03	…	<19	0.147	2	
101501	4496	434	61 UMa	G8 V	MK*	−0.070	16.68	2.3	0.311	6, 11(2)	I
103095	4550	451 A	BD +38 2285	G8 Vp		−1.266	…	2.2	0.188	11	
188512	7602	771 A	β Aql	G8 IV	MK*	−0.30	…	1.4	0.136	1, 2, 4, 5, 7	I
73593	3422	…	34 Lyn	G8 IV		…	…	…	0.117	3, 11(3)	
218935	8827	…	60 Peg	G8 III–IV		…	…	…	0.120	5	
113226	4932	…	ϵ Vir	G8 IIIab	MK*	0.00	…	3.2	…	1(3), 2(6), 3, 9(6), 11(6)	
16161	…	…	ν Cet	G8 III		−0.38	…	<17	0.111	4, 5	
104979	4608	…	o Vir	G8 IIIa	MK	−0.33	…	2.5	…	6, 11(2)	
191026	7689	…	27 Cyg	G8.5 IVa		−0.10	…	…	…	4	
108225	4728	…	6 Cvn	G9 III	MK	−0.11	…	<19	…	6	
76294	3547	…	ζ Hya	G9 IIIa	MK	−0.21	…	…	…	1, 3	
4128	188	31	β Cet	G9.5 III		0.13	…	4.0	0.187	10	
					K Stars						
185144	7462	764	σ Dra	K0 V	MK*	−0.045	…	0.6	0.215	2	I, II
3651	166	27	54 Psc	K0+ V	MK	−9.000	48.00	2.2	0.176	1, 3, 4, 5, 8	I
198149	7957	807	η Cep	K0 IV	MK	−0.32		0.6	…	1, 2	
6734	…	…	29 Cet	K0 IV		−0.25	…	…	0.131	3	
168723	6869	711	η Ser	K0 III–IV	MK	−0.42	…	2.6	0.122	6, 11(3)	
45410	2331	…	6 Lyn	K0 III–IV		…	…	…	0.127	11	I
28	3	…	33 Psc	K0 III–IV (SB1)	MK	−0.31	…	<17	…	5	
188947	7615	…	η Cyg	K0 III	MK	−0.09	…	1.8	0.103	2(2), 8	
197989	7949	806.1 A	ϵ Cyg	K0 III	MK*	−0.18	…	2.0	0.104	4(2)	
19476	941	…	κ Per	K0 III	MK	0.04	…	<17	0.110	5	
182272	7359	…	BD +33 3434	K0 III		…	…	…	…	6	
19787	951	…	δ Ari	K0 III	MK	−0.03	…	<17	0.110	5	
8512	402	…	θ Cet	K0 IIIb	MK	−0.22	…	<17	0.105	4, 5	
12014	…	…	SAO 22820	K0 Ib		…	…	…	…	3	
10476	493	68	107 Psc	K1 V	MK	−0.123	35.2	0.6	0.198	4(2), 5, 7(2)	I, II
155885	6401	663 B	36 Oph B	K1 V		−0.305	22.9	…	0.384	11	
142091	5901	…	κ CrB	K1 IVa	MK	−0.04	…	0.6	…	6, 11	I
138716	5777	…	37 Lib	K1 III–IV	MK	−0.12	…	<19	…	11	
203504	8173	…	1 Peg	K1 III		−0.14	…	<17	0.103	2(2)	
124897	5340	541	α Boo	K1.5 III	MK	−0.47	…	3.3	0.144	6(5), 9(3), 11(6)	
6805	334	…	η Cet	K2− III	MK	0.04	…	<17	0.112	4	
210745	8465	…	ζ Cep	K1.5 Ib	MK	0.75	…	<17	0.293	8	
166620	6806	706	BD +38 3095	K2 V		−0.114	42.4	0.6	0.190	1(3), 2, 3, 4(2), 6, 11(2)	I
4628	222	33	BD +04 123	K2 V		−0.235	38.5	…	0.230	4, 5, 10	I

TABLE 3—*Continued*

HD (1)	HR (2)	GJ (3)	Name (4)	T_{sp} [a] (5)	MK (6)	[Fe/H] (dex) (7)	P_{rot} (days) (8)	$v \sin i$ (km s^{-1}) (9)	S (10)	Observing Run (11)	Papers I and II (12)
22049	1084	144	ϵ Eri	K2 V	MK*	−0.165	11.68	2.0	0.496	5, 7	I
149661	6171	631	12 Oph	K2 V		−0.004	21.3	0.6	0.339	6, 11(2)	
201196	8088	…	BD +15 4340	K2 IV		…	…	…	…	1(2), 2, 3(3), 4(2)	
153210	6299	…	κ Oph	K2 III	MK*	−0.03	…	<17	0.102	6	
161096	6603	…	β Oph	K2 III	MK	0.00	…	2.5	0.103	9, 10(4)	
194317	7806	…	39 Cyg	K2.5 III	MK	−0.17	…	<19	0.148	2(2), 4, 8	
16160 A	753	105 A	BD +06 398	K3− V	MK	…0.297	48.0	…	0.226	1, 3, 4(3), 5, 7	I, II
160346	…	688	BD +03 3465	K3− V		…	33.5	…	0.300	11(3)	
219134	8832	892	BD +56 2966	K3 V	MK	−0.017	…	2.1	0.230	8	I, II
3627	165	…	δ And	K3 III (SB)	MK	0.04	…	≤ 3	…	5	
136514	5710	…	6 Ser	K3 III		−0.14	…	<17	…	6	
186791	7525	…	γ Aql	K3 II	MK	−0.29	…	<17	…	7(3)	
131156 B	5544 B	566 B	ξ Boo B	K4 V		0.19	12.28	20	1.381	11	I, II
201091	8085	820 A	61 Cyg A	K5 V	MK*	−0.06	35.37	0.6	0.658	1(2), 2(2), 3, 4(6), 5, 8	I, II
156026	…	664	36 Oph C	K5 V		…0.279	18.0	2.2	0.770	11(2)	
29139	1457	171.1 A	α Tau	K5+ III	MK	−0.16	…	<17	…	1(5), 3, 4(2), 5(4), 8	
11800	…	…	BD +59 363	K5 Ib		…	…	…	…	3	
216946	8726	…	BD +48 3887	K5 Ib	MK	−0.03	…	…	…	8	
201092	8086	820 B	61 Cyg B	K7 V	MK	−0.10	37.84	1.4	0.986	1(2), 2(2), 3, 4(2), 5, 8	I, II
80493	3705	…	α Lyn	K7 IIIab	MK	−0.26	…	…	…	8	
					M Stars						
…	…	906	V347	M0 V (K5)		…	…	…	…	8	
89758	4069	…	μ UMa	M0 III (SB)	MK	…	…	…	…	1, 11(2)	
6860	337	53.3	β And	M0+ IIIa	MK*	−0.10	…	…	0.319	4(2), 5, 8	
…	…	4 B	BD +45 4408 B	M0.5 V (K7)		…	…	…	…	8	
232979	…	172	BD +52 857	M0.5 V (K8)	MK	…	…	…	1.909	1	II
1326 A	…	15 A	GX And	M1.5 V (1) (M2 V)	MK	…	…	<2.9	…	1, 2(2), 3, 8	II
218329	8795	…	55 Peg	M1 IIIab	MK	…	…	…	0.234	1	
206330	8284	…	75 Cyg	M1 IIIab	MK	…	…	…	…	8	
39801	2061	…	α Ori	M1–M2 Ia–Iab	MK*	…	…	…	…	11(2)	
95735	…	411	BD +36 2147	M2+ Ve (1)	MK	−0.20	…	<2.9	0.424	11	
206936	8316	…	μ Cep	M2− Ia	MK*	…	…	…	…	8	
133216	5603	574.1	σ Lib	M2.5 III	MK	…	…	…	…	11(2)	
42995	2216	…	η Gem	M2.5 III		…	…	…	…	11(2)	
2411	103	…	TV Psc	M3 III		…	…	…	0.211	2(2)	
44478	2286	…	μ Gem	M3 IIIab	MK	0.11	…	…	…	8	
14270	…	…	AD Per	M3 Iab		…	…	…	…	3	
…	…	273	BD +05 1668	M3.5 V (1)		…	…	<2.4	…	1(2)	II
55383	2717	…	51 Gem	M4 IIIab		…	…	…	…	1, 11(2)	
214665	8621	…	BD +56 2821	M4+ III	MK	…	…	…	0.259	8	
120323	5192	…	2 Cen	M4.5 III	MK	…	…	…	…	11	
130144	5512	…	BD +15 2758	M5 III		…	…	…	…	11	
94705	4267	…	VY Leo	M5.5 III	MK	…	…	…	…	11	
33664	1693	…	RX Lep	M6 III		…	…	…	…	11(2)	
84748	3882	…	R Leo	M8 IIIe		…	…	…	…	1(2)	I

[a] SB: spectroscopic binary (Duquennoy & Mayor 1991).
[b] Henry et al. 1994.

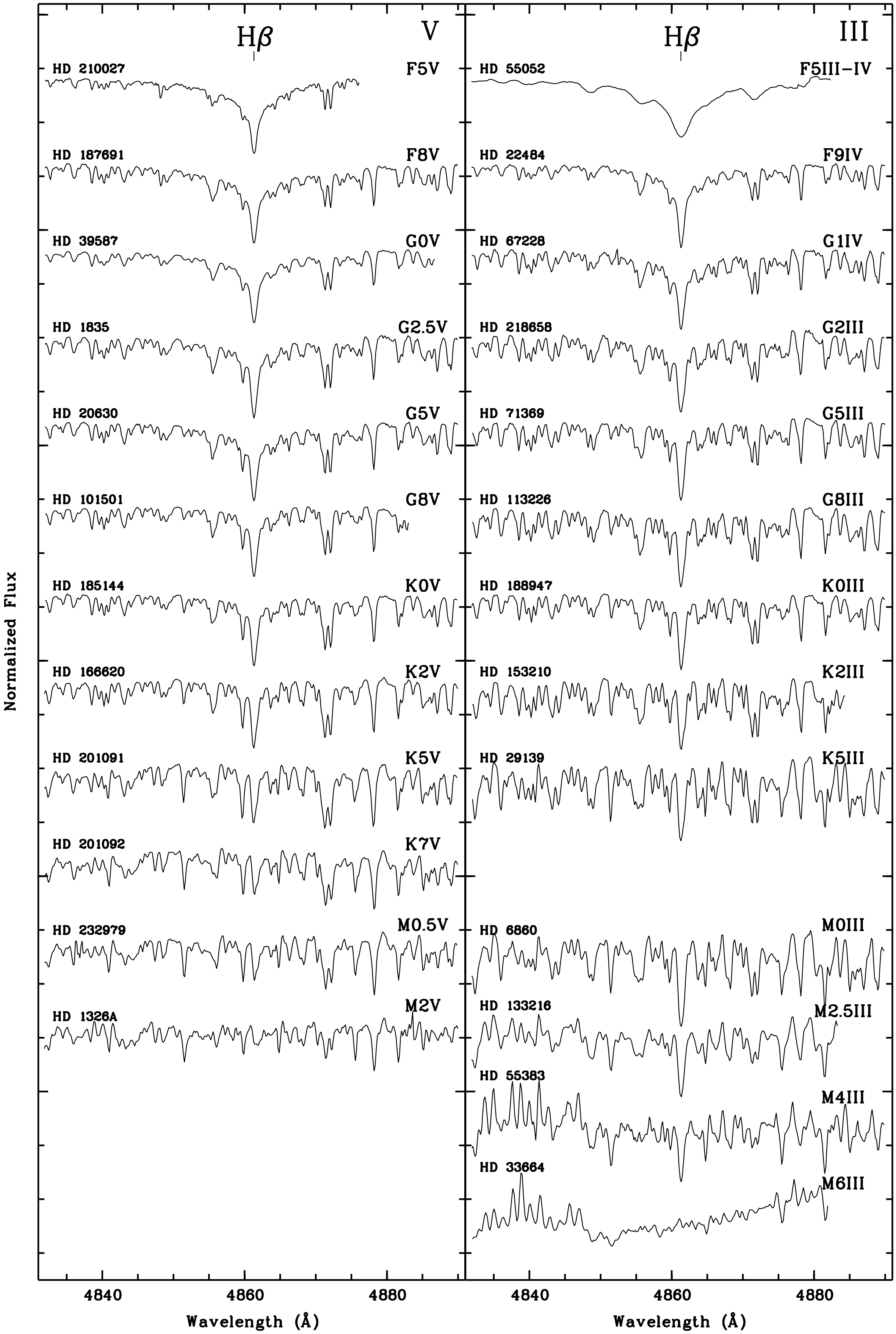

FIG. 1.—Spectra in the Hβ line region of star with representative spectral types. Main-sequence stars (V) are plotted in the left-hand panel, and giant stars (III) in the right-hand panel.

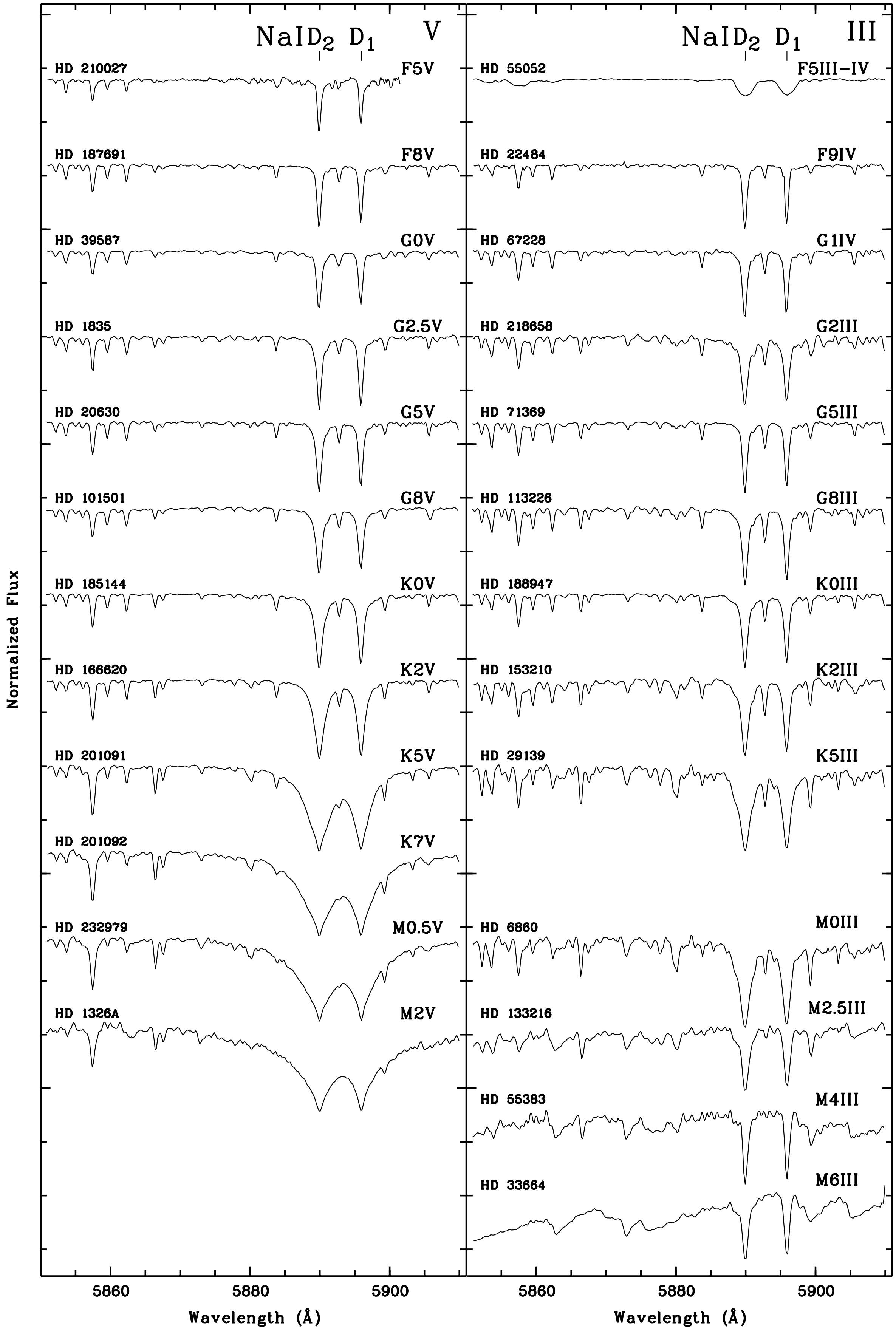

FIG. 2.—As Fig. 1, in the Na I D_1, D_2, He I D_3 line region

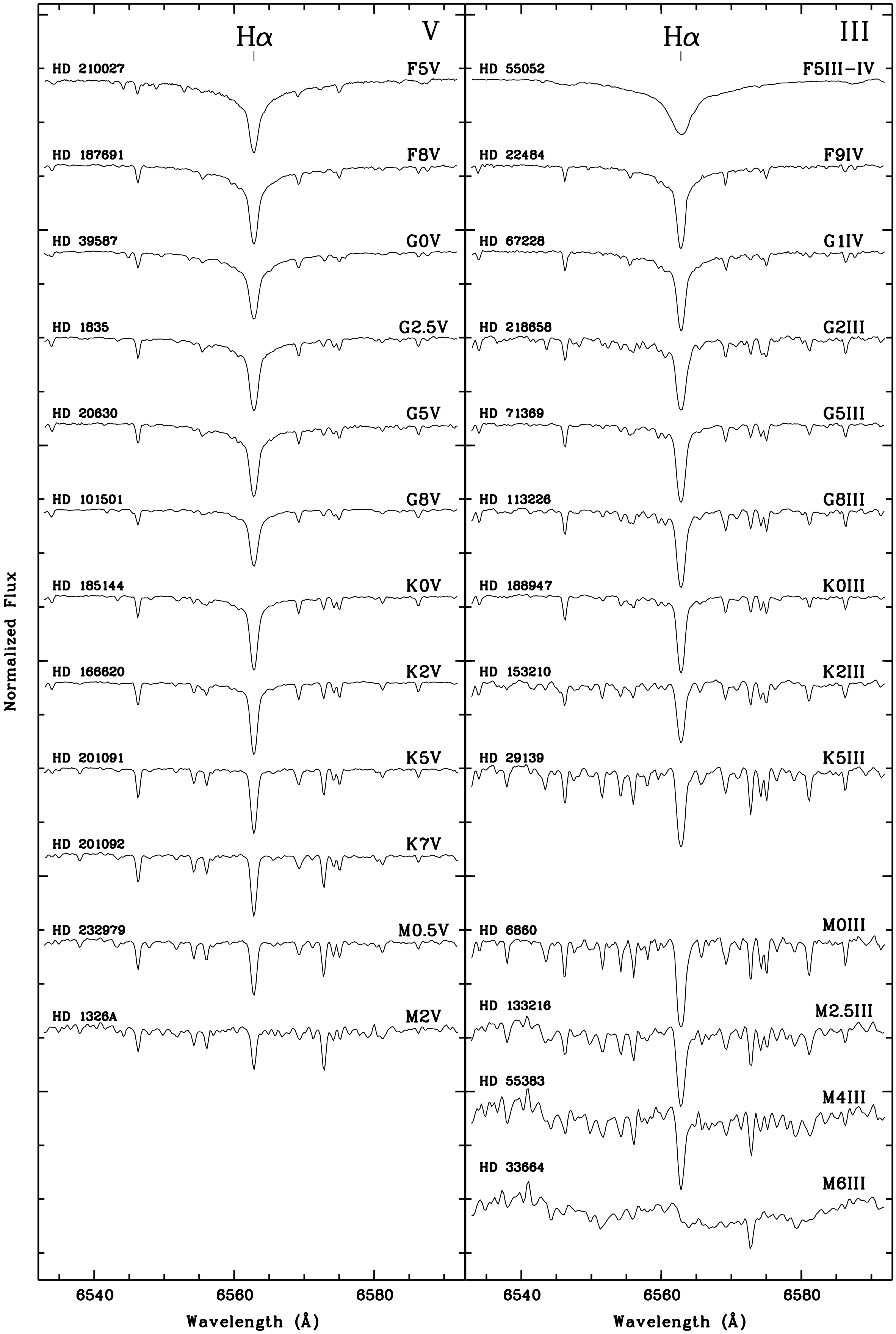

FIG. 3.—As Fig. 1, in the Hα line region

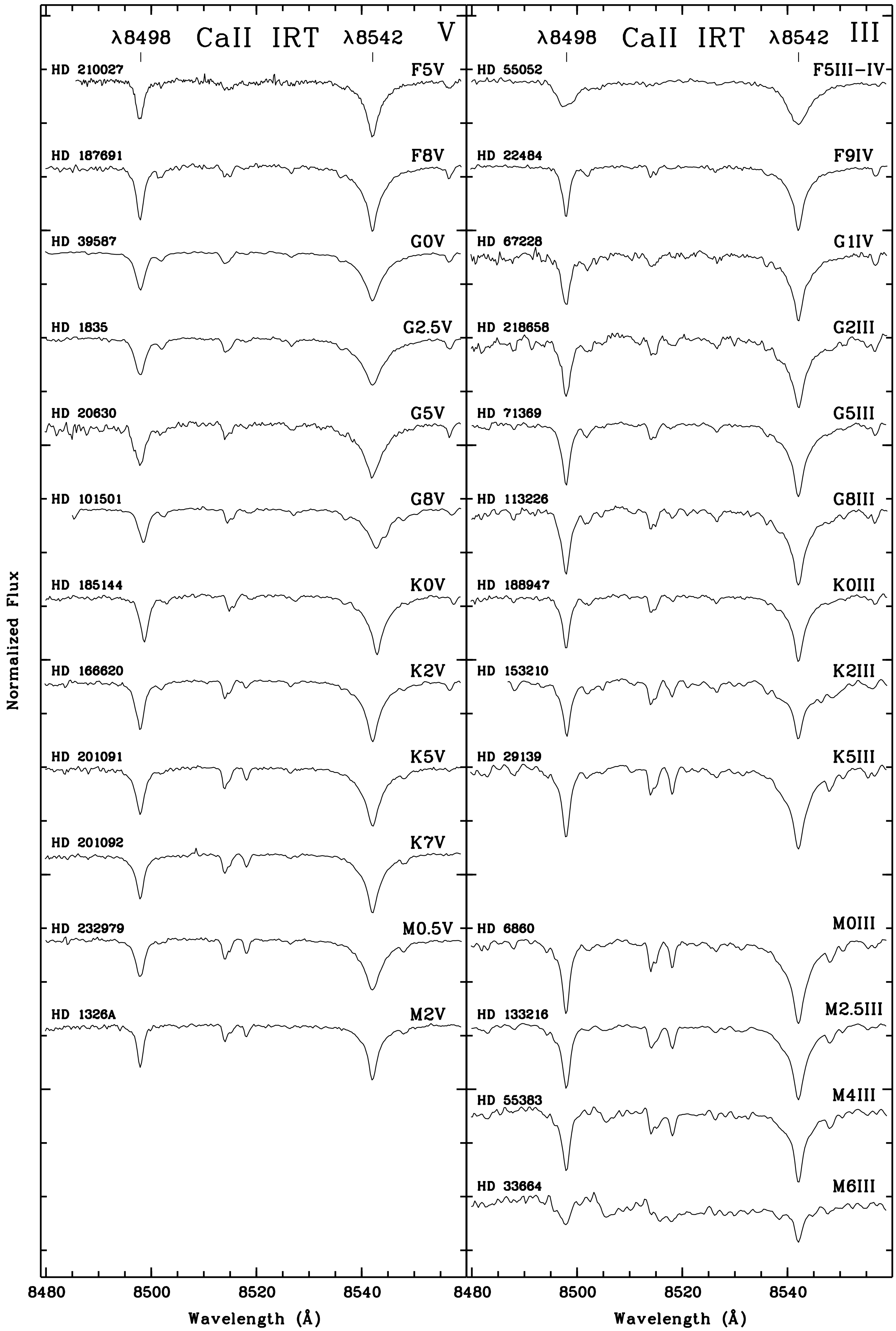

FIG. 4.—As Fig. 1, in the Ca II IRT (λλ 8498, 8542) line region

The spectra have been extracted using the standard reduction procedures in the IRAF[5] package (bias subtraction, flat-field division, and optimal extraction of the spectra). The wavelength calibration was obtained from concurrent spectra of a Th-Ar hollow cathode lamp. Finally, the spectra have been normalized by a polynomial fit to the observed continuum.

3. THE LIBRARY

As in Papers I and II, the stars included in the library have been selected as stars with low levels of chromospheric activity, that is to say, stars that do not present any evidence of emission in the core of Ca II H & K lines in our spectra (Montes et al. 1995a, 1996a), stars with the lower Ca II H & K spectrophometric index *S* (Duncan et al. 1991; Baliunas et al. 1995), or stars known to be inactive and slowly rotating stars from other sources (see Strassmeier et al. 1990; Strassmeier & Fekel 1990; Hall & Ramsey 1992).

Table 3 presents information about the observed stars. In this table we give the HD, HR, and GJ numbers, name, spectral type, and luminosity class (T_{sp}), from the Bright Star Catalogue (Hoffleit & Jaschek 1982; Hoffleit & Warren 1991), the Catalogue of Nearby Stars (Gliese & Jahreiss 1991), and Keenan & McNeil (1989). The exception is some of the M dwarfs for which we list the more recent spectral type determination given by Henry, Kirkpatrick, & Simons (1994). In column (6) MK indicates if the star is a Morgan and Keenan (MK) Standard Star from García (1989) and Keenan & McNeil (1989). MK* indicates if the star is included in the list of Anchor Points for the MK System compiled by Garrison (1994). Column (7) gives the metallicity [Fe/H] from Taylor (1994, 1995) or Cayrel de Strobel et al. (1992, 1997), and columns (8) and (9) give the rotational period (P_{rot}) and $v \sin i$ from Donahue (1993), Baliunas et al. (1995), Fekel (1997), and Delfosse et al. (1998). We also give, in column (10), the Ca II H & K spectrophometric index *S* from Baliunas et al. (1995) and Duncan et al. (1991). In column (11) we list information about the observing run or runs in which each star has been observed, using a code given in the first column of Table 1; the number in parentheses gives the number of spectra available. The last column indicates if the star was also included in Papers I and II.

Representative spectra (from F to M, dwarfs, and giant stars) in different spectral regions are plotted in Figures 1, 2, 3, and 4 in order to show the behavior of the more remarkable spectroscopic features with the spectral type and luminosity class. In order of increasing wavelength we have plotted the following line regions: Hβ (Fig. 1), Na I D_1, D_2, and He I D_3) (Fig. 2), Hα (Fig. 3), and Ca II IRT $\lambda\lambda$8498, 8542 (Fig. 4). In each figure we have plotted main-sequence stars (luminosity class V) in the left-hand panel and giant stars (III) in the right-hand panel.

A total of 130 stars are included in this library. Many of them have been observed in several observing runs and in some cases several nights during the same observing run, bringing the total number of spectra to 345. Using these spectra as well as those of Papers I and II, a study of possible short- and long-term spectroscopic variability of some of the multiply observed stars is possible.

A description of the spectral lines most widely used as optical and near-infrared indicators of chromospheric activity, as well as other interesting spectral lines and molecular bands present in the spectral range covered by the spectra, can be found in Papers I and II and references therein.

As an illustration of the use of these spectra and those of Papers I and II, we intend to analyze temperature-sensitive lines in order to improve the actual line-depth ratio temperature calibrations (Gray & Johanson 1991; Gray 1994) and spectral class/temperature classifications (Strassmeier & Fekel 1990), as well as the determination of fundamental atmospheric parameters T_{eff}, $\log g$, and [Fe/H] (Katz et al. 1998; Soubiran et al. 1998). This will be the subject of forthcoming papers.

In order to enable other investigators to make use of the spectra in this library for their own purposes, all the final reduced (flattened and wavelength-calibrated) multidimensional spectra containing all the echelle orders of the stars listed in Table 3 are available at the CDS in Strasbourg, France, and also available via the World Wide Web.[6]

The data are in FITS format with pertinent header information included for each image. In order to facilitate the use of this library further, one-dimensional normalized and wavelength-calibrated spectra, for the orders containing the more remarkable spectroscopic features, are also available as separate FITS format files.

In addition, this library as well as the libraries presented in Papers I and II will be included in the Virtual Observatory.[7] This is a project to establish a new spectroscopic database that will contain digitized spectra of spectroscopic plates as well as spectra observed digitally from different observatories. Virtual Observatory is an International Astronomical Union (IAU) initiative through its Working Group for Spectroscopic Data Archives.

This research has made use of the SIMBAD data base, operated at CDS, Strasbourg, France. This work has been supported by the Universidad Complutense de Madrid and the Spanish Dirección General de Enseñanza Superior e Investigacióna Científica (DGESIC) under grant PB97-0259 and by National Science Foundation (NSF) grant AST 92-18008. We also acknowledge, with gratitude, KPNO supporting the FOE presence from 1987 until 1996.

[5] IRAF is distributed by the National Optical Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the National Science Foundation.

[6] CDS: via anonymous ftp to cdsarc.u−strasbg.fr (130.79.128.5); WWW: http://www.ucm.es/info/Astrof/fgkmsl/FOEfgkmsl.html.

[7] http://herbie.ucolick.org/vo/.

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